HSci2005

2nd International Conference

Hands-on Science

Science in a Changing Education

July 13 -16, 2005 - Greece

The University of Crete campus at Rethymno

http://www.clab.edc.uoc.gr/2nd/

Education and Culture

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Proceedings of the 2nd International Conference on Hands on Science, HSci 2005

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HSci2005 - 2nd International Conference

Hands-on Science: Science in a changing Education

A common feature of the Education reforms effected lately or under way in most of the European and other countries is the ever increasing importance they assign to Science education. Whatever the motives are, the effectiveness of Science teaching in schools, in Technical and Vocational education and, also, in Higher education becomes a crucial parameter for the success of Science education.

Although effectiveness of Science teaching has to be considered in relation to the objectives and the aims of the specific Science curriculum, in all ways, practice work (with laboratory experiments, observations, project assignments, relation of Science to everyday life, etc) plays a very important role in the understanding of Science.

In technology dependent modern societies an ever increasing number of decisions are based on Science and Technology developments. Consequentially, the citizens' active conscious participation (which is the foundation of Democracy) to these decisions, requires a sound Science and Technology Literacy. In this sense, practice work in Science teaching acquires new importance.

The Hands-on Science (HSci) network, which is supported by the European Commission, organizes as one of its activities annual International Conferences focused on Hands-on Science activities. The HSci 2004 International Conference was successfully organized in Ljubljana, Slovenia, 5 – 9 July, 2004 and details may be found in the proceedings and in the web site http://www.hsci.info/hsci2004/.

The HSci 2005 is organized 13 – 16 July 2005 at The University of Crete campus in Rethimno-Crete, Greece (http://www.clab.edc.uoc.gr/2nd/). The conference program includes Oral presentations in plenary and in parallel sessions, Poster presentations, a Comenius Contact Seminar focusing on the formation of new consortia within the European Union SOCRATES program, Science Fair activities, Exhibitions of apparatuses and instruments, computers and software, and other means, useful to Science education, etc.

Although the majority of participants come from Europe, the persons who have submitted their work or otherwise expressed their interest to participate in the HSci 2005 International Conference represent more than 27 countries from the five continents, a fact I consider as an indication of international high calibre.

The works submitted vary extensively in their contents and include research papers, software teaching aids, teaching approaches, hands-on constructions, etc. Within the context of this Conference, we address the research area but we also value the school operation and practice. Therefore, the works accepted as Conference activities were selected either because they exhibit a high research standard or because they consider in a fresh and often in an innovative way the school Science teaching thus providing alternatives to choose for an effictive Science teaching. The mixture resulted is represented in the Conference Program and also in the Conference Proceedings.

As president of the Local Organizing Committee, I have the privilege to present the HSci 2005 International Conference proceedings. I have also the pleasure to welcome all the participants wishing a fruitful stay.

Rethimno, July 2005 **P. G. Michaelides, Professor at The University of Crete**

HSci2005 - 2nd International Conference

Hands-on Science: Science in a changing Education

13 – 16 July 2005 at The University of Crete campus at Rethimno-Crete, Greece

Conference Chair:
Manuel Filipe Costa (Portugal)

Conference vice-chair:
George Kalkanis, National and Capodistrian University of Athens
P. G. Michaelides, The University of Crete

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Stelios Mantadakis

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Hands on Science: Science in a Changing Education

13-16 July 2005 at The University of Crete campus in Rethimno-Crete, Greece

The conference program includes:

A. **Oral presentations** in **plenary** and in **parallel** sessions.
   - The plenary sessions will take place in the main auditorium of The University of Crete at Rethimno (Room Δ3) during the morning of Wednesday, July 13, 2005 (in sequence of the Opening ceremony) and on Thursday, July 14, 2005 9:00 - 11:00.
   - The parallel sessions will take place in the main Conference as follows:
     - in auditorium Δ7 (Group A),
     - in auditorium Δ6 (Group B), and
     - in auditorium B1-29 (Group C)

B. **Poster presentations.** They will be on display during the whole period of the Conference on special stands in the atrium of the main Conference area. During the time 15:30 to 17:00 their authors are supposed to be available for discussions.

C. **Comenius Contact Seminar.** Auditorium B1-26 is reserved throughout the Conference duration for group discussions and presentation of ideas aiming to form Comenius consortia. Between 15:30 to 17:00 on the days of the Conference, plenary Comenius sessions are planned where experts from National Agencies and from already formed Comenius consortia will present their experience and help participants to the formation of applications. See the **Announcements** page on the web site and the announcements during the Conference period.

D. **Science Fair.** It will operate in the atrium of the main Conference area during the whole period of the Conference. Every day of the Conference duration, from 15:30 to 17:00, responsible persons will be available to demonstrate the 'Hands-on' activities and discuss issues related to their usage in education.

E. **Exhibitions.** During the Conference period, exhibitions of computers, apparatuses, instruments and other materials useful to Science and Technology education will be on. Interested Conference participants may get information and details from the persons in charge of the corresponding stands.

F. **Visits** to schools and the EKFE's (Laboratory Centres for Natural science education) for the interested participants of the Comenius Contact Seminars.

G. **Visits to the Region of Crete** (at an extra cost – see announcements during the Conference).

Notes.
- Coffee and lunch during the breaks are included in the Conference fee. Conference dinner in the evening of Friday, July 15, 2005 is included in the Conference fee. All served in the University campus.
- Interested participants may book transportation between the centre of Rethimno city and the University campus. See the Announcement page.
- Maps of the University campus area will be available shortly at the Announcements page to download.

The HSci 2005 Conference Program in brief

HSci 2005	Wednesday, July 13, 2005	Thursday, 14 July 2005	Friday, 15 July 2005	Saturday, 16 July 2005
8:00 - 9:00	Registration			➢ Conclusion of tasks ➢ Visits to Schools ➢ Visits to EKFE's ➢ Visits to the Region
9:00 – 11:00	Conference Opening	Plenary Session 2	Parallel Sessions 4	
11:00 – 11:30	Coffee	Coffee	Coffee	
11:30 – 13:00	Plenary Session 1	Parallel Sessions 2	Parallel Sessions 5	
13:00 – 15:30	Lunch	Lunch	Lunch	
15:30 – 17:00	Plenary Comenius Contact Seminar(*) Science Fair Demonstrations Poster Sessions	Plenary Comenius Contact Seminar(*) Science Fair Demonstrations Poster Sessions	Plenary Comenius Contact Seminar(*) Science Fair Demonstrations Poster Sessions	
	(*)Plenary Comenius sessions where experts from National Agencies and from Comenius consortia will present their experience and help participants to the formation of applications. Auditorium B1-26 is reserved throughout the Conference duration for group discussions and presentation of ideas aiming to form Comenius consortia (see announcements).			
			General meeting of the 'Hands-on Science' network.	
17:00 – 17:30	Coffee	Coffee	Coffee	
17:30 – 19:00	Parallel Sessions 1	Parallel Sessions 3	Parallel Sessions 6	
20:00- 24:00			**Conference Dinner**	

The HSci 2005 Conference Program in detail

Wednesday, July 13, 2005	
8:00 – 10:00	**Registration**
Opening Ceremony **Room Δ3** **10:00 – 11:00**	**Welcome address by State Officials and University Authorities.** **Science in a changing Education: The contribution of the Hands-on Science network to the improvement of science education.** Manuel F. M. Costa, *mfcosta@fisica.uminho.pt*, Universidade do Minho, Braga, Portugal
11:00 – 11:30	**Coffee Break**
Plenary session **Room Δ3** **11:30 – 13:00**	**Constructivism 25 years on: Its contribution, missed opportunities?** (A Video Conferencing presentation) Suzanne Gatt, *suzanne.gatt@um.edu.mt* University of Malta **Preparing teachers for cognitive coaching: the case of Physics by Inquiry as an experiential basis for Science learning.** C. P. Constantinou, *C.P.Constantinou@ucy.ac.cy* University of Cyprus
13:00 – 15:30	**Lunch Break**
15:30 – 17:00	**Plenary Comenius Contact Seminar** **Science Fair Demonstrations** **Poster Sessions**
17:00 – 17:30	**Coffee Break**

Wednesday, July 13, 2005	
Sessions 1 **Group A** **(Room Δ7)** **Wednesday, July 13, 2005** **17:30 – 19:00**	**Modeling Tasks for Exploring Topics of High-School Biology in the Computer-Supported Educational Environment 'Models Creator'** Vassiliki Zogza, zogza@upatras.gr, University of Patras, Greece Marida Ergazaki, ergazaki@upatras.gr, University of Patras, Greece Vassilis Komis, komis@upatras.gr, University of Patras, Greece **Innovative ways of combining teaching ICT with teaching science: video taking and editing by students and teachers** S. G. Antonopoulos, spilios@upatras.gr, University of Patras, Greece D. M. Garyfallidou, d.m.garyfallidou@upatras.gr , University of Patras, Greece G. S. Ioannidis, gsioann@upatras.gr, University of Patras, Greece J. A. Sianoudis, jansian@teiath.gr, Faculty of Technological Application, Athens - Greece D. J. Sotiropoulos, sdimitr@primedu.uoa.gr, University of Athens, Greece A. C. Tsiokanos, tsiokan@upatras.gr, Faculty of Technological Application, Athens – Greece **Modelling activities with educational software with regard to computer's operation** Panselinas G., panselin@sch.gr, University of Patras, Greece Komis V., *komis@upatras.gr,* University of Patras, Greece Politis P., *ppol@uth.gr,* University of Thessaly, Greece **Use of specially designed Haptic Devices in a Virtual Reality environment for Educational Purposes: Requirements, Specifications, and hands-on experience derived from an IST project** S. P. Christodoulou, spc@hpclab.ceid.upatras.gr, University of Patras, Greece D. M. Garyfallidou, D.M.Garyfallidou@upatras.gr, University of Patras, Greece G. S. Ioannidis, gsioanni@upatras.gr, University of Patras, Greece E. A. Stathi, stathie@hpclab.ceid.upatras.gr, University of Patras, Greece

Wednesday, July 13, 2005	
Sessions 1 **Group B (Room Δ6)** **Wednesday, July 13, 2005 17:30 – 19:00**	**The Technology Fair as means for enhancing problem solving skills and interest in Science and Technology** Alexandros C. Mettas, *mettas@ucy.ac.cy*, University of Cyprus Constantinos P. Constantinou, *c.p.constantinou@ucy.ac.cy*, University of Cyprus **The Science Fair as a Means for Developing Children's Graphing Skills in Elementary School** Evaggelia Kyriazi, *kyriazi@cytanet.com.cy*, University of Cyprus, Constantinos P. Constantinou, *c.p.constantinou@ucy.ac.cy*, University of Cyprus, **Hands-on Experiments Demonstrations Hands-on Educational Hardware / Software in Athens Hands-on quantum physics — Introducing quantum principles to non-physics major's students** Vassilis Dimopoulos, *bdimo@primedu.uoa.gr*, University of Athens, Greece George Kalkanis, *kalkanis@primedu.uoa.gr*, University of Athens, Greece **Complete Interactive Environment for Science Training** Mattheos Patrinopoulos, *mpatrin@primedu.uoa.gr*, University of Athens, Greece Emmanouil Kantzanos, *kantzanos@k-consulting.gr*, University of Athens, Greece George Kalkanis, *kalkanis@primedu.uoa.gr*, University of Athens, Greece **Experiential phenomena as experimental activities in science laboratory based on the human body – Four cases** Dimitrios Sotiropoulos, sotiropoulosdimitris@gmail.com, Katerina Tsagaroulaki, University of Athens, Greece Tasos Svarnas, University of Athens, Greece Aggeliki Metaxa, University of Athens, Greece George Kalkanis, *kalkanis@primedu.uoa.gr*, University of Athens, Greece **Investigating air resistance using extractor fan filters and plummet in MBL** Sarantos Oikonomidis, *sarecon@otenet.gr*, University of Athens, Greece Dimitrios Sotiropoulos, sotiropoulosdimitris@gmail.com, University of Athens, Greece George Kalkanis, *kalkanis@primedu.uoa.gr*, University of Athens, Greece **The Didactics of Science Through Polymorphic Self-Made Experimental Apparatus of Quantitative Determinations: An alternative proposal for the teaching of Natural Sciences** Miltiadis Tsigris, mtsigris@edc.uoc.gr, The University of Crete, Greece

Wednesday, July 13, 2005	
Wednesday, July 13, 2005 17:30 – 19:00 **Sessions 1** **Group C** **Wednesday, July 13, 2005 17:30 – 19:00**	**Science Fair activities in Brief** **The Science Fair at the 2nd Primary School of Avgorou as a Means for Developing Investigative Skills** Evaggelia Kyriazi, kyriazi@cytanet.com.cy, University of Cyprus, **The Science Fair at the 1st Primary School of Sotera as a Means for Developing Investigative Skills** Panayiota Kyriazi – Kefala, m_kefalas@hotmail.com, 1st Primary School of Sotera Famagusta - Cyprus Antonia Kyriazi - Hadjimarkou, 1st Primary School of Sotera Famagusta - Cyprus **Mechanical and Solar Energy Projects … in Action** Nektarios Tsagliotis, ntsag@edc.uoc.gr, The University of Crete, Greece **Science Fair Experiments and Activities from the Laboratorial Centre of Natural Sciences (EKFE) of Rethymno** Tzianoudakis Leonidas, mail@ekfe.reth.sch.gr, E.K.F.E. of Rethymno, Siskakis Giannis, E.K.F.E. of Rethymno, Papagiannaki Sofia, E.K.F.E. of Rethymno, Rompogiannaki Valia, E.K.F.E. of Rethymno, Mantadakis Stelios, E.K.F.E. of Rethymno **Let's Learn Robotics and Chemistry Together!** Eduardo Pinto, Eduardo.mpinto@netvisao.pt, Center for Investigation and Development of Vocational School Gustave Eiffel, Amadora, Portugal **Technology Fair Projects** Alexandros C. Mettas, mettas@ucy.ac.cy, University of Cyprus Constantinos P. Constantinou, c.p.constantinou@ucy.ac.cy, University of Cyprus **The Theory of Relativity in Primary Education(*).** Antonis Tsalapakis, Atsalapakis@edusrv.edc.uoc.gr, The University of Crete, Greece **Science Fairs as mechanisms for University – School - Community collaborations in Cyprus** M. Evagorou, University of Cyprus L. Avraamidou, University of Cyprus Constantinos P. Constantinou, c.p.constantinou@ucy.ac.cy, University of Cyprus

Wednesday, July 13, 2005

Science Fair activities in Brief **Wednesday, July 13, 2005 17:30 – 19:00** **Sessions 1** **Group D** **Wednesday, July 13, 2005 17:30 – 19:00**	**The Science Truck High level research coming into the school** Walburga Bannwarth-Pabst, sekretariat@emg-huerth.de, Ernst-Mach-Gymnasium, Hürth, Germany **"Fun Science Club"** Emilia Păuşan, e_pausan2004@yahoo.com, "Tudor Vladimirescu" Theoretical High School,Bucharest, Romania Monica – Maria Iliescu, "Tudor Vladimirescu" Theoretical High School,Bucharest, Romania Antonia Nicolescu, "Tudor Vladimirescu" Theoretical High School,Bucharest, Romania Dănuşa Dumitrescu, "Edmond Nicolau" Technical College, Bucharest, Romania Activities: **Studying per model - LabView simulation** BURADA OANA-RAMONA, BUZILA ADINA IOANA, DRAGHICI CRISTIAN **Studying per model - LabView simulation** BURADA OANA-RAMONA, BOLOC ROBERT, GHIORGHIESCU ADRIAN **Real lab experiments made in "Fun Science Club" using a computerised system** BURADA OANA-RAMONA, URSU IOAN, BUZILA ADINA-IOANA **Real lab experiments made in "Fun Science Club" using a computerised system** URSU IOAN, CIOBANU CLAUDIA-ANDREEA, STEFAN BOGDAN-MIHAI **THE ISOBAR TRANSFORMATION** SIMION VIOLETA-MARIA, BUIU ANDREI **Global Science** Prof. Luminiţa Grigorescu, Prof. Maria Enache, Prof. Ovidiu Şerbanescu, Tehn. Lab. Eugenia Bâdrea, Prof. Corina Sibişeanu with the assistance of the following students: Claudiu Armean, Florentina Ungureanu, Mihai Ene, Andreea Panait, Valeria Ciocâlteu **The multimedia album MATH' ON MUSICAL NOTES of the PROFU DE MATE (MATH' TEACH) band** Dragos Constantinescu, profudemate2004@yahoo.com, dragos@epsilon.ro, profudemate@gmail.com, High School of Art, Valcea, Romania **Arsenic and its compounds,** Anca Adriana Arbune, Class IX-a D, Colegiul National Vasile Alecsandri, Galati, Romania **Carbon,** Elena Miu & Ciocanel Maria Veronica, Guiding teacher Manza Lidia, Colegiul National Vasile Alecsandri, Galati, Romania **Magnesium,** Ciocanel Maria Veronica & Cringanu Ioana Andrea, Guiding teacher Manza Lidia, Colegiul National Vasile Alecsandri, Galati, Romania **'Intercultural pedagogic perspective on Science Education in a changing Education' WHAT EFFECTS INTERCULTURAL EDUCATION?** Hans Lorentz, Department of Education at Lund University – Sweden **Sculpting Virtual Reality for Teaching Science History** Radu A. Sporea, "Politehnica" University of Bucharest, Romania

Thursday, July 14, 2005	
Plenary session **Room Δ3** **Thursday, July 14, 2005** **9:00 – 11:00**	**The Junior Certificate Science –Revised Syllabus** Deirdre Knox *dmgknox@ireland.com*, Irish Science Teachers' Association Presentation Secondary School, Loughboy, Kilkenny, Ireland **Nine Years of Scientific Research Training in Hungary** Peter Csermely *csermely@puskin.sote.hu* Semmelweis University, Hungary Szilárd Kui, *szilardkui@nyex.info* Network of Youth Excellence, Budapest, Hungary **Sixth Framework Programme: Structuring the European Research Area Science and Society – European Science Education Initiative** Walter Staveloz *wstaveloz@ecsite.net* ECSITE, Belgium **Demands on an European Teacher** Ingrid Hantschk, Hans Fibi *fibi@pabw.at*, Pädagogische Akademie des Bundes in Wien, Austria
11:00 – 11:30	**Coffee Break**
Sessions 2 **Group A (Room Δ7)** **Thursday, July 14, 2005** **11:30 – 13:00**	**Web-based Instruction in IT Hardware** Iryna Berezovska, *iberezov@hotmail.com*, Ternopil State Technical University, Ukraine Mykola Berchenko, *nberchen@mail.lviv.ua*, Lviv Polytechnic National University, Ukraine andRzeszow University, Poland **Conceptual Learning of Science and 3D Simulations** Sasa Divjak, *sasa.divjak@fri.uni-lj.si,* University of Ljubljana, Slovenia **A Teaching – Learning Sequence Concerning Dynamic Interactions: The Need for Appropriate Software** Petros Kariotoglou, *kariotog@eled.auth.gr*, University of Western Macedonia - Greece Anna Spyrtou, *aspyrtou@eled.auth.gr,* University of Western Macedonia - Greece **Newton-3 : A Software For Teaching Dynamic Interactions.** E. Hatzikraniotis(1,a), *evris@physics.auth.gr*, Aristotle University of Thessaloniki - Greece A. Theodorakakos(1,b), *anaton@the.forthnet.gr*, Aristotle University of Thessaloniki - Greece A. Spyrtou, *aspyrtou@eled.auth.gr,* University of Western Macedonia - Greece P. Kariotoglou, *kariotog@eled.auth.gr*, University of Western Macedonia -Greece

Thursday, July 14, 2005	
Sessions 2 **Group B (Room Δ6)** **11:30 – 13:00**	**Techno-Sciences and Mathematics: Vehicles for a Sustainable Future and Global Understanding** Vasilios Makrakis, *makrakis@edc.uoc.gr*, The University of Crete - Greece Nelly Kostoulas-Makrakis, *kostoulas@rhodes.aegean.gr*, University of Aegean – Greece **Optics and Pool: Play the Game** Carlos Filipe S. Lima, *Fillima@portugalmail.pt*, Escola Secundária Carlos Amarante, Braga, Portugal Manuel F. M. Costa, *mfcosta@fisica.uminho.pt*, Universidade do Minho, Braga, Portugal **Robots at School. The Eurobotice project** Manuel F. M. Costa, *mfcosta@fisica.uminho.pt*, Universidade do Minho, Braga, Portugal José F. Fernandes, *filipeflemos@hotmail.com*, Escola EB 2,3 João de Meira, Guimarães, **Using Physics to Innovate Practices in Family Type Firms** Carlos Jorge Leite Oliveira Teixeira, *carlucci@sapo.pt*, Escola Básica 2,3 de São Torcato, Portugal
Sessions 2 **Group C (Room B1-29)** **Thursday, July 14, 2005 11:30 – 13:00**	**Hands-on Science in Romania, Act II** Dan Sporea, *sporea@ifin.nipne.ro*, National Institute for Lasers, Plasma and Radiation Physics, Romania **Methods Used in Romanian Schools to Increase Students' Interest in Learning Physics** Liliana-Violeta Constantin, *lilianaaa29@yahoo.com*, "Elena Cuza" National College, Bucharest, Romania **Introducing Concepts of Physics into Primary School** Marinela Ruset, *rusetcristian@yahoo.co.uk*, High School "Stefan Odobleja", Romania Mariana Mogos, High School "Stefan Odobleja", Romania **Appliances of First Degree and Second Degree Mathematical Equations in Solving of Some Physics Problems** Constantin Lucian Vladescu, *lucconstvl@yahoo.com*, The school with I-VIII classes, Romania
13:00 – 15:30	**Lunch Break**
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17:00 – 17:30	**Coffee Break**

Thursday, July 14, 2005

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Sessions 3 **Group B (Room Δ6)** **Thursday, July 14, 2005 17:30 – 19:00**	**Van de Graaff Generator** A. J. Martins, anajoaom@gmail.com, University of Minho, Braga, Portugal H. M. Pinto, University of Minho, Braga, Portugal **Motivation and Hands-on Experiments** Josef TRNA, trna@ped.muni.cz, Masaryk University in Brno, Czech Republic **Teaching Ninth-Grade Genetics Through Inquiry** M. I. Hadjimarcou, hadjim@ucy.ac.cy, University of Cyprus C. P. Constantinou, c.p.constantinou@ucy.ac.cy, University of Cyprus Z. Zacharia, zach@ucy.ac.cy, University of Cyprus **"Teaching Science by Experimentation: Hands-on method".** Carlos Filipe S. Lima, Fillima@sapo.pt, Escola Secundária Carlos Amarante, Braga, Portugal
Sessions 3 **Group C (Room B1-29)** **Thursday, July 14, 2005 17:30 – 19:00**	**Science interpretation in high school** R. Villar Quinteiro, rosavillarq@yahoo.es, Instituto de Estudos Miñoranos, Spain B. Vázquez Dorrío, bvazquez@uvigo.es, Universidade de Vigo, Spain **An informal interactive science and technology centre** S. Rodríguez Muñoz, I.E.S. Escolas Proval, Spain J. Fernández Rodríguez, I.E.S. Escolas Proval, Spain J.A. Ansín Agis, I.E.S. Escolas Proval, Spain A. Lago Rodríguez, Instituto de Estudos Miñoranos, Spain B. Vázquez Dorrío, bvazquez@uvigo.es, Universidade de Vigo, Spain **Environmental Education in Greek Schools: The Viewpoint of the Local Coordinators** Georgios Kimionis*,geokim@edc.uoc.gr, The University of Crete, P. G. Michaelides, michail@edc.uoc.gr, The University of Crete, **The Promotion of Scientific Literacy with Alternative Methods and Activities. The experience of the Laboratorial Centre of Natural Sciences (EKFE) of Rethymnon** Tzianoudakis Leonidas, mail@ekfe.reth.sch.gr, Person in charge of the E.K.F.E. of Rethymno

Friday, July 15, 2005	
Sessions 4 **Group A (Room Δ7)** **Friday, July 15, 2005 9:00 – 11:00**	**Computer-Aided Simulations for Hands-on Physics Experiments** G. Demirjian, *dega@web.am*, Gyumri State Pedagogical Institute, Armenia V. Harutyunyan, *volhar@mail.ru* , *sashar@rambler.ru*, State Engineering University of Armenia, Armenia S. Harutyunyan, State Engineering University of Armenia, Armenia **A Web Site about Historic Experiments (HE) The Galileo Free Fall Experiment The Topics – The Structure** L. Papatsimpa, *lpap@pi-school.gr*, Greece P. Dimitriadis, Greece E. Kyriaki, ekyriaki@tiscali.be, Belgium **Teacher's Role in a Changing Education. A Case Study of Asynchronous Education at Technological Education Institute (TEI) of Crete** Kalogiannakis Michail, *mkalogian@laposte.net*, University Paris 5- René Descartes, France Psarros Michail, *psarros@telecom.tuc.gr*, TEI of Crete, Greece Vassilakis Kostas, *kostas@cs.teiher.gr*, TEI of Crete, Greece **The New Technologies in the Teaching of Geometric Optics** G. ANAGNOSTAKIS, The University of Crete, Greece V. MANTADAKIS, The University of Crete, Greece V. PAPAVASILIOU, *vpapav@edc.uoc.gr*, The University of Crete, Greece **Entertaining Experiments in Electrostatics** Chung-chih Chen, *sc121@mail.fy.edu.tw*, Fooyin University, Taiwan
Sessions 4 **Group B (Room Δ6)** **Friday, July 15, 2005** **9:00 – 11:00**	**The Effect Of Using Simple Equipment On The Acquisition Of Plan Map Concepts In The Vocational Schools** Eskandar Fathi-Azar, *e-fathiazar@tabrizu.ac.ir*, University of Tabriz, Iran **Modern teaching methods in physics** Mircea Rusu, *mvrusu@yahoo.com*, *mrusu@dnt.ro*, Faculty of physics – Bucharest - Romania Diana Melnic, *dz_diana@yahoo.com*, " Teacher Training Center"- Bucharest- Romania Stefan Grigorescu, *grigorescu_stefan2003@yahoo.com*, " Teacher Training Center"- Bucharest –Romania **The curriculum reform and the schools' ability to innovate** Lomos Catalina, *lomoscatalina@yahoo.com* *lomos_alina@yahoo.com*, RUG University, Netherlands **Science, Technology and Society in Chemistry Learning** Cristina Carvalhinho, *c.carvalhinho@clix.pt*, Escola Secundária Manuel de Arriaga,Horta,Açores **Environmental Issues on the Newspapers of HERAKLION - CRETE** Theodore Antoniou(*), *antoniou@edc.uoc.gr*, TheUniversity of Crete

Friday, July 15, 2005	
Sessions 4 **Group C (Room B1-29)** **Friday, July 15, 2005** **9:00 – 11:00**	**Technologies in School** Marisa Andrade, *marisa_andrade11@hotmail.com*, Escola Secundária Manuel de Arriaga, Faial Açores **Learning science towards a sustainable development** Rui M. Vila-Chã Baptista, *ruibaptista@prof.min-edu.pt*, Escola Secundária C/ 3º Ciclo de Vieira do Minho, Portugal Paula Silva, *pcmsilva@sapo.pt*, Escola Secundária C/ 3º Ciclo de Vieira do Minho, Portugal Manuel F. M. Costa, *mfcosta@hsci-pt.com*, *mfcosta@fisica.uminho.pt*, Universidade do Minho, Braga, Portugal **Chemistry and Robots** Eduardo Manuel F.M.Pinto, *eduardo.mpinto@netvisao.pt*, Escola Profissional Gustave Eiffel, Portugal Paulo Jorge C. R. Ernesto, *paulo.ernesto@cooptecnica.pt*, Escola Profissional Gustave Eiffel, Portugal **Potenciality of an integrated approach to teach the topic Improving Life on Earth to 9th grade students of Physical and Natural Sciences** Manuel Sequeira, msequeira@iep.uminho.pt, Universidade do Minho, Braga, Portugal Luísa Ferraz, *lferraz@iep.uminho.pt*, Universidade do Minho, Braga, Portugal **Practical Work to Promote Interdisciplinarity Between Physical and Natural Sciences: A Teaching Experiment with 7th Grade Portuguese Students** Maria da Conceição Duarte, *cduarte@iep.uminho.pt*, University of Minho, Braga, Portugal Manuel Sequeira, *msequeira@iep.uminho.pt*, University of Minho, Braga, Portugal Paula Barbosa, *pbarbosa@quimica.uminho.pt*, University of Minho, Braga, Portugal
11:00 – 11:30	**Coffee Break**

Sessions 5 **Group A (Room Δ7)** **Friday, July 15, 2005 11:30 – 13:00**	**Kolb's Experiential Learning Model: Enlivening Physics Courses in Primary Education** Evangelos I. Manolas, *emanolas@fmenr.duth.gr*, Democritus University of Thrace, Greece. Theodoros I. Kehagias, , 6th Primary School of Argyroupolis, Athens, Greece. **Forms of Energy: Cooperative Learning in the University Classroom** Evangelos I. Manolas, *emanolas@fmenr.duth.gr*, Democritus University of Thrace, Greece. Walter Leal Filho, *leal@tu-harburg.de*, Department of Environment and Biotechnology, TuTech, Germany **CONNECT: Designing the Classroom of Tomorrow by using Advanced Technologies to connect formal and informal learning environments** Sofoklis Sotiriou, *sotiriou@ellinogermaniki.gr*, Ellinogermaniki Agogi, Greece Stavros Savas, Ellinogermaniki Agogi, Greece Elias Vagenas, Ellinogermaniki Agogi, Greece Nikolaos Ouzounoglou, National Technical University of Athens, Greece Michael Gargalakos, National Technical University of Athens, Greece Rodoula Makri, National Technical University of Athens, Greece Petros Tsenes, National Technical University of Athens, Greece Lynn D. Dierking, Institute for Learning Innovation, Annapolis, USA Salmi Hannu Sakari, HEUREKA – The Finnish Science Center, Finland Avi Hoffstein, Weizman Institute of Science, Israel Sherman Rosenfeld, Weizman Institute of Science, Israel **Teaching for Conceptual Change in Science Laboratory** Grigoris Epitropakis, *grigorise@acn.gr*, Second Laboratorial Center of Natural Sciences of Heraklion, Greece
Sessions 5 **Group B (Room Δ6)** **Friday, July 15, 2005 11:30 – 13:00**	**The Effect of Inquiry-based Chemistry Course on Students' Understanding of Atom Concept, Learning Approaches, Motivation, Self-efficacy and Epistemological Beliefs** İ. Sevilay Caliskan, Middle East Technical University, Ankara, Turkey Esme Hacieminoglu, *hesme@metu.edu.tr*, Middle East Technical University, Ankara, Turkey Hamide Ertepinar, *hamide@metu.edu.tr*, Middle East Technical University, Ankara, Turkey Ömer Geban, Middle East Technical University, Ancara, Turkey **Contemporary Scientific Concepts in Primary Schools: A Test Case on the concept of Systems.** N. Kountourakis, *koudya2000@yahoo.com*, Primary School Teacher, Souda, Greece P. G. Michaelides, *michail@edc.uoc.gr*, The University of Crete, Greece

Friday, July 15, 2005	
Sessions 5 **Group C (Room B1-29)** **Friday, July 15, 2005 11:30 – 13:00**	**Applying Concept Map to develop a new Technical Writing technique for enhancing Reading Comprehension performance** Hung Ha, hmh61@uow.edu.au, Wollongong University, Australia **Interdisciplinariness in the Curriculum of the nursery school: An example of thematic approach of the key concepts 'evolution'** Nicoletta Gliaos - Christodoulos, Pedagogical Institute of Athens Effy Gourgiotos, egourg@yahoo.gr, Pedagogical Institute of Athens **Landscapes for Learning – Rediscovering the Mediterranean Landscapes – & the Case of University of Crete's woodland in Rethymnon.** Sophie Nikolakaki – Hajaje, snikol@edc.uoc.gr, The University of Crete, Greece **Review the changing role of intellectual property in the microelectronics sector** Qazi Moinuddin Abro, qaziabro@yahoo.co.uk, Mehran University of Engineering and Technology, Pakistan Zahid Ali Memon, memonzahid2000@yahoo.com, Mehran University of Engineering and Technology, Pakistan Arabella Bhutto, rbll_bhutto@yahoo.com, Mehran University of Engineering and Technology, Pakistan Qazi Ali Muhammad, mehranian@hotmail.com, National Rural Support Program, , Pakistan
13:00 – 15:30	**Lunch Break**
Friday, July 15, 2005 15:30 – 17:00	**Plenary Comenius Contact Seminar** **Science Fair Demonstrations** **Poster Sessions** **General meeting of the 'Hands-on Science' network.**
17:00 – 17:30	**Coffee Break**
Sessions 6 **(Room Δ7)** **Friday, July 15, 2005 17:30 – 19:00**	**Available for Group Discussions. Ask the Conference secretariat.**

Friday, July 15, 2005	
Sessions 6 **Group B (Room Δ6)** **Friday, July 15, 2005** **17:30 – 19:00**	**The Experimental Approach of Physics in Secondary School** Elena Vladescu, *elenavladescu@yahoo.com*, National Vocational College "Nicolae Titulescu", Romania **Data acquisition and analyzis of real signals experiments** Elena-Mihaela Garabet, mihaela_garabet@yahoo.com, Liceul Teoretic "Grigore Moisil"-Bucureşti, Romania Ion Neacşu, iv_neacsu@yahoo.com, Liceul Teoretic "Grigore Moisil"-Bucureşti, Romania **Data aquisition experiments for Science Lessons** Elena-Mihaela Garabet, mihaela_garabet@yahoo.com, Liceul Teoretic "Grigore Moisil"-Bucureşti, Romania Ion Neacşu, iv_neacsu@yahoo.com, Liceul Teoretic "Grigore Moisil"-Bucureşti, Romania **A LabVIEW Simulation of the Ideal Gas Transformations** Marinela Ruset, rusetcristian@yahoo.co.uk, High School "Stefan Odobleja", Bucharest, Romania George Bleaja, george_bleaja@gmail.com, SC Nova System SRL, Bucharest, Romania
Sessions 6 **(Room B1-29)** **Friday, July 15, 2005** **17:30 – 19:00**	**Available for Group Discussions. Ask the Conference secretariat.**
20:00 – 24:00	**Conference Dinner at The University campus with traditional Greek food, music and dances**

Saturday, July 16, 2005	
Saturday, July 16, 2005 **The whole day**	➢ Conclusion of tasks. Groups from the Comenius Contact Seminar may have this day to conclude, approve and finalise their applications. Ask the Conference secretariat for support. ➢ Visits to Schools. Interested Conference participants may visit schools of the region. State your interest to the Conference secretariat. ➢ Visits to EKFE's. Interested Conference participants may visit the 2 EKFEs (Laboratory Centre for Natural Sciences) that support the schools of the region in relation to the Laboratory work in the teaching of Natural Sciences. There is one EKFE for secondary education (middle and high school) and one for primary education (established in 2004). State your interest to the Conference secretariat. ➢ Visits to the Region. Interested Conference participants may join, at an extra cost, special guided tours to the region of Crete. See the Announcements page of the Conference web site and the announcements during the Conference.

Science in a changing Education. The contribution of the Hands-on Science network to the improvement of science education.

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Abstract. Science and Technology have a major increasing role in today' Society and in the lives of everyone of us. No further substantive and sustainable development of our economy and society may be foreseen without a leading enlarged and improved scientific and technological research. Improving Science Education is fundamental as well as effectively setting as major priority to raise the levels of scientific and technological literacy at all levels of our society.

The enlarged European Union facing new developmental challenges and aiming a decisive global affirmation in the world needs to grow effective steps towards the establishment of a sound science and technology culture in our societies, as steady basis for the improvement of Science and its technological applications. Practice work is essential to the understanding of Science and thus fundamental to Science and Technology literacy.

The new stringent requirements of the modern society demand not only the gathering of specific knowledge but also and especially of the competencies and the ability of acting interactively to be able to find analyze and solve new interdisciplinary problems. The best way of achieving an adequate education of our students on these issues is by inducing the students to an active committed participation in the teaching/learning process, through practice and experimentation. The pedagogic approach we suggest to be used relies on a functional integration of different pedagogical theories and practices namely the constructivism, conceptual learning and pro-active learning by hands-on experimentation and research. Responsibility, critical reasoning and observation, method and flexibility, interdisciplinarity, volunteer self-rewarding commitment, joint efforts and teamwork, are among the main keywords that should guide all pedagogical activities in our modern schools.

Education reforms are being implemented in many countries. The type and extent of the reforms vary significantly but share the increased significance given to Science Education that is becoming a major constituent of school curriculum. The need of practice and experimentation in the S&T learning process is also being increasingly recognized. And this is also the main goal of the Hands-on Science network.

In order to define the best paths to assess prove or justify the importance of active learning of science by hands-on experimental work the network organized already many different activities. Last year in Ljubljana the "1st International Conference on Hands-on Science. Teaching and Learning Science in the XXI Century" was an excellent forum where 120 participants 13 countries presented and discussed the main aspects of modern Science Education establishing the basis for the work the network developed thereafter. The stringent problems of the access of women to Science both in education and as career, and the challenges of EU' development and the importance of scientific literacy were discussed in two thematic workshops organized in Köln in June 2004 and in Malta in January this year. Next year the issue of life-long learning and scientific literacy will be the theme of our 3rd workshop.

The network promoted and induced several new cooperation projects at EU level in the field of Science and Technology education. Six Comenius 1 school' projects and two Comenius 2 projects were presented and many more will be in the future. A Comenius training course on "School' Robotics" for schoolteachers was rather successfully organized in April this year. Others will in different topics on the months and years to come. The establishment of student' Science Clubs is being supported in different countries. Science fairs, contests and other

informal or non-formal educational activities that bring together students, teachers and education specialists, research institutions, the industry and the community in general were promoted or supported. Several scientific papers and communication were produced and published in different languages.

Experiment's guides, books, CDROM and DVDs were produced. A public relations campaign is on the way aiming EU' schools, governments, parliaments and decision makers, universities, networks and national and transnational associations, science museums and other institutions involved with non-formal or informal education, the industry, local communities and the citizens in general. New Associated Members from most of the European countries are constantly entering the network enlarging the impact and effectiveness of our activities.

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Constructivism 25 Years on: Its Contribution, Missed Opportunities?

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Abstract. *Science Educators have endorsed and advocated adopting a constructivist approach in science teaching for these past 25 years. This is indicated by the massive research published during this period about children's ideas and describing teaching schemes developed within a constructivist framework. Yet, as the PISA results [14] highlight, students' performance across the world vary widely and too many students still lack the basic scientific literacy needed to understand and apply basic scientific principles to contexts.*

The aim of this paper is to review the development of constructivist learning theory highlighting its main contributions. The main approaches: cognitive conflict; scaffolding; and metacognition will be each discussed in detail. However, like any other theory, constructivism has its shortcomings, particularly in treating the learning context in a holistic way within a sociological perspective. Reasons for which constructivism has not brought about the significant improvement in the understanding of science as predicted by science educators will be put forward. Possible directions that constructivism can take up in dealing with the new demands of the social impact that major current scientific research such as cloning is making, will be proposed.

Keywords. Children's Ideas, constructivism, review, teaching approaches.

1. Introduction

Students' performance and level of understanding has been a cause for concern for as long as there has been research in science education. Science teaching has experienced a shift from the traditional 'transmission' approach [14] to focus on process skills and discovery learning (see Nuffield Science) to constructivism. The shift has been in two directions: from teacher-centred to child-centred; and from a passive view of learning to one which considers the learner as actively involved with the learning content.

In the transmission view, the learning process is considered as the simple transfer of knowledge from the teacher (the knowledgeable) to the pupil (the less knowledgeable). The teacher is the active participant whereas the student is the passive receiver of knowledge, hence the teacher-centred approach. Science educators soon recognised the insufficient adequacy of the transmission view [14]. It was recognized that effective learning could not take place without the active participation of learners. One thus finds the famous statement 'children learn by doing' approach as advocated in the Nuffield approach [2]. This was a shift from one extreme to another whereby students within the 'discovery approach' were left to their own devices to understand not only the scientific concepts but also what they were supposed to learn. Hence, one finds the criticism put forward by Rosalind Driver [3] who compared this approach to a simple guessing game where students were more concerned with finding out what they were supposed to learn rather than focusing on understanding the concepts involved in the situation presented to them. Constructivism succeeded the Nuffield Science, following research findings that students already hold ideas (and often wrong ideas) about scientific concepts. This implied that students naturally like to make sense of things and consequently learning involves recognizing these ideas and building on them. Thus the constructivist approach endorses a child-centred approach as well as considers the learning process as the active construction of knowledge by the learner.

2. Contribution of Constructivism

Constructivism has provided a number of significant contributions to the teaching of science, these being listed to mainly include: developing teaching approaches based on theories of learning; recognising students' ideas; changing the role of scientific knowledge from objective and infallible to being socially constructed; recognising the role of language as a part of the learning process; changing the role of practical work.

Despite the evident little improvement in the learning and understanding of science, constructivism has none the less, provided a contribution to the understanding of the learning process. Not only has it consolidated the shift from teacher-centred to child-centred approach, but it has also provided insight into how learners construct knowledge. Although the main criticism put forward to constructivism is that it does not tend to be much of a theory [], on the other hand it has great potential in its possibility for application in the classroom. Many teaching schemes and approaches in fact have been developed under the umbrella of constructivism. This is also reflected in the number of theories developed by key people such as Piaget, Ausubel and Vygotsky. A common theoretical basis for each teaching approach developed is that they all view the learner as a cognitive process where the learner is actively engaged, on a personal level internally and/or within a social context with the learning material in the process of constructing knowledge. So one finds applications such as the use of cognitive conflict [1], scaffolding [12] as well as metacognition [10, 19].

Cognitive conflict can be considered as a means of provoking the construction of knowledge. When there is difference between an experimental outcome, learning material or other students' ideas with those that the learner holds, the learner experiences a state of dissonance. Consequently accommodation (using Piaget's language) takes place during learning. We thus find examples [8] where students were asked to predict actual experiments' outcomes. These activities are usually designed in such a way that they bring out students' alternative frameworks which differ from correct scientific concepts creating cognitive conflict. One also finds examples of group-work which is used to get students to spell out their ideas about specific scientific concepts with the aim of generating different models and ideas. This also creates cognitive conflict. In any case, these are situations where students are given ownership of their own learning as they would want to know whether their ideas are correct and if not for what reason. The successful use of cognitive conflict depends on the types of conflict created. It cannot be too difficult as otherwise it would be beyond the students' capabilities. On the other hand, it shouldn't be too easy as it would not be challenging enough to motivate the students. It should be targeted within Vygotsky's zone of proximal development [17].

Work by Vygotsky [17] based on his theory of zone of proximal development and the use of scaffolding is another example of how teaching schemes have been developed within a constructivist approach. In scaffolding the teacher provides support so that students are able to do activities that they would not otherwise be able to tackle. As students gain experience, the teacher removes the amount of help and support provided gradually until they can perform the task on their own. The role of the teacher is to create learning situations and support structures so that mediation of learning takes place. Such an approach can be considered to be within the constructivist approach as the responsibility for learning shifts from the teacher to the student.

Metacognition can be described as the ability to 'think about one's own thinking'. Such cognitive process is at a higher level of thinking than cognitive conflict and scaffolding. Whereas the latter two deal directly with the learning context, metacognition goes further as it requires the learner to reflect on his/her process of thinking in dealing with the learning content. Approaches devised include examples where students are asked to describe their learning path at the end of a teaching session [8], or at the end of a teaching scheme. Metacognition is difficult to achieve but it provides the learner with control over his/her developed learning processes.

Another major contribution of constructivism is that it acknowledges the existence of students' ideas and gives value to them. If one goes through literature published during the 80's one finds many studies on children's alternative

[6, 7] in practically any area of science. Whole publications, for example Driver et al [6, 7] and Pfundt & Duit [15] are classic examples of such collections. These studies have brought insight of the ideas that students hold, before and often also after formal science teaching, to science education. Consequently, they have shifted the focus from the teacher and content to the students and given value to their existing "knowledge". This was a major shift since up to that point science educators tended to focus mainly on content and its logical structure from an epistemological point of view rather that from the students' learning point of view. It also served to acknowledge students' attempt to understand natural scientific phenomena that they encounter in their everyday life. The commonly used label of alternative frameworks [5] fully endorses the value given to students' ideas.

Going to a completely different type of contribution, constructivism has changed the way that science educators view scientific knowledge. Within a constructivist perspective, science educators hold the view that learners, and likewise scientists, construct models and theories about natural and scientific phenomena. Thus scientists are also involved in the social construction of knowledge. Scientific knowledge has thus lost its positivistic image of being totally objective and infallable. Scientific knowledge is now recognised as being constructed by the community of scientists. This change of view has brought closer the accepted scientific views to the students' alternative frameworks. However, the latter still have much lower status compared to that of the scientific knowledge within the community of scientists.

Another contribution of constructivism is the recognition of the importance that language has as a tool to promote the construction of knowledge. Language is not only the means through which scientific ideas are communicated, it is also the medium through which ideas are constructed [18]. Language can be used for more than transmitting knowledge to learners. It is also the vehicle through which learners become aware of their own thoughts, thus facilitating understanding. This brought about a change in the types of activities organised within science classrooms. Constructivist teaching promotes student participation in discussions, group-work, in interacting with texts etc. This is a move from the passive student or the physically active learner, to the cognitively active learner.

In the same way as the role of language has changed in science education, so has that of practical work. Traditional practical work tends to consist in the illustration of relationships and concepts described in class. Experimental reports usually followed (and often still do) the same traditional format of aim, method, results etc. Constructivism has placed practical work at the heart of the learning process. Worksheets developed within a constructivist perspective are designed in such a way as to provoke student thinking and reflection on what happened in the experiment and more importantly to explain why. The why requires students to try and make sense of their observations using their existing frameworks. When these fail to provide plausible explanations, then, hopefully construction of good scientific understanding, takes place. Such an approach falls within, but is not exclusive, of the conceptual change [11] teaching strategy.

3. Criticisms to constructivism

If one had to make up a list of the most overused and abused words within educational settings, constructivism would feature high on the list. In the literature one finds all sorts of constructivism such as: cognitive constructivism, sociocultural constructivism, piagetian constructivism, sociological constructivism, pragmatic constructivism, radical constructivism to structural constructivism within sociology of education. Too many labels for one construct leads to confusion. One theory cannot have so many aspects. This leads to a situation where different educators mean different things of else that the theory is too wide. A too open a theory tends to become vague and is prone to be interpreted in many different ways. In any case such situation weakens the position of constructivism from being recognised as a serious and well developed theory of learning.

The main criticism that I bring to constructivism comes from another point of view. This is that it does not deal with the learning process holistically but limits itself just to the cognitive aspect of learning. As stated in the beginning of this paper, constructivism refers to learning as the active construction of knowledge, whether this is considered to take place internally at a personal level or in a group within a social context. It, however, fails to include a sociological perspective to learning. If one were to review the many constructivist methodologies developed, the main focus tends to be students' alternative ideas within a psychological perspective. The focus is just on making students construct scientific knowledge where the only difference between the learners tends to be mainly the different alternative frameworks. There is no recognition of other types of conceptions that students hold and bring with them to the learning situation. Let us just consider one extreme situation. What if a student in a classroom comes from a poor background, does not even have basic living conditions at home, has always been told that he is slow, incapable of learning, would get up to no good in life. How can a student with such background possess the desired readiness that leads to learning. Unfortunately, science educators have failed to include this perspective within their schemes. This nearly total disregard of the sociological perspective may be the root as to why constructivism has fallen short of providing the so much desired improvement in student learning. Sociological readiness to learning is the basis on which psychological readiness stands. It is only when both are in place that valid and effective construction of knowledge takes place. This is thus an aspect that educators need to keep in mind when developing new methodologies within a constructivist framework.

4. A word in defence of constructivism

However, the inability to improve significantly student understanding may not only necessarily be the inadequacy and limitation of constructivism, but rather that constructivism has not been given the chance to be fully implemented within the educational system. What does this mean? The constructivist approach, whether involving cognitive conflict, scaffolding or any other approach, has one thing in common. It is time consuming. It thus requires much more time to help students learn content material in a constructivist methodology than the typical transmission approach. This has created great practical limitations to the implementation of constructivism since syllabi have not really changed much in amount of content over the past years. Constructivism is not really as yet, the main approach adopted when teaching in science. One can say that developments in science education research have not really found their way to actual classroom practice. Hence, maybe, it would be unfair to blame constructivism for failing to bring about the much desired improvement in students understanding. It is not sufficient to expect significant and long-term effect from short 3-6 weeks of constructivist teaching. It is thus a problem that constructivism has never really been fully implemented than its failure as a valid theory of learning.

A similar argument can be put forward with respect to assessment procedures. Assessment procedures have more or less remained unchanged within education systems worldwide. Many still prefer a summative approach. If students have an examination at the end of the school year, this tends to promote the accumulation of knowledge. In many cases students are faced with a thick pile of notes which they need to know well. This is a type of assessment that promotes the accumulation of knowledge. It is thus often the case that many students cram their learning, resorting particularly to rote learning. Students thus, may not find constructivist teaching that fruitful within a summative structure of assessment. Rote learning tends to give good results in the short term, as often examinations tend to ask student to regurgitate content covered in class. On the other hand, constructivism has a more long-term effect which could not be in line with the students' goals at the time. Assessment thus sends a strong message to students that learning demands the accumulation of knowledge without the need to really 'understand' it, making constructivism and the learning of knowledge appear futile and a waste of time to learners.

5. What are the challenges that science education is currently facing?

If one looks at recent publications, there appears to be shift in the interest of science educators. Constructivism has moved away from centre stage. There is now more interest in social aspects of science and citizenship. These are not just the result of researchers' personal interests. They are the consequence of the impact that scientists' work such as that in the field of genetics related to cloning and the use of stem cells for research is having on the role that science is currently taking up in society. There is suddenly a great crisis where citizens are being bombarded with information about scientists' work and are expected to have opinions and to express them, and to give consent or to disapprove not only as politicians but also as citizens. One case in point is Italy, where normal citizens were asked to express their opinion about this issue in a referendum. Such circumstances mean that science education does no longer only have the responsibility of preparing young people with a basic level of scientific knowledge. It now needs to equip young people with the ability to realize what the social implications of certain scientific activities are, to consider them from an ethical point of view, and to know how to weigh the pros and cons of such activity in order to be able to participate as active citizens in the debate.

One may wonder in what way constructivism can contribute to this new challenge. Science educators are now faced with the additional problem of understanding how attitudes, values and ethical consideration are taught and in what way do students develop a critical attitude that will help them to weigh up social implications. Constructivism can be that framework within which researchers can work to start understanding this new process of learning attitudes and values, reflection and civic action. In addition, if one were to take a wider view of constructivism and include the sociological perspective, then society and social implications will be integrated within constructivist theory.

So how can this new dimension of constructivism be implemented within the classroom. If one is to include the sociological aspect within the constructivist theory of learning, then it must also be present when it is applied to classroom practice. Part of the science education that students are to experience need to include the discussion of science and its social implications. One, however, would need to go beyond simple role playing. Social players involved can be taken inside the classroom, asked to view their concerns and then students are helped with weighing the implications and deciding what opinion they would like to have and for what reasons. This would help students construct attitudes and values. In this case, rote learning would not provide better assessment. Attitudes and values cannot be assessed through a written examination. Constructivism would then be the better approach for them to adopt.

6. Conclusion

As always it is much easier to talk about possibilities than implementing them. It is my hope that what I put forward as a possible alternative today can be one possible direction for research in science teaching that would promote further growth of constructivism rather than its eventual extinction.

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Preparing teachers for cognitive coaching: the case of Physics by Inquiry as an experiential basis for science learning.

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Abstract. *This article proceeds from the premise that teachers should be trained as facilitators of children's cognitive development. As professionals, teachers should have ultimate responsibility for creating and maintaining a science learning environment that promotes intellectual growth. The inadequacy of the present system of preparing teachers is examined and an argument is presented for offering special science courses integrated into a coherent science teacher preparation program also including science methods courses closely linked with extensive school experience. We describe the Physics by Inquiry program as a context for discussing the type of intellectual objectives and instructional methods that should characterize such courses. We highlight the important role of students gaining authentic experiences with the power of real conceptual understanding and subsequently reflecting on (a) the various aspects of knowledge that comprise science learning and (b) the complex support mechanisms that need to be in place in order to facilitate learning in the science classroom. We will illustrate the interdependency of these issues with specific examples from the Physics by Inquiry program.*

Keywords: Physics by Inquiry, Science Teacher Preparation.

1. Introduction

It is generally accepted that science education is in serious difficulty on a global scale. In Cyprus, between the eighth and twelfth grades, the number of students who are able to keep up with curriculum objectives drops by more than 50%. When achievement is compared, Cypriot students perform significantly below the international average at all grade levels [26-28]. Internationally, performance measures repeatedly demonstrate disappointingly low achievement in tasks that require fundamental understanding, systematic reasoning or creative thinking.

There are surely many aspects of our educational systems that contribute to this problem. They include the lack of adequate support for our teachers, the complex expectations from a single profession that translate into unrealistic expectations from individual teachers and the excessive standards that are routinely specified by our societies. All these aspects contribute to a global culture of largely ignoring the essential aims of science education in favor of finding ways to bypass the learning process at all levels of the educational system. Another such aspect that is commonly ignored is the failure of the scientific community that is concerned with education to formulate established terminology and procedures that it can then use as a basis for making progress. The cultural tendency of this community to be more political than technical (falsely justified as being in the interest of political correctness and humanitarian ethos) has tended to make it prone to continual re-invention of past practices and new fads. It has also largely prevented it from gradually weaving scientific expertise with widely recognized and respected applicability. This article focuses on one facet of the current crisis: the failure of our universities to provide the type of preparation that pre-college teachers need to teach science effectively. The discussion is in terms of physics, but the situation in other sciences is similar.

1.1 The problem

The problem of inadequate teacher preparation extends throughout the spectrum from kindergarten to high school [11]. Lacking the proper background, adequate preparation and the support necessary to teach with enthusiasm and confidence, teachers often pass onto students a dislike of science, especially physical science. With a negative attitude often firmly established by ninth grade, most students do not voluntarily take physics in high school. Failure to do so decreases the likelihood that students will go on to complete a University course in the natural sciences or engineering. On the other hand, taking physics in high school does not necessarily ensure adequate preparation for later study. Incompetent teaching may leave students serious deficiencies early on that are bound to make it increasingly difficult and uninteresting in subsequent years. Poor performance in high school physics not only closes the gateway to a career in physics, but to participation in other science related professions as well as the technical decision making procedures that modern knowledge-based societies rely on for their democratic underpinnings.

The chain of events described above has other serious ramifications. One is the early limitation of opportunity for students who cease to respond to science teaching early in their teen years partly caused by under-prepared teachers. A disproportionately large number of these students belong to groups under-represented in the physical sciences and engineering: minorities and women. The result is unequal opportunity for a large segment of our population and a waste of potential talent that might otherwise increase the pool of students pursuing advanced degrees in science and engineering. This also constrains the degree of public appreciation and enjoyment of science as one of the major aspects of human cultural achievement. The low level of scientific literacy produced by our educational system has another serious consequence [20]. In a democracy, the formulation of national and local policy is highly susceptible to public opinion. Therefore, uninformed judgments on important technological issues may have an effect that extends beyond the scientific community to our entire society. This is the most alarming aspect of the current situation. The consistently poor performance of science students to demonstrate conceptual understanding by applying their knowledge successfully in order to make appropriate predictions in unfamiliar situations and to rely on transferable creative thinking, problem solving and reasoning skills in order to analyze decision making situations will continue to hamper the ability of our societies to make best use of available talent both for technological and cultural advancement.

1.2 The perspective

The perspective taken in this article reflects the cumulative experience of the Learning in Science Group at the University of Cyprus where holistic teacher preparation has been an integral part of a comprehensive program in research, curriculum development and instruction for some years. Our research focuses on investigations of student understanding of physics and on the design, development and research validation of innovative curriculum to promote that understanding. The research results into student understanding are used to guide the development of instructional strategies and activity sequences to develop coherent conceptual understanding by addressing specific conceptual and reasoning difficulties encountered in the study of physics. Curriculum development takes place as an integral part of our instructional program. Our program includes special physics courses for prospective and practicing teachers at all grade levels as well as extended school-based intervention programs for children. Continued international support for years has made it possible to devote a major effort to the production of instructional materials that can be used to teach physics and physical science in pre-college classrooms. Our instructional program takes a holistic approach to teacher preparation and owes its success to committed effort, continuous monitoring and evaluation and above all to careful tuning of four mutually complementary components: science content classes, science method classes, extensive pre-service school experience and support for in-service practice. Our work has benefited immensely from international collaboration, especially with the Physics Education Group at the University of Washington.

2. Suggestions for solving the problem

To help define our point of view, it may be useful first to examine some popular proposals for improving the quality of science education in schools. The remedy most frequently suggested by teachers themselves involves increased financial investment in school laboratories and equipment. Although experiences with physical world phenomena provide the foundation for constructing conceptual understanding, there is little evidence that hands-on approaches per se are more effective than more traditional techniques. In particular, hands-on without minds-on activities routinely deteriorate into recipe routines devoid of any meaning other than getting "the right answer" at the end. To the contrary, there is a lot of evidence indicating that practical work that is conceived as a support measure for demonstrating the origin and applicability of knowledge explained in lecture format is doomed to failure in terms of promoting real student understanding.

A popular recommendation among physicists for increasing the number of good teachers is to offer financial incentives combined with relaxing the requirements in education for certification. Such a change would allow more individuals with a strong background in physics to take up teaching immediately after graduation. Many physicists assume that students who have studied physics at university are adequately prepared to teach the subject well. The experience of many countries, including Cyprus, with appointing teachers immediately after graduation with a first degree in the discipline, does not bear this out. This assumption will be examined in greater detail later in the article.

Some governments have pushed for increased if not total emphasis on practical school experience. Given the state of the art in student science learning outcomes, apprenticeship is hardly a suitable model. Furthermore, technical training tends to emphasize routine administrative procedures with only an indirect influence on quality education, differentiation, flexibility and fulfillment of student potential.

Many governments have recently placed much emphasis on assessment procedures. It is true that student behavior in upper secondary and university education is almost entirely determined by assessment practice. It is also true that traditional assessment procedures tend to be thoroughly inadequate as measures of real student understanding. However this approach rests on the erroneous premise that if ineffective practice is currently determined by assessment, improving assessment procedures can spontaneously improve learning. Indeed quality in assessment may be a necessary pre-requisite but it is also most likely to be an insufficient pre-condition for quality in learning. Furthermore, it has been repeatedly demonstrated that good assessment practice is thoroughly integrated with instructional approaches and is well tuned both with the range of abilities among examinees and with the content of the course including all pre-requisites, an issue that is commonly underestimated.

A popular recommendation among education professionals for improving the quality of science learning is to increase the requirements for pedagogical training of science teachers. The rationale relies on psychology, sociology and philosophy providing a framework for these teachers to be able to critically analyze the development of individual needs, classroom situations and school environments so that they can then develop appropriate interventions with a high degree of personal ownership. Alas, an operational framework of this kind has never been properly conceptualized by education scientists. Partly as a result, there is little or no evidence that the traditional foundation subjects actually influence classroom practice in any substantial manner. Only exceptionally talented students are able to bridge theory in any of the foundation disciplines to influence practice. The question of identifying what type of transformation is required to synthesize aspects of the foundation disciplines into principles that can influence actual classroom practice still remains largely unresolved by contemporary research.

Another proposal involves entry into the classroom of technically trained professionals as teachers. In some countries, a small but significant number of scientists and engineers are opting for mid career and late career shifts into teaching. It is taken for-granted that the technical competence of these individuals ensures that they have the necessary command of the subject to be effective teachers. However, working in industry does little to develop the requisite depth of understanding, either of the subject matter or of the learning process. Practical experience is usually sufficient for carrying out day-to-day duties. Furthermore, during the years of industrial employment, the scientist or engineer has been away from the school environment and is likely to be less aware than a classroom teacher of the special difficulties physics presents to students.

Volunteer teaching in the classroom by scientists and engineers has been suggested as an alternative way of improving the quality of pre-college science education. Such efforts can be highly motivational to young students in the short term, but occasional or intermittent visits are unlikely to result in sustained long-term learning. Experience has also shown that volunteers seldom succeed in leaving the teacher better equipped to teach science independently. Indeed, very often the result of having a visitor in the classroom is to provide relief for the teacher, who turns attention to other matters.

The measures discussed above are simple in concept and in many places could be implemented relatively quickly, provided financial and administrative complications could be resolved. However, such remedies are temporary at best and usually cannot be applied on the scale of an actual educational system. It is essential that teacher preparation be a major focus in any effort at reform.

An effective teacher education program must take into account the needs of two different populations: (1) prospective (or pre-service) teachers who are not yet certified and (2) practicing (or in-service) teachers who are already in the classroom. Pre-service teachers have the flexibility to attend day courses at the university. However, in-service teachers have less flexibility and may be unable or unwilling to participate in a standard instructional program unless special arrangements are made. Important differences also exist in the preparation needs of elementary and secondary teachers.

The emphasis in this article is on the subject matter preparation of both pre-service and in-service teachers. We have concentrated on science as an example even though much of the discussion relates to other disciplines as well. Throughout the discussion, the word "teachers" refers to both prospective and practicing teachers; the modifiers "pre-service" and "in-service" are reserved for cases in which a distinction needs to be made. The only aspects of in-service teacher education that are considered are those that can be addressed through the regular departmental structure of a college or university. No attempt is made to give an overview of the variety of in-service programs.

3. Traditional approach to teacher preparation

In recent decades it is common for pre-college teachers to be educated in the same universities as the general population.

In Cyprus, prospective secondary teachers must complete a Bachelor's degree in the discipline and also obtain certification by completing the requirements of a seven month pedagogical training program. In many countries, two independent administrative units are involved in the process of producing science teachers: a department or school of education and a school of sciences (or equivalent). Faculty in education offer courses on methodology and on the psychological, social and cultural aspects of teaching and learning. Faculty in the sciences offer courses on the subject matter. In Cyprus, the situation is even more disparate since two independent institutions are involved: the University of Cyprus offers the Bachelor's programs and the Pedagogical Institute is responsible for the pedagogical training. In primary education the situation is much simpler. Prospective kindergarten and elementary school teachers must simply complete a four year Bachelor's degree in Education offered entirely by the Department of Educational Sciences at the University of Cyprus.

3.1 Traditional Program Design

Most teacher preparation programs, whether for prospective primary or prospective secondary teachers, consist of varying proportions of subject matter content, educational research methods, psychological, social, philosophical and cultural foundations of teaching and learning and a period of school practice [5]. As indicated by the common requirement for a discipline - based first degree, the greater emphasis in secondary education is on subject matter content. Primary education often presents a more equal and far wider representation of the different components. However, even here the content coverage tends to be immensely broad in the hope of producing multi-dimensional professionals that are capable of teaching any discipline at this age level. The underlying premise that *a good teacher can teach anything* continues to plague the programs offered by education departments the world over.

The greatest shortcoming of traditional teacher preparation programs at both levels is fragmentation and lack of coordination. The courses are offered by scientists specializing in the different disciplines, often in the same department but sometimes not. Hence, teacher educators often hold variable cultural values and very different priorities with little or no incentive to collaborate in order to make the overt connections that are necessary for students to build a coherent whole out of the different aspects. Students often simply perceive an immense breadth in coverage with little opportunity for in-depth analysis or critical application. In the eyes of the students, the fragmentary presentation of the disciplines invariably reduces to a series of assessment hurdles that students have to overcome before getting certification. It is extremely rare to witness a situation where a student is able to synthesize the operational understanding necessary to make appropriate decisions on developmental appropriateness, group management and adaptability in motivating and rewarding students. Good teachers develop some of these characteristics after years of experience and only in particular contexts.

3.2. Inadequacy of the traditional approach in Physics Departments

Subject matter preparation for teaching science is often distributed among the respective discipline departments. Prospective science teachers generally take standard departmental courses. Usually no special attempt is made to take into account the needs of these future teachers.

Many science faculty seem to believe that the effectiveness of a pre-college teacher will be determined by the number and rigor of courses taken in the discipline. This attitude seems to prevail in most physics departments. Accordingly, the usual practice is to offer the same courses to future teachers as to students who expect to work in industry or to enter graduate school. However, traditional physics courses generally do not provide the type of preparation that teachers need nor do they meet the needs of people who will be guiding the development of student understanding. The breadth of topics covered in the typical introductory physics course allows little time for acquiring a sound grasp of the underlying concepts or of linking them with applications to real life phenomena. Ordinarily, no special effort is made to address the common conceptual and reasoning difficulties that prospective teachers, like other students, encounter. The lecture format encourages passive learning. Students become accustomed to receiving knowledge rather than helping to generate it. The emphasis in these courses tends to be on solving traditional exercises through application of formulae rather than on the conceptual understanding that is a crucial pre-requisite to teacher effectiveness. This routine algorithmic problem solving that often characterizes introductory physics courses does not help teachers to develop the reasoning ability necessary for handling the unanticipated questions that are likely to arise in a classroom situation.

The laboratory sequence that often accompanies the introductory physics course also does not address the needs of teachers. Often the equipment used is not available in the teachers' schools and no provision is made for showing them how to plan laboratory experiences that utilize simple apparatus. A more serious shortcoming is that experiments are mostly limited to the verification of known principles. Students have little opportunity to make observations and perform the reasoning involved in formulating these principles. As a result, it is possible to complete the laboratory course without confronting conceptual issues or understanding scientific processes.

The most worrying outcome of science content courses is not that our students emerge without good understanding of many science topics. Often prospective teachers emerge with a misconstrued notion of what it means to understand and how one would go about developing good understanding. By definition, students who have not come to a fundamental appreciation of the nature of conceptual understanding in science through experiencing understanding themselves, cannot be helped by science methods courses.

A year of introductory university physics is admittedly insufficient for preparing science teachers. However, it does not follow that advanced physics courses provide useful preparation for teaching, either. The abstract formalism that characterizes upper division courses in physics is not of immediate use in the pre-college classroom; neither are the complicated experiments and sophisticated equipment of advanced laboratory courses.

Although work beyond the introductory level may help some teachers deepen their understanding of physics, no guidance is provided about how to make appropriate use of this acquired knowledge in teaching younger students.

Sometimes, in the belief that teachers need to update their knowledge, a university instructor may give a lecture course on contemporary physics. Such courses are of limited utility. The information may be motivational but does not help teachers recognize the distinction between a memorized description and substantive understanding of a topic.

3.2 Inadequacy of the traditional approach in Education Departments

Sometimes content courses are offered within education departments, particularly in the case of primary teacher training programs. Often these have similar disadvantages for teachers as undergraduate courses offered by the other departments. To help fill the gaps in background and to match school curriculum coverage, instructors often attempt within a short period of time to present a large portion of the content covered in a traditional physics course. There seems to be a tacit assumption that if the material is well organized and clearly presented, teachers will be able to absorb the information quickly and disseminate it to their own students. However, the amount of material and the rate of presentation may be so overwhelming that learning is impossible at any but the most superficial level.

Content courses taught by education departments often have an additional disadvantage. In education we use the term theory somewhat more freely than is common practice. For instance, we do not require our learning theories to have predictive capability that can be checked at the classroom or individual level. In addition, science education has suffered from complete domination of the constructivist paradigm as an all encompassing theory of learning that for many years has been beyond dispute. In this context, science educators are often keen to apply their "theory", usually some version of constructivist strategy, to their teaching. The consistency in thinking that transcends the researcher and teacher roles is admirable. However, when theory is reduced to blind strategy, with little or no evidence of effecting real learning, it can have a detrimental effect both on the course and on prospective teacher perceptions of science education as an enterprise aiming to promote science learning. One common example of this detrimental influence is the indiscriminate application of cognitive conflict as a classroom strategy. While usually justified as a constructivist strategy, it often tends to leave the student in despair at the perceived pleasure that their instructors take out of student ignorance. In contrast, the constructivist paradigm could be viewed as a basic principle that characterizes human learning and has important implications for the design of teaching interventions. This principle could then inform strategies for developing curriculum and other resource materials that teachers badly need in order to respond to the challenges and the level of responsibility we expect of them.

The total separation of instruction in methodology from instruction in content decreases the value of both for teachers. Effective use of a particular instructional strategy is often content specific. If teaching methods are not studied in the context in which they are to be implemented, teachers may be unable to identify the elements that are critical. Thus they may not be able to adapt an instructional strategy that has been presented in general terms to specific subject matter or to new situations. The consequences of underestimating the amount of teacher preparation needed for implementation of a new science curriculum has been demonstrated repeatedly with various reform initiatives that have been undertaken from time to time. Even detailed directions cannot prevent the misuse of excellent instructional materials when teachers do not understand either the content or the intended instructional approach.

The traditional approach to teacher preparation has another major shortcoming. Teachers tend to teach in the same way as they have been taught. If they have learned through lecture, they will essentially lecture to their own students, even if this type of instruction may be inappropriate. Many teachers cannot, on their own, separate the physics they have learned from they way in which it was presented to them. It is especially unrealistic to expect large adjustments in instructional approach if teachers must teach material soon after having learned it themselves. Even very able teachers, who eventually might be able to adapt content learned through lecture to activity-based instruction, cannot be expected to do so quickly. More crucially, both science courses for teachers and curricular specifications for schools are often concept centered and ignore other important aspects of science such as reasoning and procedural skills, epistemological awareness and evidence-based decision making. This commonly leads to erroneous understanding of the nature of science and hence a misconstrued conception of its teaching. The model of science that teachers commonly adopt as a result of our courses is incongruous both with the nature of science as a process of inquiry and with effective science learning.

4. Development of holistic programs for science teachers

A well-prepared teacher of physics or physical science should have, in addition to a strong command of the subject matter, knowledge of the difficulties it presents to students as well as expertise and experience with identifying patterns in student thinking and in formulating appropriate sequences of questions to guide their students in further developing their thinking [9]. To counter the public perception that physics is extremely difficult, the teacher must be able to teach in a way that allows students to achieve adequate mastery of the topics studied and confidence in their ability to understand and apply what they are learning in their daily life. Since neither traditional physics courses nor foundation or professional education courses can provide adequate preparation for pre-college teachers, there is a need for a new conceptualization of our teacher preparation programs including in particular special science content courses for teachers [21]

In an effort to meet this need at the University of Cyprus, we completely redesigned from first principles our science teacher education program. The program described here was implemented for the first time as a whole in the 1998-99 academic year within the elementary education program offered to a total of 600 students at any one time by the Department of Educational Sciences. The program includes special science content courses specifically designed to meet the background knowledge needs of primary school teachers [13]. These courses are carefully linked to science method courses and a specially designed school practicum structure to enable implementation and continued refinement of a structured conceptualization of science learning and its facilitation in a formal environment that identifies and nurtures differentiation in a collaborative forum.

The special science content courses for teachers have provided an environment in which we can empirically refine our understanding of their academic needs. We originally used the insights gained by researchers elsewhere [15] to define substantial objectives for such courses [14]. We then designed a structure that allows us to continuously monitor the evolving nature of our understanding of these needs and the effectiveness of our conceptualization at any one time in promoting quality in the preparation of our teachers. In addition to the instructional function, all our courses have provided a context for research on the nature and facilitation of the learning and teaching of physics and a setting for the development of structured curriculum to promote these aspects of teacher preparation in a systematic manner [30].

The following commentary is a distillation of what we have learned and what we are currently trying to implement [12, 17-19]. The discussion below is not an exhaustive summary of all that should be done to prepare teachers. Practical matters, such as laboratory logistics and classroom management are not addressed. The focus is on intellectual aspects.

4.1 Intellectual objectives

Initial courses for teachers should emphasize the content that the teachers are expected to teach. A primary intellectual objective should be a sound understanding of important concepts and their formal representations. Equally critical is the ability to perform the reasoning that underlies the development and application of both concepts and representations. Conceptual understanding and capability in scientific reasoning provide a firmer foundation for effective teaching than superficial learning of more advanced material. Teachers should be given the opportunity to study introductory physics in depth, beyond what is possible in a typical introductory physics course. They need to examine the nature of the subject matter, to understand not only what we know, but on what evidence and through what lines of reasoning we have come to this knowledge [22].

Teachers should develop proficiency in both quantitative and qualitative reasoning. It has been demonstrated that university students enrolled in the standard courses often lack certain basic skills, such as the ability to reason with ratios and proportions and to describe the line of reasoning that has led them to a stated conclusion [22]. Courses for teachers should cultivate these skills, which tend to be overlooked in traditional instruction. Also important is the development of facility in the use and interpretation of scientific representations, such as graphs, diagrams, and equations. If they are to make the formalism of physics meaningful to students, teachers must be adept at relating different representations to one another, to physical concepts, and to objects and events in the real world.

Teachers must be able to solve the types of problems that are included in the typical introductory physics text. However, the main emphasis in a course for teachers should not be on acquiring facility with mathematical manipulation nor on developing procedures for precise determination of fundamental constants. As necessary as quantitative skills are, ability in qualitative reasoning is even more crucial. For example, teachers should be able to distinguish observations from inferences and to do the reasoning necessary to proceed from observations and assumptions to logically valid conclusions. They need to recognize what is considered evidence in physics and what is meant by an explanation. They must recognize the difference between naming and explaining. Problems in which the use of mathematical formalism alone suffices for a solution are not effective measures of conceptual understanding. Thus, instead of concentrating on the type of algorithmic problem solving that characterizes most physics courses, the instructor should assign problems that require careful reasoning and should insist that an explanation of the reasoning be part of the solution. Explanations of reasoning should form crucial aspects of any assessment. Careful analysis of student answers should provide feedback to instructors and students alike as to the development of student understanding and the various conceptual, reasoning and epistemological difficulties that tend to arise along the learning pathways of individual students.

An understanding of the scientific process should be an important objective in a course for teachers. The scientific process can only be taught through direct experience. An effective way of providing such experience is to give teachers the opportunity to construct a scientific model from their own observations. Teachers should go through the step by step process of making observations, drawing inferences, identifying assumptions, formulating, testing, and modifying hypotheses. The intellectual challenge of applying a model that they themselves have built (albeit with guidance) to predict and explain progressively more complex phenomena can help teachers deepen their own understanding of the evolving nature, use, and limitations of a scientific model. Furthermore, we have found that successfully constructing a model through their own efforts helps convince teachers (and other university students) that reasoning based on a coherent, consistent model is a far more powerful approach to problem solving than rote substitution of numbers in memorized formulae.

In addition to the instructional objectives discussed above, which in principle are equally appropriate for the general student population, teachers have other requirements that special physics courses should address. For example, it is particularly important that teachers learn to express their thoughts clearly. The indiscriminate use of words that have both technical and common meanings hinders development of conceptual clarity. Teachers need practice in formulating and using operational definitions. To be able to help students distinguish between related but different concepts (e.g., velocity and acceleration, mass and volume, heat and temperature), they must be able to identify in words precisely and unambiguously what the significant differences are.

Teachers must also be able to anticipate common conceptual difficulties that students are likely to encounter in the study of a topic in physics or physical science. Such information may come from the teachers' own experience in learning the material or, if they have avoided the usual pitfalls, through knowledge of results from research in physics education and through careful and continuous monitoring of the development of their own students' understanding. To help students overcome specific difficulties, teachers need to be familiar with instructional strategies that have proved successful and that are likely to be effective with pre-college students. Again, direct experience is one way of gaining such knowledge; another is through awareness of research.

Courses for teachers should also help develop the critical judgment necessary for making sound choices on issues that can indirectly affect the quality of instruction. For example, teachers must learn to discriminate between learning objectives that are meaningful and those that are trivial. When instruction is driven by a list of objectives that are easy to achieve and measure, there is danger that only shallow learning will take place. Memorization of factual information often falls in this category.

Teachers need a framework for evaluating instructional materials, such as textbooks, laboratory equipment, and computer software. They should become familiar not only with the most popular texts, but also with others that the instructor considers exemplary. They should recognize the strengths and weaknesses of using the computer in various ways (e.g., simulations, microcomputer-based laboratories, interactive tutorials) [23]. Aggressive advertising and an attractive presentation often interfere with objective appraisal of intellectual content. We have observed teachers react with enthusiasm to an appealing format, while they ignore serious flaws, such as developmentally inappropriate objectives, inadequately sequenced content and a lack of accuracy in physics [4].

The ability to make wise decisions on matters such as the foregoing is important since, through service on professional committees, individual teachers can often have an impact that extends beyond their own classrooms. A poor curriculum decision can easily deplete the small budget most schools or even educational systems have for science without resulting in the anticipated improvement in the quality of the learning experience for students and the instructional experience for teachers.

4.2 Instructional methods

Teachers should be prepared to teach in a manner that is appropriate for the pre-college level. Science instruction for young students is known to be more effective when concrete experience establishes the basis for the construction of scientific concepts (1, 2). We have found, as have others, that "hands-on" laboratory investigations guided by appropriate questions also help foster concept formation at the college level. Therefore, in addition to learning how to teach their own students most effectively, teachers benefit directly from instruction that is centered in the laboratory.

The curriculum used in physics courses for teachers should be in accord with the instructional objectives. If the capacity to teach "hands-on" science is a goal of instruction, then teachers need to work through a substantial amount of content in a way that reflects this spirit. However, there is another compelling reason why the choice of curriculum is critical. We have found that teachers often try to implement instructional materials in their classrooms that are very similar to those which they have used in their college courses. Even though it has not been our intent to have young students work directly with the materials that have been developed specifically for teachers, the curriculum has been used in this way.

Whether intended or not, teaching methods are learned by example. The common tendency to teach physics from the top down, and to teach by telling, runs counter to the way pre-college students (and many university students) learn best. The instructor in a course for teachers should not transmit information by lecturing. However, neither should the instructor take a passive role, but instead should assume responsibility for student learning at a level that exceeds delivery of content and evaluation of performance. Active leadership is essential, but in ways that differ markedly from the traditional mode.

The instructor's role is characterized below by a few examples that are described in general terms. Instructional strategies in the context of specific subject matter are illustrated, either explicitly or implicitly, in several of the references that are cited in the article [8, 10].

The study of a new topic should begin with an opportunity for open-ended investigation in the laboratory in which teachers can become familiar with the phenomena to be studied. Instead of introducing new concepts or principles in the customary manner by definitions and assertions, the instructor should set up situations that suggest the need for new concepts or the utility of new principles. By providing such motivation, the instructor can begin to demonstrate that concepts are created as useful scientific tools and concept formation is a process in which the student must be actively engaged. Generalization and abstraction should follow, not precede, specific instances in which the concept or principle may apply. Once a concept has been developed, the instructor should present the teachers with new situations in which the concept is applicable. This process of gradually refining a concept can help develop an appreciation of the successive stages that individuals must go through in developing a sound conceptual understanding.

As the teachers work through the curriculum, the instructor should pose questions designed to help them to think critically about the subject matter and to ask questions on their own. The appropriate response of the instructor to most questions is not a direct answer, but another question that can help guide the teachers through the reasoning necessary to arrive at their own answers. Questions and comments by the instructor should be followed by long pauses in which the temptation for additional remarks is consciously resisted [24].

A course for teachers should develop an awareness of the conceptual and reasoning difficulties likely to be encountered by students. For example, research has helped identify numerous alternative ideas that are usually discrepant with the formal concepts of physics [16]. Some of these ideas result from a misinterpretation of daily experience [6], others from a misunderstanding of formal instruction [7]. Regardless of origin, certain alternative conceptual schemas are at such a fundamental level that, unless they are effectively addressed, meaningful learning of the relevant content is not possible. Teachers should learn to recognize such alternative conceptual frameworks and routinely use these as points of departure for their teaching. More recently, research has also shown that, during learning, a number of difficulties emerge that hamper students' efforts to construct meaningful knowledge. Teachers should also learn to recognize these difficulties and gain practice in implementing effective activity sequences for guiding students to overcome such obstacles to their learning [25].

Mere discussion of research findings, an approach that is often taken in Education departments, is not sufficient for this purpose. Teachers need to work through the material and have the opportunity to make their own mistakes. When student difficulties are described in words, teachers may perceive them as trivial. Yet from experience we know that often these same teachers, when confronted with unanticipated situations, will make the same errors as students and will themselves encounter persistent difficulties that will need to be overcome if an operational understanding is to be constructed.

Exposure to findings of research should also include critical examination of instructional strategies designed to address specific difficulties. The instructor should illustrate these strategies as the opportunity arises during the course. If possible, the discussion of a specific strategy should be postponed until after it has been used in response to a discrepant event that has actually occurred. Teachers are much more likely to appreciate important nuances through an actual example than through a hypothetical discussion. Without specific illustrations in the context of subject matter with which they are thoroughly familiar, it is difficult for teachers to envision how to translate a general pedagogical approach into a specific strategy that they can use in the classroom. Teachers need extensive practice in addressing common difficulties and in guiding learning procedures and this practice needs to be firmly grounded in their own learning experiences of science topics.

It is not only poorly prepared teachers who can profit from the type of instruction described above. Those with a strong background can also benefit. The experience of working through carefully structured curriculum that is validated through research can help all teachers identify the difficulties their students may have. Those who understand both the subject matter and the difficulties it poses for students are likely to be more effective than those who know only the content. Moreover, unless teachers have experience with learning science through active inquiry, they are unlikely to foster this behavior in students.

4.3 Illustrative course structure

The brief description below of the science component of the elementary teacher education program at the University of Cyprus shows how we have addressed some common administrative problems. Although special courses for teachers can be organized in a variety of ways, the example illustrates an arrangement that has worked well with large student enrollment within a department of education that is part of a research-oriented university. The specific details are not essential for implementing the intellectual objectives and instructional methods discussed above.

At present, six semester-long pre-service courses have been developed to accommodate students with a wide range of previous preparation. Each course meets for 6 hours a week in a laboratory setting.

Two of the courses are designed as content courses placing greater emphasis on the development of conceptual understanding by teachers themselves in very specific subject matter areas. There are no prerequisites other than moderate facility with arithmetic and algebra. Often in one of these courses we focus on observational astronomy where teachers can carry out the whole process from collecting original data to defining useful concepts to constructing explanatory models that allow them to predict when and where they can see the moon and what phase it will be in. Astronomy is a useful initial motivator for two reasons: many of our students have not taken formal instruction in this topic before and are often intrigued by it; many of us have direct experience with many astronomical phenomena such as sunrise and sunset and the phases of the moon, yet only few of us have constructed explanatory models that allow us to use the sun to orient ourselves or to make predictions on the direction of the moon at different times or on the time of moonrise for different days. As such, astronomy is pedagogically useful as a context for illustrating the process of developing conceptual understanding by starting from evidence and using logical reasoning. In other content courses we teach topics such as light and shadow, electric circuits, magnetism and heat and temperature. In all these courses, even though the emphasis is on developing understanding by the teachers themselves, we continuously model a teaching approach which we call *Physics by Inquiry*. In this approach the curriculum provides the structure for student work. Teachers working through the curriculum have to make decisions on what to investigate, what equipment they will need, how to represent and make sense of their measurements, what concepts to define and how to use their understanding to make predictions. In this type of semi-structured inquiry, we as instructors function as facilitators listening carefully to student ideas and using semi-socratic dialogues to ask sequences of carefully structured questions to guide student thinking. We always respond to a question with another question, routinely referring the teachers to their experiments and to their reasoning for finding answers. This is the same instructional approach that we are also adopting in the school science curriculum that we are developing through a concurrent research program. Our students know this and are encouraged to participate in our curriculum design and development efforts as part of the third compulsory course, the teaching methods course. At the end of the two compulsory content courses, students with previously negative experiences and

The teaching methods course serves as a reflective opportunity on their own learning but also as a bridge for formalizing, generalizing and transferring some of their own experiences with developing meaning into classroom practice. The course bridges over two gaps: the gap between their own experience with developing conceptual understanding and ways of implementing science as a process of inquiry and the discrepancy between science content courses at the University and routine practice in schools to which they become exposed during the subsequent school practicum. Teachers gain practical experience in addressing common difficulties and in guiding learning procedures through examples of specific learning strategies. As a preparation for the school practicum, students encounter and practice specific ideas for assessing conceptual understanding and use these to evaluate the effectiveness of teaching interventions through a systematic observation protocol that has been developed and validated over the years. They are thus equipped with the necessary armor to face the school system with purpose on the one hand, but skillfully avoiding controversy by always documenting their ideas and approaches on the other.

These compulsory courses are supplemented with two elective courses on school based research and evaluation and on communication and information technology for science learning. These courses are taken by 20-25% of our enrolled pre-service elementary teachers and aim to prepare specialists who are able to function as science resource teachers within a school district.

The school practicum in science takes place over a nine-week period and is taken as an opportunity for our students to put into practice inquiry based science and gain feedback as to the effectiveness of their implementation. In the mentor training program we emphasize use of the same classroom observation protocol as an instrument for providing feedback to our students. We also emphasize the importance of flexibility and the need for allowing pre-service teachers room for experimentation. The emphasis is more on implementing suitable strategies for knowing the extent to which a classroom intervention has been successful rather than on discussing particular content or approach which tends to take on an aura of evaluation that does not help the students need for confidence building. In the preparation period for students, we emphasize the importance of understanding the substantial learning objectives of every lesson and the importance of carefully designing questioning strategies that can guide children to reason for themselves and to develop the skills for autonomous investigative initiatives and control over their learning. In terms of classroom strategies we also emphasize the importance of giving children physical and temporal space to design their thinking approach and to reflect on their efforts. Teachers learn to intervene rarely, gradually and methodically with the sole aim to attain group and classroom convergence on learning outcomes.

One of the things we do not emphasize in our teacher training program are approaches to science curriculum development even though that is central to our research interests. The reason for this is a fundamental belief that effective curriculum development can only take place as a process of research undertaken by a multidisciplinary team involving teachers, curriculum specialists and scientists. We firmly believe that it is unrealistic to expect teachers to design their own lessons and at the same time expect those lessons to support quality and innovation in student learning.

5. Conclusion

The present difficulties in physics education can have serious consequences for the future of the knowledge society. The effect on the greatest number of students is during the pre-college years, particularly the late elementary and early middle school years. The point of view taken in this article is that improvement can take place only when the underlying problem of inadequate teacher preparation is successfully addressed. The debate about teachers as scientists in contrast with teachers as technicians, that has accompanied the transfer of teacher preparation from colleges to universities, has proven too simplistic and polarized. The type of instruction that can meet the needs of teachers is not available in the standard courses offered in most physics, other science or education departments. The traditional University structure of administering these courses as determined by course enrollments, credits, and grading standards encourages too much fragmentation and a general lack of coherence in seemingly disparate activities such as science content, teaching methods and school practicum courses. An effective mechanism for accomplishing this task is through special courses that aim for coherent, wholesome teacher preparation with a clear view of what is manageable by single individuals and what support they need to rely on to promote quality in education. The emphasis in these courses should be on preparing individuals to implement research-based curriculum promoting science as a process of inquiry by acting as cognitive coaches. Providing original experiences with developing meaning and conceptual understanding through inquiry and developing questioning and other skills related to facilitating learning and cognition should figure prominently in the objectives of any teacher preparation course.

The argument presented above has an important implication for university departments. It is unrealistic to expect faculty to dedicate a significant amount of effort to an activity not recognized by the academic reward structure. The general perception in some university departments is that serious teaching effort may even be penalized. The teaching program of a department of education is not the responsibility of its individual members. It is the cumulative responsibility of the common professional identity of the department and should receive communal attention that transcends perceived needs to protect intra-disciplinary boundaries, using as the ultimate reference criterion only the quality of the impact on the educational system as demonstrated by research.

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The Junior Certificate Science –Revised Syllabus

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Abstract. *In 1989, a revised science syllabus was introduced into Irish Second Level schools, which incorporated some aspects of applied science e.g. electronics and food science.*

This syllabus was found to be too long allowing little time for proper scientific processes and investigations and no reward was given to the students for practical work. The syllabus committee was reconvened in 1998 and a review of the syllabus was undertaken again.

The content of the syllabus was reduced and students will now be awarded marks for completing their practical work at the end of the three year cycle.

The revised Junior Certificate syllabus is activity-based in its design, emphasising the individual's experience of science as a 'hands-on' one. The importance of the processes of science, as well as knowledge and understanding, is reflected in the syllabus structure. Through a variety of investigations and experiments, students attain the specified learning outcomes, developing appropriate science process skills and a knowledge of underlying science conceptsStudent motivation, collaborative working and opportunities for discussion are all part of learning science using an investigative approach, as is the opportunity for students to reflect on, and evaluate, their own work and progress.

In performing investigations students have to make their own decisions, either individually or in groups. They have a certain amount of control over how the investigation is carried out and in doing so can take some responsibility for their own learning. Students have to use procedures such as planning, measuring, observing, analysing data and evaluating.

However, no matter how open-ended an investigation is, the teacher still plays a pivotal role in how the investigation is carried out and how useful the experience is for the student.

In my presentation I will give an overview of the syllabus and relay the experience of teachers and in-service providers of implementing the revised syllabus.

Keywords. Rationale, Content, Structure, Practical activities, Assessment, Professional Development

Introduction

Pupils enter the secondary system at age twelve and complete a five to six years programme.

In the first three years the students take on average ten subjects and sit their first formal state exam at the end the this three year cycle. This is called the Junior Certificate exam. Science is a taken by the majority of pupils but it is not a core subject in all schools – many schools offer science as an option subject.

Prior to 1989 there were two science syllabi (similarly for other subjects) Syllabus A and Syllabus E. The latter was taken by a small number of pupils in vocational schools and included a project component for final assessment.

The Department of Education and Science (DES) decided to combine both syllabi into one and asked the NCCA course committee to examine both and produce a new syllabus. The syllabus was to be examined at two levels – Higher level and Ordinary level. This was also in line with all other subjects. The syllabus was ready for incoming first years in 1989 and for examination in 1992. It will be examined for the last time for the majority of schools in 2005 and is referred to as the current syllabus.

The current syllabus is divided into four sections- physics chemistry biology and applied science. The applied science section contains topics such as material science, horticulture, earth science, food science, and electronics and energy. The students have to study physics, chemistry biology and any two of the six sections from applied science. However,

Main Topic	Sub-topic	Learning Outcomes **Students should be able to**
1A1 Food	Examine the content of a variety of foods as described on their labels Food as a necessary source of energy and growth material for the body Constituents of a balanced diet	Recall that a balanced diet has six constituents: carbohydrates, (incl fibre) fats, proteins, minerals, vitamins and water Each with different function. Describe a food pyramid and give examples of food recommended for a balanced diet Carry out qualitative food tests for starch, protein reducing sugar and fat. Read and interpret labels and compare energy content of foods **Investigate the conversion of chemical energy in food to heat energy**

students taking the ordinary level course only study any three of the sections biology, physics, chemistry and applied science. Some students can opt to omit the applied science section and submit a 'local studies' project instead. There is no assessment of practical work.

After a number of years of examining this syllabus a number of issues came to light:

(i) The students taking the syllabus at lower level were omitting the chemistry section in favour of the applied science section and within this section food science and material science were most popular.

(ii) There was an obvious under representation of chemistry in the applied science section.

(iii) The number of students taking physics and chemistry at senior level was falling.

(iv) The course was too long for all students to have hand-on experience for all the prescribed practical activities.

The DES at this time withdrew dedicated funding for science from schools. Instead the school got general funding for the whole school with recommendations for the amount to be spent on science.

In 1998, the DES asked the NCCA to reconvene the course committee and revisit the syllabus to try to restore the balance of physics and chemistry to the syllabus.

The course was to be shortened in line with other subjects at Junior Certificate.

The NCCA course committee comprises teachers from different sectors within the profession. There are representatives from the teacher unions, the ISTA, inspectorate, third level sector, schools managerial body, and the NCCA itself.

The committee began meeting in late 1999 and began and overhaul of the syllabus. It was ready for implementation in Sept 2003 for the incoming first year pupils. About 10% of schools in 2003 however felt they could not implement the revised syllabus at this time and were given a derogation by the DES to continue with the current syllabus. Almost all of these schools began to teach the syllabus in 2004.

The consequence of this action by these schools is that in 2006 there will be two examinations –one based on the new syllabus and one based on the current syllabus.

Revised Syllabus structure and content

The syllabus reverted to the 'old' type syllabus in that there are three main sections- physics, chemistry and biology. Some content from the applied science was incorporated into the appropriate section e g. food tests are now in the biology section and electronics are introduced in physics. Some content had to be omitted to reduce the content and to allow time for a hand-on approach to practical activities. The current syllabus has no mandatory practical and no from of assessment of practical work.

The revised course is activity based in its design. It emphasises the practical nature of science. A wide range of teaching methods is encouraged as is the use of dataloggers for collecting the results of experiments. The table below is an example of one section of the biology course. The topic is Food. It is hoped that the learning outcomes will be achieved through teacher instruction, discussion and practical work.

Practical Activities

It is hoped that the practical activities will encourage observation, promote logical thinking, develop skills, arouse interest in science and make it more real. Having completed the practical activities it is hoped pupils will emerge with a well developed logical thinking and problem solving skills.

Activities fall into two main categories – investigations and experiments.

Investigations are processes where the pupil will seek information about a topic in a manner that is not predetermined in either procedure or outcome.

e.g. investigate the reaction between zinc and hydrochloric acid.

Experiments are testing a theory or confirm a hypothesis.

e.g. carry out a test for starch on a sample of food.

The importance of process over product in carrying out the activities as well as knowledge is reflected in the structure of the syllabus.

This is also reflected in the chemistry, physics and biology syllabi at senior level.

Thirty of the practical activities are described as mandatory and students will be awarded credit for doing these activities. This is the first time that students are being awarded for doing practical activities in any of the science subjects. There is not however a practical examination.

In the second term of the third year the DES will send three activities to all students. Students will carry out an investigation on any two of the three investigations. Students may opt to choose their own investigation if they wish. This proviso is to cater for students who previously would have taken the local studies project.

Assessment

The science syllabus will be examined at the end of the three year cycle as part of the Junior Certificate Examination. The first examination will be in 2006. The final grade is based on three separate course work

Coursework A	Coursework B	Coursework C
Experiments and investigations specified in the syllabus Marks: 10%	Additional specified investigations or one investigation of the student's own choice Marks: 25%	**Terminal examination** Section 1: Biology Section 2: Chemistry Section 3: Physics Mark 65%

Coursework A – mandatory experiments and investigations

In each of the main sections of the syllabus, ten experiments or investigations are identified as mandatory (indicated in bold print in the syllabus). These represent a minimum of practical work. Each student must keep his/her own individual record of these thirty activities over the three years of the course, and this must be available for inspection. As part of the assessment, marks will be awarded on a pro rata basis for the satisfactory completion of this coursework.

Coursework B – student assignments

In the third year of the course, students will be required to carry out two specified investigations, which will be based on the topics and learning outcomes in the syllabus. These will be set by the State Examinations Commission and will vary for each yearly cohort of examination candidates. As an alternative to the set investigations, a student may substitute a single investigation of his/her own choosing, provided that it meets the criteria laid down by the State Examinations Commission.

Students will complete their investigations under the follow headings:

My interest in carrying out this investigation

Period in which the investigation was carried out

Introduction to the investigation (including background research undertaken in preparation for

the investigation: people, books, websites, etc. as sources of relevant information)

Preparation and planning

(i) List of the equipment needed for the investigation

(ii) List of tasks to be carried out during the investigation

(iii) Particular safety precautions required by this investigation

Labelled diagram (where appropriate)
Procedure followed in the investigation
Recorded data / observations
Calculations / Data analysis
Conclusions and Evaluation

By arrangement with the school authorities, the set of reports should be submitted for retention in the school no later than the date of the terminal examination for Junior Certificate science.

Coursework B serves a dual function. It allows for assessment of the learning in science that has taken place over the previous years, that is, the extent to which the student has developed the skills necessary to conduct scientific inquiry, to think critically and logically, and to make evidence-based conclusions. At the same time, it integrates, and acts as a revision of, the knowledge and understanding that might be required when answering questions on the examination paper that are related to science investigations.

Terminal examination paper

There will be separate Ordinary level and Higher level examination papers, each with three sections corresponding to the structure of the syllabus. The examination papers will assess the candidates' knowledge and skills in relation to topics and learning outcomes in the syllabus. Separate examination papers will be set for Ordinary level (1½ hours) and Higher level (2 hours). Each examination paper will be in booklet form, with appropriate provision for candidates to enter their answers on the examination booklet itself.

Teacher Training and Professional Development.

The DES appointed a support team in Sept 2003 Ten teachers were seconded and began intensive inservice training for teachers. The inservice training was held regionally and for small groups of teachers. Unlike the previous inservice programme DES provided funding for substitution for teachers attending inservice. Attendance at in service in voluntary and the uptake is about 80%. The inservice programme provides an intensive training not only on the contents of the course but on different methodologies that could be used in teaching, and carrying out the activities.

There is greater emphasis on a hand-on approach to the teaching practical activities.

The DES also provided substantial grants for schools to purchase the necessary equipment to successfully implement the revised syllabus. This grant was awarded on the basis of the age and state of the existing laboratory/ies.

Summary

In the junior cycle, the study of science contributes to a broad and balanced educational experience for students. Science education in the post-primary junior cycle is concerned with the development of scientific literacy and associated science process skills, with an appreciation of the impact that science has on our lives and environment. In the age of rapid scientific and technological change, the study of science is fundamental to the development of the confidence required to deal with the opportunities and challenges that such change presents in a wide variety of personal and social contexts.

Arising out of their experience in the junior cycle, it is hoped that many students will be encouraged to study one or more of the science subjects in the senior cycle, thus preparing themselves for further study or work in this area.

Acknowledgements

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Nine Years of Scientific Research Training in Hungary

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1. Introduction

Between 14 and 21 years is the age of self-discovery, when the adolescent explores his or her capabilities and limits and seeks a place in society. In short, puberty is a challenging time for many parents and teachers when their children and students question their "wisdom", and set out to find answers to problems that they think their parents cannot properly address. Science and research offer a unique opportunity for adolescents to quench their thirst for answers and explore their intellectual strengths and capabilities. Research in a laboratory and interaction with other scientists provide a new social environment for these students, where they can earn recognition of their capabilities and find role models that they might not encounter at school, at home or with their friends. Moreover many students who carry out research in a laboratory are often also able to find their first real friends in this new environment.

Attracting young students to scientific research has also become a topic of growing importance from science's point of view because the numbers of students who choose a career in the natural sciences is decreasing. Many senior scientists, economists and politicians in the USA and Western Europe concern about a potential bottleneck of scientists and engineers, which could hamper the growth of high-tech industries, particularly biotechnology and information technology. These problems –how to give young people a basic knowledge of science and technology and potentially awaken their interest in a research career– are clearly recognized and have become a subject of many conferences.

These are some of the reasons why an unprecedented initiative has been presented by Peter Csermely, Professor of biochemistry at the Semmelweis University (Budapest, Hungary), which resulted the foundation of the Hungarian Research Students Movement in 1995.

2. The Mentorship Program

The main goal of the Movement is to help talented and motivated students in the ages between 14 and 21 (free of charge) in order to obtain first-hand experience of scientific research in Hungarian universities or research institutes. The idea immediately gained an overwhelmingly positive response from the Hungarian scientific community. We were able to start the programme in 1996, with approximately 300 scientists willing to act as mentors and accept high-school students in their laboratories.

The cooperation between talented students and the professors is helped by a book containing the list of our mentors who accept high school students in their laboratories. We are proud to say that nowadays there are more than 700 researchers who support our initiative. Many of these senior scientists are of the highest scientific merit: 118 are members of the Hungarian Academy of Sciences, including Nobel Laureate George Olah. The list of mentors is originally published as a book and it is delivered to each member also via e-mail containing a wide range of keywords (approximately 3000 from abortion to x-ray micro-analysis) to help the students decide what their field of interest really is. Every high school head teacher gets it in Hungary and in the surrounding countries as well, because we have several hundred ethnic Hungarian students from neighboring countries (Slovakia, Ukraine, Romania, Serbia, Croatia and Slovenia). Since the beginning, we have been able to offer more than 7,000 students—not only from Hungary, but also from other Eastern European countries—a chance to work in a real research laboratory. It has been a great success so far, as many of these students become interested in pursuing a career in scientific research or teaching. But, equally important, we have also gained a great deal of experience of how to get young people, who are still open to outside influences and new challenges, interested in science.

To recruit new students, the list of mentors is sent to each Hungarian high school and to more than 600 high-school teachers who help us with the recruiting. Any interested student can apply in writing or via our website[1] by answering two simple questions: *"Why do you want to pursue research?"* and *"Why do you feel that you are better than other students?"* The aim of these questions is to test the students' motivation, self-esteem and maturity. The registered students get our list of mentors and here comes the next screen: after having made up his or her mind, the student has to approach the mentor of choice alone. Parents - dreaming of their children as future Nobel laureates - are purposefully excluded from the recruitment process. If students feel disinterested or experience any trouble, they can contact the coordinator, and he helps them to solve their problems, or find another lab. We also have no strict age limit. The youngest student we have enrolled so far was 11 years old however, most of the students are between 17 and 19. Very importantly, 50% of registered high school students have always been girls which shows an equal interest for scientific research in both genders. More than half (59%) of recruited students work in life science laboratories, while 27% and 16% pursue their research in other natural sciences and social sciences/humanities, respectively. These ratios, which have been fairly stable over the last four years, show the popularity of the life sciences among the young generation, especially the fields of environmental and medical research.

Among the Hungarian students, a quarter have come from Budapest, 29% from Hungarian towns with a population of more than 100,000, another quarter from smaller towns and 21% from villages. We are particularly glad about this last fraction, because our initiative gives them a unique chance to change their life and break out of the closed and often depressing environment of these less developed regions. We have also had many student researchers from Roma families and from state orphanages, who are probably the real successes of our initiative. "You completely changed my life!" is a remark we often hear from participants. "I met a new world here. I learned perseverance and endurance during my years of research. The friendly atmosphere helped me to overcome my shyness, and the wide variety of topics in the mentor database made me realize what am I really interested in life and pursue it with full devotion," explained one of our 17-year-old student, emphasizing the effect it has had on her life. Indeed, many of the first high-school research students are now about to finish their PhDs, or have returned to their schools as teachers and are now helping to recruit the next generation of student researchers.

There are no rules or expectations about what a research student should achieve. Some end up with only limited experience, by reading and discussing a book or scientific papers with the mentor. However, most of the students find a stimulating environment, even with their first research team. Clearly, not every interested student could easily get their own research project, as mentors have the right to test them how prepared they are. There are labs where the students have to pass oral or written exams of material the professors give them. After a year, the research results are often matures enough to be presented in a student conference. Many times the students' work evolves even further –some high school research topics have developed into undergraduate or even Ph.D. projects. It has been a great success so far, as many of these students become interested in pursuing a career in scientific research or teaching. Some of them have returned to their schools as teachers and now help to recruit the next generation of student researchers becoming mentors.

In 1998, a Research Student Foundation was established to manage finances, and the annual budget of the Foundation grew to approximately €60,000 by 2004. Twenty-five per cent of these funds come from the Hungarian Ministry of Education, another 25% from foreign institutions, including UNESCO (the United

[1] www.kutdiak.hu

Nations Educational, Scientific and Cultural Organization), FEBS (the Federation of European Biochemical Societies), 30% is received from grant applications and 20% is donated by Hungarian firms. In 1999, students, mentors, high-school teachers and scientific research clubs also formed a Hungarian Research Student Association (Csermely et al., 2000). All decisions, including those about finances, are made by the student president, at present Katalin Sulyok, and their two deputy presidents, who are elected each year by the best 80 student researchers during a one-week research camp.

After the Research Student Foundation announced in 1999 that it would help to establish science clubs in high schools (Csermely et al., 2000), more than 200 such clubs have been founded in Croatia, Hungary, Romania, Slovakia and Serbia. Members of these clubs cooperate in larger research projects and inform each other regularly of their progress. Most of the research clubs invite established scientists to speak about their lives in research, or to talk about recent advances in their field.

A student if once a scientific project is carried out has the opportunity every year to present the results at seven regional conferences held in Hungary, Transylvania and Serbia, the best third of the student lecturers get a chance to present their results at the national conference where the most prominent persons of Hungarian science make the jury evaluating the presentations and performances in different sessions: human and natural sciences are both to be found. The best students of the National Conference - approximately 80 each year - are invited to a one-week summer camp in July near Lake Balaton. The best Hungarian scientists are invited here to talk about their approach and devotion to science just like a few respected writers, clerics and successful business- or statesmen with whom the opportunity of discussion is open for the participants. University undergraduate psychologists help these outstanding student researchers to cope with their loneliness and other personal problems; grant agencies present their funding programs, teaching students how to apply for funding, and the Hungarian Patent Office demonstrates the importance of protecting intellectual property. Another essential event takes place here every year the President and the two Vice-President of the Hungarian Research Student Association gets elected. The winners of the National Conference can take part in other international science-camps, and the best Hungarian high-school research student is invited to the Nobel award ceremonies each year in Stockholm, Sweden. The selection of the student is made by a special interview of the best ten students, organized jointly with the Hungarian Association for Innovation. It is our goal to extend international contacts in the future, and to improve the regional co-operation in Central and Eastern Europe.

We also established a network of 600 high school teachers to recruit research students to the initiative and/or establish science clubs in their own school. Starting in 1999, we have organized annual conferences for these teachers to exchange information on fundraising, and how to establish science clubs organize local conferences and recognize talented students. The conferences also include discussions with government officials on governmental help to enhance research activities in high schools, and to increase the number of Ph.D. studies among high school teachers. In 2005 these high-school teachers agreed to establish the Hungarian Research Teacher Association in order to give an official framework of their cooperation.

Why is this movement successful? Because it approaches the future scientists in their most susceptible age. Science is an open-ended endeavor. The tremendous challenge of discovery brings a great power of motivation for teenagers. Being in science - they become free. They can discover their talent - and the limits of this talent, too. Our movement is creative, flexible and playful - like research itself. This movement is based on volunteer work; there is no benefit for getting involved but the joy of help, but the joy of science. This movement is self-organizing: it is led by the high school students themselves. They learn not only research, but research ethics, science communication, co-operation, management-, and leadership roles. These are all much-needed values in our disorganized, segregated societies. Moreover, half of the students come from small towns and villages. This movement gives an unparalleled opportunity to break social barriers. At home - these research students are deviants, a kind of high school E.T.-s. Here - they discover friendship and find a new home. Science becomes their home. And this bond is strong.

Our first students got their PhD and became mentors, or went back to their schools as teachers and started to organize research teams. But those may be the best treasures, who will not pursue science. Wherever they go, be it business, politics or raising their children: they will remember – science *was* their home. The long-range links these research students build in their most susceptible age have an unparalleled value. These links promote public understanding, help to stabilize our societies and keep our best talents to return to Europe - wherever they go. We are happy that this idea has been recognized by the EU: the movement received the Descartes Award of Scientific Communication in 2004.

3. The Network of Youth Excellence

All around the world there is an increasing number of initiatives that ensure research possibilities for motivated secondary school students. These initiatives, however, work in isolation and in many places they work almost completely out of public knowledge. This is why it is deemed important that UNESCO and other sponsors ensured a possibility for the exchange of experiences among the best initiatives worldwide within the framework of the Network of Youth Excellence. More then 30 countries all over the world already consider to join to this network. The Network of Youth Excellence has only organizations as its full members, all regional, national and international organizations are eligible, which have an experience of at least two years in extracurricular education of young students - ages below 21 - in science and technology. The Network is completely independent, and works closely with the UNESCO World Academy of Young Scientists to establish contacts with other young scientists working as university undergraduates, Ph.D. students or postdoctoral fellows world-wide. The backbone of the Network are two mailing lists - one for full members and another for interested organizations and individuals – and the new website.[2]

Full Members of the Network agreed on a Memorandum of Understanding which sets out the main objectives of the Network of Youth Excellence:

- promote cooperation between existing scientific research training projects for students until the age 21 and their teachers in a wide array of scientific areas;
- promote research collaborations between students and teachers of different programs and countries;
- facilitate the collaboration with international organizations of young scientists such as the World Academy of Young Scientists (WAYS);
- better the existing projects by exchanging their experiences and outlining successful organizational and fundraising tactics;
- help the initiation of scientific research training projects in countries where they currently do not exist;
- initiate international joint scientific student/teacher projects;
- promote the participation of students in the organization of research training programs;
- encourage an inter- and multidisciplinary dialog on the ethical and responsible conduct of research and use of scientific knowledge as well as on social aspects of scientific research;
- draw the attention of policy makers and the media to the importance to start the recruitment to scientific research at a very early age.

The Network treasures the diversity:

- of the approaches for science education and research training in target group (talented, underprivileged, motivated students; science teachers; society around the students and teachers, etc.),
- content (subject- or scientific discipline-based projects; participation in top science; broad, interdisciplinary projects; fun-type projects, etc.),
- methods (courses, summer schools, weekend seminars, continuous projects, lab-type projects, school-type projects, cyber-courses, distance-learning, etc.)
- aims (information transfer, ability development, raising self-confidence, raising long-lasting interest and commitment to science, help in science communication, help in applied research, promotion of public understanding, etc.).

The formal establishment of the Network is a currently ongoing process, so far more than 15 organizations have joined the Network as Full Members, and there are 12 organizations who

2 www.nyex.info

applied for Organizational Partnership. The Network is governed by the Board - each Full Member has a representative - while the everyday decisions are made by the Executive Board comprising the Chairperson, the two Vice-Chairperson, and one representative of the Secretariat. To be cost effective the Network does not have an own administration body, the role of Secretariat is performed by one of the Full Members for a four years period of time.

4. Conclusions

After nine years, we have gained a lot of experience about how to attract young people to science and research. The first and most important fact that we learned is that students must be offered the possibility of doing real science, not didactic, over-organized pseudo-research or experiments with a guaranteed outcome. Students clearly appreciate the world of research with all its frustrations, uncertainties and technical troubles—and with all the joy that comes with a real discovery. As mentioned above, students between 14 and 21 are eager to try things themselves and explore their limits, so we can present them with new challenges and tasks. Schools might overload them—or rather mis-load them— but science performed in a proper environment never overwhelms their abilities. Consequently, it is also important not to set standards: even the smallest bit of knowledge and understanding that a student gains in a laboratory is worth it. Adolescents at this age need emotional support and personal guidance, so the scientists who serve as their mentors must therefore be willing to get involved and actually spend quite a bit of time with them. It is also important that mentors have a high level of credibility—not only as scientists, but also as role models. A hierarchy-free, democratic research environment, where the only credit goes to real achievement, is a must. Students are also eager competitors, which gives them great strength and motivation to continue, even after repeated failure. But we must not over-use their competitiveness.

We do not want successthirsty gladiators in the laboratory, we want to educate our future research colleagues. Last, but not least, students also gain a lot of personal experience that has nothing to do with science or research. They still seek their place in society and explore their strengths and capabilities. Just by giving them a chance to spend some time in a new environment and by positively reinforcing their strengths - and showing them their limits - we can help them to gain a clearer vision of what they can expect from the future. For the vast majority of students, such an experience will create a long-lasting commitment to science and research. However, high-school students who choose a different career are not failures, and the energy we put into them is not a waste. They will keep their commitment to science, wherever they go. And if they return home with the experience of how scientific research works, they often become key opinion makers in their home environment, that is, within their age groups, their families and their local societies. As our commitment to younger students can significantly improve the credibility of scientific research in society in general, we have to mobilize all efforts to show them the joys of science. The best students deserve the best treatment. They are our future.

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Modeling Tasks for Exploring Topics of High-School Biology in the Computer-Supported Educational Environment 'ModelsCreator'

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Abstract. *This paper reports on part of our work for the project 'ModelsCreator' in regard with the didactic approach of specific topics within the secondary biological education. Considering the already reported difficulties of high-school students in adequately grasping complicated biological processes of abstract nature such as photosynthesis or inheritance, we developed corresponding educational scenarios within the computer-supported environment 'Models Creator' to be implemented in experimental as well as in real classroom settings. The development of these scenarios which include a series of modeling tasks organized in students' worksheets is discussed here.*

Keywords. Computer-Supported Modeling, High-school Biology, Inheritance, *'ModelsCreator'*, Photosynthesis, Plant growth.

1. Introduction

A number of computer-supported educational environments have recently been developed in a *'socio-constructivist'* theoretical framework ([4], [18]) with the aim of supporting the teaching and learning process in a qualitatively different way ([5], [10]). Such environments attempt to give students the opportunity to express, explore and refine their mental representations about natural phenomena by providing them with appropriately designed building and testing tools ([17]). Thus, computer-supported dynamic modeling is employed in order to facilitate students' active engagement in a process of integrating specific parts of knowledge into broader explanatory or merely descriptive mental structures ([15], [16]).

'*ModelsCreator'* is a computer-supported educational environment that - apart from purely qualitative or purely quantitative approaches to the natural world, such as concept maps or mathematical models- allows for semi-quantitative modeling as well as for modeling with logical operands (i.e. IF, AND, OR, THEN) (http://www.ecedu.upatras.gr/modelscreator/). It practically constitutes an 'open' modeling environment where students are supposed to analyze problems in terms of *'objects'* relevant to the problem, *'properties',* that is factors characteristic of these objects and finally *'relationships'* between the *'properties'* of one or more *'objects'*.

The type of *'relationships'* actually defines the type of modeling. In case of using semi-quantitative reasoning, namely mathematically informed *'relationships'* of qualitative character, students are able to construct semi-quantitative models, while when using logical operands they can come up with models of logic.

In this paper, we present two educational scenarios we developed for the environment of *'ModelsCreator'*. The first one, 'Photosynthesis & Plant Growth', focuses on photosynthesis not only as a biochemical process, but also as an essential parameter of plant growth and engages students in the construction of semi-quantitative models. On the contrary, the second one, 'Inheritance', requires the construction of models of logic having to do with the way that dominant or recessive genes located on autosomic or sex chromosomes pass from parents to offspring.

The questions to be highlighted for both scenarios hereafter are:

- Which is the theoretical background for developing each educational scenario and which are the aims of it?
- Which are the suggested modeling tasks within the environment of *'ModelsCreator'* and which are the underlying didactic objectives?

2. The educational scenario of 'Photosynthesis & plant growth'

Research on students' expressed models about photosynthesis and plant nutrition has actually revealed a series of cognitive obstacles ([6]). Some of them in regard with the concept of *'food'* and its environmental origin seem to derive from transferring the animal model of *'heterotrophic nutrition'* to plants. Several studies have actually shown ([19], [20]) that students of different ages find it rather difficult to realize that plants produce their own food instead of taking it in from the environment. Having serious difficulties in understanding *'food'* as a source of energy and building blocks necessary for an organism's growth and maintenance to life, students frequently identify *'soil minerals', 'oxygen', 'carbon dioxide'* or *'water'* as *'food molecules'* on the basis of being externally provided to plants and generally contributing to their well being ([3]).

The concepts of *'energy'* and *'energetic transformations'* within living organisms and especially plants seem also to raise serious obstacles ([14]). Students have trouble in understanding sunlight in terms of *'light energy'* which needs to be transformed into *'chemical energy'* by plants in order to become available to all living things through food webs.

Finally, the concepts of *'air'* and *'soil'* as well as the one of *'chemical reaction'* are problematic, too ([13]). This is rather expected since students are required to realize that an unobservable gas (carbon dioxide) *and* a liquid (water) within the 'solid' and 'compact' soil are taking part in a biochemical mechanism (photosynthesis) in the interior of the plant to finally become its *'food'*.

In the light of these data from the domain of Biology education research, a didactical approach of photosynthesis on the biochemical level of a *'reaction'* transforming unobservable chemical substances does not seem to be meaningful enough to young students. On the contrary, setting photosynthesis in the context of the observed phenomenon of plant growth and studying it in terms of a *'food making'* process could probably support students in constructing knowledge-based links between the macro level of the environmentally affected plant growth which is easier to conceptualize and the micro level where the photosynthetic mechanism lays ([7]). In other words, it might help students to use the latter as an explanatory framework for the former, instead of considering it as an isolated piece of hard to remember school science.

This idea upon which we've actually developed our educational scenario within *'ModelsCreator'* can also be traced in the biology schoolbooks used the last few years in secondary education in Greece. In the 1st grade *'Biology'* ([8]), photosynthesis is briefly presented in the context of the exclusive characteristics of living organisms and specifically in the sub-context of growth, while it is further examined in the context of nutrition. In both cases there is a common pattern of connecting the growth of every living organism with energy, the energy with the breakdown of food and finally -especially for plants- the food with photosynthesis. Students are provided with a simplified form of the photosynthetic reaction and are introduced to the idea that plants use 'material' from their environment to make into their own body glucose, their food. The ecological dimension of photosynthesis is also pointed out through the categorization of the organisms of an ecosystem as *producers, consumers or decomposers* and the introduction of the concepts of *food chain and food web.* This aspect is actually the main focus in the 3rd grade *'Biology'* ([1]).

However, establishing a meaningful inter-connection of photosynthesis and plant growth through food and energy -which is actually the aim of this educational scenario- is not an easy task. Attempting to reduce the cognitive load associated with the *abstract* nature of the topic by providing students with visual representations of the employed concepts instead of requiring from them to be restricted to their own imagination, seems quite purposeful. Thus, in the environment of *'ModelsCreator'* students can have a dynamic view of the used objects (i.e. plant, leaf, air), first according to the specific concepts they activate for each of them (i.e. food, photosynthesis, carbon dioxide). Of course, it is not argued that such symbolic representations (i.e. cyclic arrows of different size for different 'rates' of photosynthesis) could in any case completely reduce the status of theoretical concepts like *'light energy', 'chemical' energy'* or *'biochemical reaction'* from 'abstract' to 'concrete'. However, it is our view that it might help students in organizing their ideas into a visual dynamic 'web', appropriate for reflection with the teacher and introduction of the target scientific ideas. For instance, representing both 'plant's food' and 'leaf's glucose' with same-colored hexagons within *'ModelsCreator'*, may provide an initial visual framework for students' effective introduction to the idea that the six-carbon sugar of glucose produced in a plant's leaves *is* actually its food.

More specifically, the environment of *'ModelsCreator'* for this educational scenario consists of a set of 5 *objects*, each having a subset of *properties*: PLANT (growth / food / energy), SOIL (water / minerals), SUN (light), AIR (oxygen / carbon dioxide), LEAF (carbon dioxide / water / photosynthesis / glucose / oxygen). Furthermore, there is a set of *semi-quantitative relationships* (i.e. 'increases-increases', 'increases-decreases' or 'increases-increases less') upon which students draw to define the *inter-connections* of the given structural elements they wish in a more formalistic manner.

The construction of a model requires selecting '*objects*', moving them in the working space, selecting '*properties*' for each *object*- the visual representation of which is accordingly changed- and also connecting the '*properties*' with '*relationships*' selected from the given set. After having completed their model, as well as at any point in the process of constructing it, students have the option of testing its behaviour by making use of the built-in testing tools of the software.

But how exactly do we pursue the aim of supporting high-school students in establishing a meaningful link between photosynthesis and plant growth in the *'ModelsCreator'* environment just described?

The educational scenario is consisted of five one-hour tasks, organized in worksheets which are divided in 2 parts. In the 'Task-part', students are assigned with a specific modeling task and being provided with basic technical instructions regarding the modeling process within the environment of *'ModelsCreator'*. On the other hand, the 'Let's think'-part requires from students to explore instructional questions in the light of which they could possibly think about their model more scientifically.

The five-task sequence is initiated with shaping the organizing framework of plant growth on the basis of the concepts 'food' and 'energy'. Dealing with the first modeling task, students focus on 'food' as an essential requirement for the 'growth' of all living organisms - and consequently for plant growth - and they are actually required to expand the relationship of 'food' and 'growth' through the concept of 'energy'. Thus, they are supposed to come up with a serial model where all the three *'properties'* of the *'object'* 'plant' - 'food', 'energy', 'growth' - are inter-connected so that each functions as a prerequisite for the next one.

Introducing the idea that *'food is required for plant growth since it is the source of the required energy',* this task actually leads to the key issue of *'where do plants get their food?'*. Focusing especially on whether or not *'plants get their food from the soil',* the next task - 'Plants and Soil'- aims at destabilizing the most commonly held misconception at all ages. In the light of a leading experiment set up by Van Helmont in the 17^{th} century, students are required to explore a ready-made model where soil minerals are wrongly presented as plant's food. This authentic experiment offers the opportunity of a potentially powerful cognitive conflict between the provided model which reflects the target misconception and the 'facts' as revealed through Van Helmont's appropriately designed measurements. Students are supported in interpreting the experimental results they are provided with for developing a reasoning strand like:

- 'If the soil was *indeed* the source of plant's food and thus responsible for its growth, then the increase of plant's 'weight' measured by Van Helmont *should be* similar to the decrease of the soil's weight', but
- 'Since the former is found to be excessively more than the latter according Van Helmont's results, then the source of plant's food must be searched elsewhere than the soil itself'.

So, after attempting to seriously challenge the highly resisting idea of the soil being plants' food source, we set our focus on the 'photosynthesis'-mediated inter-connection of two environmental factors with plant growth, making also use of the 'energy'-mediated inter-connection of 'food' & 'growth' already explored in the first task.

Thus, the next two tasks -'Plants and Sun' and 'Plants and water'- aim at supporting students in explaining the effect of the environmental factors sunlight and soil water on plant growth by appealing to their relationship with photosynthesis considered as a food-making process. In other words, students are required to come up with models connecting each environmental factor with plant growth through photosynthesis, which is to be further inter-connected with glucose, food and energy.

Finally, the last modeling task of this educational scenario examines photosynthesis as biochemical reaction. Students are required to construct a model upon the *'object'* of leaf by activating all its five *'properties'* and inter-connecting them with each other to show that the light-driven photosynthetic mechanism located into plant's leaves requires water and carbon dioxide in order to produce glucose and oxygen. This task may also function as a basis for enhancing students' interest in photosynthesis invoking oxygen production. Pointing out that photosynthesis makes possible for plants to produce oxygen which is subsequently released in atmosphere and becomes available to all living organisms that depend on it for their own survival, can possibly result in recognition of photosynthesis' key role in the living world.

3. The educational scenario of 'Inheritance'

Genetics is considered to be one of the most demanding biological topics ([2], [11]). Research in the domain of Biology education has revealed a number of cognitive obstacles deriving from the *'complex and abstract'* nature of the topic ([9]). In fact, students are presented with an extended series of rather complex and abstract concepts, which are required to understand and furthermore interconnect, in order to come up with the view of inheritance that the school science dictates.

A rather long list of difficulties encountered by students when dealing with high-school genetics and of the alternative conceptions that they seem to hold - sometimes even after they have been taught in class-, is actually available. Such misunderstandings may concern inheritance of acquired characteristics (i.e. characteristics acquired through parents' lifetime are thought of as transmittable to offspring), parental contribution to the genetic profile of offspring according to their sex (i.e. daughters are thought of as most likely inheriting maternal characteristics, while sons paternal ones), genes as the '*material entities'* passing from parents to offspring and finally the idea of probability as the key parameter in the process of inheritance ([12]).

Moreover, the mechanism that underlies the formation of sex cells and consequently the inheritance itself - the so-called meiosis - is usually studied separately from the transmission of specific genetic traits from parents to offspring ([9]). However, such a didactic option can not actually support students in developing a deep understanding of the topic. On the contrary, it is possible to encourage them in coming up with standard solutions to the required genetic crosses without really being aware either of simulating meiosis when separating 'letters' - that is *alleles* - to define gametes - that is *eggs and sperms -,* or of how important randomness is in this process.

The educational scenario that we developed for the computer-supported educational environment *'ModelsCreator'* aims at supporting students in getting more familiar with the probabilistic character of inheritance on the basis of recognizing meiosis as the underlying process.

Since genetics may be discouraging to a significant part of young students due to its increased cognitive load, we attempted to enhance the motivation for studying it carefully by assigning students the role of an imaginary genetic counselor responsible for making reliable predictions about the possible offspring of couples having specific genetic profiles. Thus, students are presented with a series of family situations that mainly concern the appearance of specific human diseases and then they are asked to inform each couple of future parents about the possibility of having offspring suffering from the disease that is in question each time.

The environment of *'ModelsCreator'* for this educational scenario provides a set of five *objects*: WOMAN, MAN, CHILD, BOY, GIRL. Each of them has a sub-set of five *properties*: Thalassaemia, Huntington Disease, Hair Type, Color Blindness and Haemophilia. Each *property* has either three ('sick', 'carrier', 'healthy') or two *values* ('sick', 'healthy') and each *value* may be tagged with a *probability* ranging between 0 and 1. Students are also provided with a set of logical operands (IF, THEN, AND, OR, NOT) upon which they draw to set up the required genetic crosses in terms of qualitative reasoning (i.e. IF the woman is sick with x AND the man is x's carrier, THEN each child of the couple has an a% probability of being sick with x, a b% probability of being x's carrier and a c% probability of being healthy regarding x').

The construction of a model requires selecting '*objects'*, moving them in the working space, selecting *one* same '*property'* for each *object* (since the software does not allow for the study of dihybrid genetic crosses), selecting *values* for each *object's property*, defining a *probability* for each value (which results in a change of the object's visual representation) and finally selecting logical operands from the given set to set up the target genetic cross. After having completed their prediction about the couple's offspring through constructing a model of logic, students have the option of testing the validity of their prediction by comparing their own model with the one saved earlier in the software by their teacher as a *'model of reference'*.

So, how exactly do we pursue the aim of supporting high-school students in coping with the probabilistic character of inheritance within the described environment of *'ModelsCreator'*?

The educational scenario is consisted of five one-hour tasks, similarly organized in students' worksheets. In the beginning of each worksheet, students are assigned with the 'mission' of predicting the offspring of a couple usually on the basis of specific information about a genetic trait of the couple itself or of their parents.

Before being provided with basic technical instructions about the modeling process within the environment of *'ModelsCreator',* students are faced with a number of questions which they are supposed to explore as a prerequisite for the construction of their model within the software. These questions practically aim at supporting students in organizing their thought around the idea of *'probability'* in order to come up with valid predictions.

After modeling their predictions, students are required to test their model against a *'model of reference'* and moreover to focus on meiosis, the mechanism that underlies the formation of eggs and sperms. Thus, in the last part of each worksheet students are first asked to draw one body cell of the mother and one body cell of the father, as well as the nucleus of each, where they are supposed to add only one pair of chromosomes with the alleles for one specific trait as dictated by the task. Then, they are given the necessary instructions in order to have a 'paper & pencil' simulation of meiosis resulting in possibly different sex cells, which they finally have to combine in all possible ways to come up with all possible cases for each child of the couple. In the light of the above, students have the option of revising their model in order to reflect a possibly different understanding of the genetic cross they are working with.

The five tasks of the scenario deal with genetic traits -mainly human diseases- that have been selected on the basis of the type of the responsible gene. Thus, the first two tasks concern the inheritance of autosomic genes, recessive in the case of Thalassaemia, while dominant in the case of Huntington Disease. On the contrary, the last two tasks concern the inheritance of recessive sex-linked genes in both the cases of Colour-Blindness and Haemophilia. Finally, the inheritance of a special type of genes, the so-called co-dominant genes, is the only one not studied in the context of a disease but of the hair-type trait.

Analyzing the scenario tasks a little bit further, we should notice that the first one, set in the context of Thalassaemia, is rather 'open'. Aiming at presenting students with the idea that multiple genotypic and phenotypic combinations may be possible on the individual as well as on the couple level, this task does not provide students with concrete information about the couple's phenotypic or the genotypic profile for Thalassaemia to have them engaged in combinatorial thinking. Thus, students have to come up with all the possible combinations within the couple, which practically means to set up six different genetic crosses. This actually requires that students also realize that reverse crosses like for instance 'woman / sick x man / healthy' and 'woman / healthy x man / sick' may be omitted since they would result in identical offspring because of the gene-type responsible for Thalassaemia.

Exploring then how the Huntington Disease, caused by a dominant autosomic gene, is passed from generation to generation, students are not provided directly with information about both the candidate parents. Knowing only about the woman's father, students first need to set up a cross for the family she comes from and define her possible genotypes for the disease. Based on this first model, they have then to proceed in setting up a new cross concerning the family that the woman plans to have and come up with the possibility that she gives birth to a sick child every time she gets pregnant.

On the contrary, in the third task students are provided with both the future parents' phenotypes regarding the hair-type trait, as well as with the necessary information about the phenotypic expression of co-dominant genes. Thus, after defining the couple's genotypes in the light of the above, students have to set up only one genetic cross to make their prediction about each child of the couple.

Having explored the transmission of three types of autosomic genes, students are next introduced to the inheritance of sex-linked genes. In the fourth task, they are required to predict the possibility of a colour-blind child being born from a sick woman and a healthy man in each pregnancy. Because of the gene-type, students now need to realize that the *'object'* child wouldn't be good enough for their model. On the contrary, they have to set up a genetic cross resulting in girl and a second one resulting in a boy. Furthermore, students are prompted to set up the reverse cross and realize that in case of sex-linked genes reverse crosses may result in quite different offspring.

Finally, in the last task students are required to predict the possibility of a haemophiliac child being born from a carrier woman and a sick man in each pregnancy. Thus, they have the chance to go once more through the ideas that the sex of the child is important when studying the inheritance of sex-linked genes, as well as the sex of the parent who is sick or carrier. Finally, attempting to set up the reverse cross this time, students are practically faced with the idea that the concept of 'carrier' in the case of sex-linked genes is not applicable in males.

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Innovative ways of combining teaching ICT with teaching science: video taking and editing by students and teachers

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Abstract. *Science and technology are omnipresent in everyday life and they play a very important role in today's culture. Encouragement is needed for students to study science because, for greater economic wealth, education should aim to attract a greater number of young pupils to study science, so as future scientists and engineers emerge from them. It is also important for school-leavers to have acquired skills such as searching for new information, as well self-educating skills that are consider of vital importance for all citizens in modern society.*

A growing number of schools in Europe already have computer laboratories available. Introductory courses on ICT are already integrated in primary school curricula. Now may be the time, therefore, to revise existing curricula so that they incorporate ICT and become more attractive to the students while avoiding overlaps. We believe that while integrating in the school curricula ICT teaching with the teaching of different subjects, one might attempt at the same time to introduce different learning methods while paying more emphasis to students' own actions and self-directed learning abilities. In the teaching approach suggested, the teacher selects a certain scientific topic deemed suitable for his class and the students are asked to create their own medium. Students choose the content, plan on it, decide which are the important points and which ones have less importance, they develop a teaching "scenario" and thereby act according to it, they learning by their own actions.

Keywords: ICT education, educational technology, new teaching methods, Science education, self-directed learning, teaching science.

1. Introduction

Science and technology are omnipresent in everyday life and they play a very important role in today's culture. Because of their pre-eminence, school curriculum should try to comply with these new data. Students should study science and technology:

- Because the economic strength, the progress and the wealth of all modern societies is based on Science and Technology[1]
- Because science is an integral part of human culture and as it thrives on independent and creative thought, understanding science develops one's independent and creative thinking[2].
- Because education should aim to greater depth in pupils' scientific understanding[3]
- Because education should, also, aim to attract a greater number of young pupils to study science, so as future scientists and engineers emerge from them[1],[5]
- To gain knowledge about the material world, simply because it is both interesting and profoundly important – and to feel the sense of excitement that scientific knowledge brings [5].
- Because the understanding of the nature of science is essential if people are to make sense of socio-scientific issues and participate in the decision making process[3]

- Because the ever-growing importance of scientific issues in our daily lives demands a populace who has sufficient knowledge and understanding to follow science and scientific debates with interest, and to engage with the issues science and technology poses – both for themselves individually, and for our society as a whole[3]

The knowledge on how to search for new information as well as the acquisition of such new information in the course of normal schooling, self-training, or re-training is of immense importance today. Indeed, the ability to acquire new knowledge is a vital skill for all citizens in modern society.

A growing number of schools in Europe already have computer laboratories utilising modern computers. Introductory courses on ICT are already integrated in primary school curricula or soon will be. Apart from that, PCs are present in a continuously growing number of homes, and the age children start using computers decreases continuously. It is about time, therefore, to revise existing or develop new ICT curricula. On developing these new curricula due attention should be paid to the fact that activities such as text editing or painting have already been introduced to the students in primary school. Something different, more advanced, and more exciting is needed, therefore, for the high school (and lyceum) curricula. We believe that one possible course of action would be to integrate in the curriculum ICT teaching with the teaching of different subjects, while at the same time to combine different learning methods by paying more emphasis to students' own actions and self-directed learning abilities.

2. Constructivism in action: the case for self-directed learning

According to **constructivist** theory, pupils cannot be considered as "tabula rasa". They have preconceptions or "alternative frameworks" (according to which they tend to think in order to explain whatever they experience), and which they therefore play an essential role in their learning process. **Constructivism** pays much emphasis on students' ideas, as these ideas represent the raw material that the students themselves are called for to **reconstruct**. Professors and teachers play a supporting role in this process. Meaningful learning demands that pupils construct their own knowledge.

Self-directed Learning is a didactic concept where students set their own goals, analyze a given problem, observe their own learning progress, and assess the educational results.

The innovative teaching approach suggested in this paper, aims to help students achieve the goal of self-directed learning. The students learn by their own actions for a change, instead of passively hearing teachers teach. Furthermore, students have to choose the content, evaluate it, decide which are the important points and which ones have less importance, they develop a teaching "scenario" and they execute it. They also have to collect the materials and apparati needed for the experiment to be performed, set the experiment up, make sure that everything works and then start the shooting.

The video-editing phase follows and any corrections needed are performed. Students are asked to evaluate their own work, and if the end result does not satisfy them they may decide that the process should be repeated. Alternatively, they may decide to just alter the narration (boring voice) etc. Students develop abilities such as judging their own work and finding arguments to justify their opinion. They learn to hear their classmates and evaluate the arguments presented. All these abilities are considered essential for a modern citizen. Apart from that, the teaching approach suggested offers a very strong motive to the students. Their work will remain at school for other students to use it in order to learn, (or perhaps it may be uploaded via the internet to a streaming server so that other schools may have access to it. Students can also visit their own school page and show to their friends and relatives their own product. In case the same procedure will be performed in parallel in different classes or different schools, a competitive spirit will be easy to take hold. Teachers may also wish to cultivate such a constructive situation by splitting their class into two or more groups and institute a procedure in which all groups take turns in presenting their work. This way, students are given a stimulus to try to outperform the other groups.

In the process of doing so, students learn to collaborate with other members of their group, to evaluate their own work and to make the best of the assets they have available. Students, therefore, learn to develop collaborative characteristics, such as helping each other and to develop their social competence in working as a team. They learn by themselves and by taking into account the opinion of their friends and co-workers on their project. This whole procedure is also bound to enhance their mutual and social skills (group interactivity).

3. Innovative ways of using ICT at school

We have already explained the didactical merits of the innovative learning approach advocated, namely that it allows students to develop their collaborative spirit, learn to help each other and achieve social competence in working as a team. The practicalities of such an endeavour will now be expanded.

Digital video cameras and digital cameras (offering the possibility of limited video capturing) are nowadays cheap and common enough (even mobile phones have such capabilities nowadays). We believe that it is about time to start using media-editing application software in the classroom as a good new method for introducing ICT in everyday school practice.

The teaching approach suggested in this paper is part of an ongoing research, contributed by a number of the authors to the e-stream (Minerva) research effort. Several different didactical projects are currently running in parallel, involving students of different ages (from primary school students up to twenty-year-old ones). The main aims are (a) to find the difficulties faced by students of different ages, interests, and socio-economic backgrounds, and (b) to evaluate different teaching activities in order to find the most appropriate ones for students of different ages. Overall, this approach should have considerable impact on the way teachers prepare their lessons, which in turn, will modify the lessons themselves.

To help along these lines, we present some teaching scenarios for combining ICT (developing of media) with other school curricula. In the present paper, the emphasis is in combining teaching Science with teaching ICT, and therefore the examples are from science teaching.

As the media content is concerned, these can be categorised in 4 major categories as follows:

A) Scientific experiments with the use of computers (sensors/actuators). These have two subcategories.

A.1 The teacher performs the experiment, the capturing, and the editing. The product is then used in class. As sensor equipment is not yet available in all schools, the cooperation of a TEI (Technological Educational Institution) or a University is (for the time being) essential for the shooting.

A.2 A certain experiment is assigned to the students. In this case, the procedure might take place in the school lab a university or a TEI (Technological Educational Institution) might lend the necessary equipment and perhaps a researcher to help if necessary, or it may be combined with one or more visits to a university/higher education training centre that has the equipment for the shooting

The scientific experiments using sensors that were recorded and subsequently used in this educational trial were designed developed and performed in the Department of Physics, Chemistry & Material Sciences at the TEI (Technological Educational Institution) of Athens, and were financially supported by the research program "Archimedes".

B) Scientific videos: e.g. physics experiments, or instructions on constructing a device requiring a certain level of technological skill. This one has two sub categories.

B.1 The teacher performs the experiment the capturing and the editing and he/she uses the final product at his/her lesson

B.2 A certain experiment is assigned to the students. They should study the scientific topic decide on the "narration", collect the material and apparati needed, test them, perform the experiment, do the video capturing and proceed with the video-editing.

These two aforementioned categories (A) and (B) are considered to contain a high educational value. This is even more the case, when students are asked to create their own medium. Students will be responsible, in this case, for the end result. The teacher will be, of course, the one that will select the scientific topic deemed to be suitable for his class. In both these cases, (still under investigation):

- The students are asked to investigate and find the theoretical background.
- They will design and plan the content of the video.
- They will decide (roughly or even vaguely) for the narration that may also appear as text.
- They should collect the necessary equipment/materials and test them in an experimental setup before perform the shooting.
- They perform the video shooting.
- They perform the video editing.

C) General knowledge video: the presentation of a well-known monument (there are plenty of such places in Greece e.g. Acropolis, Olympia, Delphi, a certain town) and its history.

This should be considered of contain a medium-level educational value. The quality of the video is an important factor to the success, in this case. In the present paper, we will not deal in depth with this category, as we believe it requires a very different approach that presents its own didactical challenges and all that warrants a new and separate study.

D) Videoing real time events to record (and) reproduce the information it is contained. This real time event might derived from one of the following:
   a) Lectures: The lecturer and the topic he chooses are the factors that determine the educational value of the media. Seen in this light, the educational value of this approach does not differ much from attending the same lecture on a TV program. There is not much difference even from listening to this lecture on the radio since very little information is on the visual part. For some people reading the same lecture from a book, be that an electronic or a printed one, might be preferable. And this because they can stop and search for an unknown word, or re-read a paragraph that it was not clear enough. In this case, the quality of the video is not, really, all that important. The important information is to be found in the content, while the information contained in the image is of lesser value, and in certain cases the image might be even distracting (jewellery, clothing, gestures etc.)
   b) A real time event such as a song competition, a sport event, students presenting something etc.
   c) A school event such an excursion of a ceremony etc.

Normally such videos have limited educational value, as they only serve as an object to exercise and perfect the ICT-video capturing and editing proficiency of the students who take the video, while the real educational value is limited to that. The medium can be used for discussion about the subject e.g. the music, the presentation etc. The quality of the video is again of lesser importance as the details do not play such an important role. In this case, only some limited video editing is normally necessary. The medium is almost ready to use in the first place.

Such activities require the cooperation of teachers of different “specializations” and skills. The Science (or History) teacher is called to cooperate with the ICT teacher. There are reasons to believe that such activities make the learning process more interesting and, finally, the percentage of the knowledge remaining to the students is higher.

Activities like these can be performed after the normal class hours in a daylong school, at the “free activity zones” or in locations that students can visit at any time (as, for example, “houses of knowledge” or “science museums”).

Students can work in small groups. Working in small groups is, of course, most beneficial for the students because they learn to work in teams, to develop collaboration and communication skills, as well as to practice self-learning techniques. This approach encourages teachers to use information and communication technologies as well as collaborative tools, in order to widen the students’ opportunities while facilitating the interaction with each other and with distributed information resources. However the pedagogical challenge is to choose and assess the technology available and to use it in ways that are pedagogically appropriate and relevant to the learners.

4. Difficulties in using the new approach

In order to reveal the difficulties that would be faced by a teacher attempting to use this teaching approach, the decision was taken to organise and perform various teaching activities to test these tasks in practice.

1. Materials and equipment to be used in the experiment had to be collected and tested beforehand. This step is considered crucial. Multiple sets of the materials/equipment that will be used are absolutely necessary (e.g. batteries, lamps, materials that might be cut down, burned, or destroyed during the experiment, experimental tubes etc.)
2. The video-shooting equipment should be tested in advance, and the person using the camera should have pretty good knowledge of the capabilities and limitations of the camera. Using the camera manual and performing experiments in front of the camera will increase dramatically the time needed.
3. Special care should be paid to small details such as the background of the experiment, the surface on which the experiment takes place, but also to the hands of the performer (rings, watches, long nails with strange colours etc.) may attract the "eye" and shift the viewer's attention from the experiment to something irrelevant
4. Normally the LCD screen on the video camera shows a slightly smaller frame than the one stored on the tape/PC. Connecting the camera to a personal computer is considered necessary, especially if we are dealing with small objects in scientific experiments. If we do not do so, things irrelevant to the experiment will appear in the video and will distract the child's attention. A video editing program can be used to crop "noise" but this increases the time and the effort devoted to the editing phase. This step should be omitted for outdoor shooting due to safety and mobility reasons (moving around with a laptop that operates, connecting with a camera)
5. The camera should be kept very steady, especially when videoing scientific experiments. A "professional tripod", a heavy and steady one, is recommended for this purpose.
6. The camera is best to be operated via remote control, due to several practical reasons

a) If the tripod used is not a professional one the final image will suffer greatly as it would allow small movements and vibrations during the time of video capture (even if we handle the camera with care)

b) If the performer and the "shooter" is the same person it allows him to start/stop the camera easier,

7. If the performer and the "shooter" are different persons and the video shooting is an indoor activity that is going to take place in a small area, a second screen will be needed to allow a full view of the shooting area to the performer.
8. For shooting scientific experiments professional lighting equipment is required to increase the amount of light available and in doing so to increase the depth of field of the image taken. It might be proven that setting up the lighting (avoiding shadows etc,) is a time consuming activity

The camera should be set to the mode that allows saving the video to the tape and simultaneously sending it to the PC. That means that 1 PC file and a tape file are produced at the same time (redundancy).

9. The camera should have a high resolution and the connection to the PC should be through a firewire exit. This produces a much higher resolution video in the PC than a USB connection. The resolution can be dropped at the final step (editing and compression) but the only way to add details, is to re-shoot the experiment.
10. It took us about 2 hours to set up the lights, PCs, Tripods, Cameras, find the right shooting position etc.
11. The videotaping could not go on one take (i.e. one shot). The possibility to get the narration recorded correctly while shooting is very low. The probability to also get the narration right might be higher if the text for the narration is prepared in advance and a second person reads it on an external microphone (if the camera allows it) while the experiment is

being performed. We, therefore, need multiply takes (shots). Video editing is needed afterwards, of course. For the video editing a modern computer is recommended (The more the RAM it has and the more free disk space it has, the better. A second disk for the video is recommended)
12. If the video includes several steps, it is recommended to shoot it step by step and gradually store it in a different file. This ends up in editing smaller pieces, and putting them together at the end.
13. Moreover, finally yet importantly, we should mention that this procedure is time consuming. It took us 3 hours for about 8-15 minutes of row video.

Decision such as which video editing program will be used, which analyses etc should be used must also be considered.

The next step is video editing and synchronisation with the narration.

5. Conclusions

While the economic strength, the progress, and the wealth of all modern societies are based on Science and Technology, it is also well known that Science seems to be the most difficult, and the least interesting subject for most students. Considering its true size and its importance, Science is the single major subject in which only minimal amount of hours are devoted in the school timetable. Research has highlighted that "proper" (e.g. laboratory activity – based) science - teaching or such as the science teaching advocated in this paper, is extremely time consuming. Therefore, the first challenge is to find more teaching hours for science.

We also mentioned that introductory courses on ICT are already integrated in primary school curricula or soon will be. Therefore, new teaching approaches more advanced and more exciting could be considered for possible implementation. Techniques such as video capturing become easier and more common. We believe that by combining tasks in the way shown in this paper, will prove to be very beneficial to the students.

This teaching approach helps students to develop collaborative spirit, and to improve their self-learning skills. Students also develop their own judgment as to what is important and what is not, while learning to elaborate arguments to justify their opinion. These are important characteristics of adult people to have. Finally, students also acquire some (often quite considerable) technical expertise.

Another advantage of this approach is the following: Certain events (e.g. the Olympic games, or a school excursion to a certain place such as a centre dedicated to environmental education, or an art exhibition, or an event paying homage to an important artist or a famous author or poet) do not occur every day. Certain events might be rare or even unique and, in addition, they may carry an important educational message worth to be kept as a record. The emotional importance, to the students, to the effect that they themselves record something important or unique, should not be underestimated as it generates excitement.

In the case of recording laboratory experiments, it should be stressed that some such experiments cannot be performed in a normal school-lab. This is because (a) they demand very expensive equipment which can only be found in places where schools go for a visit and (b) experiments may be too difficult to perform at school due to several reasons (e.g. too dangerous to carry out or they demand a tutor with specialized knowledge to perform it). In these cases, the material developed by the students might be useful to the other classes who may be interested to watch it and learn from it.

The ultimate challenge faced by this type of teaching approach is to design activities that are suitable to different age-group students, as well as to students of different interests and abilities.

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Modelling activities with educational software with regard to computer's operation

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Abstract. *In this work we present the design and the evaluation of a set of educational scenarios with the use of the modelling educational software «ModelsCreator». The scenarios in question are related with the learning of basic significances of computers' technology in the secondary education. This work aims to contribute in the study of growth and of use of model instructive material based on open educational software on the ground of didactics of Sciences and more specifically on didactics of Informatics.*

Keywords. Didactics of Sciences, instructive intervention, instructive scenario, modelling software, teaching computers' hardware.

1. Introduction

Nowadays Informatics constitutes a basic course in the Greek secondary education while the problems that her teaching places have not been yet studied sufficiently in the frame of Didactics of Sciences. Didactics of Informatics, as a proper sector of Didactics of Sciences mainly has dealt with the instructive subjects that concern programming. In reverse, in the classroom or in the computer lab, learning and teaching of personal computer's hardware constitutes an exigent and complex cognitive subject [7] that very little has been studied. The concepts that concern this thematic area are not always immediately and optically remarkable by the students and the teacher. In the same time, parameters that affect in personal computer's performance (as an intergraded system of hardware and software) are several and complex. So, in the frame of school, easy and effective implementation of experiments with real software and computer devices is not possible.

In the frame of this questioning we designed and implemented educational material with use of computer modelling environment gunning for the learning of computer's operation. The expediency of using computer modelling environments in educational process has been explained sufficiently by modern pedagogic research [3], [5]. At the same time, Computer Science uses models in order to study real or hypothetical phenomena and manufactures [3].

In the first part of this work we study a complete instructive scenario that concerns in the thematic unit of internal structure, organisation and operation of personal computer as intergraded system of software and hardware. In the second part of work we analyze an instructive intervention that became in a real classroom situation with the use of scenario in question and we study the instructive problems that resulted from this application.

2. "ModelsCreator" software and instructive scenarios of Informatics

2.1. "ModelsCreator" software

"ModelsCreator" (MC) is a computer-modelling environment that permits students to create and test models representing different aspects and phenomena of natural world. The models' behaviour test takes place by direct manipulation and multiple representations (simulation, bar charts, graphs, tables, etc.) [8]. "ModelsCreator" contains objects that have a mediating role helping students in mental manipulation of abstract entities and concepts (properties of objects). Properties of the same entity or other entities can be connected with qualitative, semi-quantitative or quantitative relations (figure 1). "ModelsCreator" integrates semi-quantitative models, quantitative models, and executable decision making models as well as static qualitative models (concept maps), with special emphasis on semi-quantitative modelling. These models meet the requirements of many curriculum subject matters, permitting interdisciplinary use of the modelling process.

2.2. Case of instructive scenario of Informatics with "ModelsCreator"

Aim of instructive scenario of Informatics with "ModelsCreator" software is the creation of an alternative instructive approach against the schoolbook-based approach. This alternative approach concerns in the modelling of an intergraded computer system, using its distinct units, and in the study of this system's behaviour from the user's point of view, under various real situations. Thus a more "authentic" [1] learning environment of the specific matter of study is created.

In the framework of the scenario in question students are asked to create a personal computer's model, by selecting relations between the various properties of processor, of RAM memory, of hard disk, of graphics' card and of computer system's speed. After having created a personal computer's model, they try it with various applications. They count the time of application's commands execution and observe the general model's behaviour. Thus, they evaluate the relations that themselves have selected. We use four types of applications (Desktop applications, Image Editing Tools, Multimedia applications, 3D Games), for which we simulate the count of their execution time under various hardware systems.

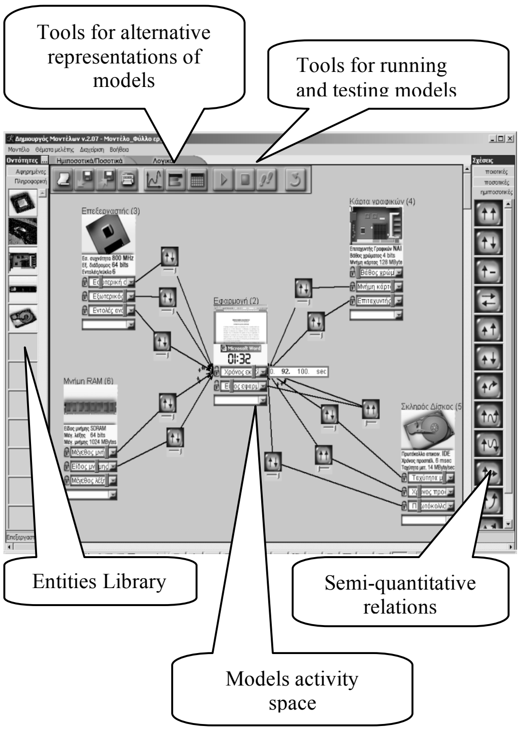

Figure 1. "ModelsCreator" interface

For the specific's instructive scenario needs, "ModelsCreator" interface (Figure 1) includes an entities' library, which contains 5 entities and more specifically: Processor, RAM Memory, Hard disk, Graphics' card and Application. Certain properties can be attributed to these entities. The modelling activities that we propose in the particular thematic unit are approached, in the framework of instructive transformation of scientific knowledge [9], with the help of semi-quantitative reasoning:

A. Relation "when the one is increased then the other is decreased":

«As long as the size of internal's frequency operation of processor's core is increased, so much the time of application's commands execution is decreased » [13]

B. Relation "when the one is increased then the other is increased":

«As long as the access time of hard disk is increased so much also the time of application's commands execution is increased » [13]

Γ. Relation "changes in the one do not influence the other":

«The changes in the word's size in memory RAM do not influence the time of application's commands execution » [13]

In every case of relation between entity's attribute and time of application's commands execution, we consider that the other parameters that also influence the execution time remain constants.

Model's creation procedure presupposes entities' determination, entities' properties determination and relations between properties determination as well, in the workspace of the environment. The trial or the execution of the model becomes or manually, or automatically, or step by step, using the execution's model tools. The environment also permits the user to observe simultaneously the simulation of model's real situation (optical representation) and the model's evolution via an alternative representation (bar charts, graphs, tables).

In the environment of "ModelsCreator" the modelling and trial activities concerning a personal computer can bring up students' alternative perceptions with regard to personal computer's structure, organisation and function as an intergraded system of software and hardware. Thus, it is possible that the activities in question can constitute the frame in which the instructor will attempt facilitate the construction of corresponding scientific perceptions by the students.

3. Study of instructive scenario in conditions of real computer lab

In this section we will shortly analyze a case study with the use of instructive scenario that was developed previously. The case study took place in conditions of real computer lab. The all activity is included in an instructive effort of instructive objectives achievement of "Computer's hardware" course curriculum in the framework of initial professional education.

Three workgroups of students participated. The two workgroups were consisted of two students and the third one was consisted of three students. All the students were coming from the Information Technology and Networks section of a Technical Professional School. Instructor during the activities was one of the researchers.

The instructive-training activity with each workgroup kept about 50 up to 60 minutes. Each workgroup was separately informed about the environment and it used the ModelsCreator's tools before the instructive-training activity. This process kept roughly 10 with 15 minutes. The common instructive-training activity-intervention was recorded. Digital camera recorded the non-verbal communication of the students; however the computer screen was not recorded. During the activity, only the workgroups of students and the instructor were in the computer lab.

As resulted from the total educational dialogue analysis, the training activity total followed the structure Initiation – Response - teacher-led discussion – Initiation - Response (IRtlDIR). We consider that this structure was initially and fundamentally shaped by the "open" type educational environment we used, as well as from the objectives that we had placed for the activity in question. The environment is characterized as "open" with the significance that it has the role to convert the

3.1 Episode 1: Appropriation of the symbols' system – Initiatives for grounding

students' proposals and not to guide them by prompting or making indications. That "open" educational modelling environment created a context in which the element "Follow-up" of the communication structure (Initiation-Response-Follow-up) [6] breaks down as "teacher-led discussion" and new informed "Initiation" and "Response". Thus, when we refer to the "activity of model's construction and execution" we talking about the educational dialogue that took place during the students' and teacher's initiatives with regard to model's construction and execution (Initiation) and to transformation of these initiatives (Response) from itself the educational environment through user interface's exterior representations and simulations. We are not talking about the discussion which was guided and supported by the teacher (tlD), in which the environment tools and representations were not finally used and which followed the first (IR) phase and preceded the final (IR) phase.

In the first (IR) phase students expose their collective option concerning the cognitive object by selecting relations between the processor's properties and his performance. The model's execution with instructor's initiative does not ground the educational workgroup's dialogue. Only that it accomplishes is student's appropriation of the symbol's system used by the educational environment. For example, it accomplishes in order that the students associate the significance of "reverse proportion", with a simulation that uses alternative representations: numerical values' fluctuation, bars' fluctuation or entities exterior representations' change (optical representation). The entities exterior representation's change however was not associated with the real phenomenon of upgrade and test of a computer system performance, at least not for all the students.

In episode 1, during the model's construction and execution, student A shows that she has appropriated the symbol "increase-increase". Student A, as well as the student S, they try to ground their choice concerning the relations by asking either their schoolmates or the instructor; in no case however they do not try to achieve grounding coming from the user's interface simulation and representations. The instructor refers in grounding that will be carried out later (in the phase of tlD) or he calls them to decide based on their collective experience and knowledge. It is obvious that this call does not bring result as is not produced any type of creative discussion.

(We mention a dialogue which took place during the students' effort to accomplish a relation between "processor's internal frequency" and "application's execution time" using the chart tool, as well as part of dialogue for the choice of remainder two relations between "exterior data bus width", "commands per circle", and " application's execution time")

Instructor: Let's see again. We can see it also with a chart. That means we can put a chart right here. And after that I can put this property and that one also and then I press the OK button./ Let's see now how it works. /Now it played fast, very fast, agree? / Let's put it step by step./ As long as the internal frequency is increased, so much also the application execution time is increased all right? This property you have selected therefore put and the other properties put and the other relations.
Student A: Is this correct?
Instructor: I don't know, you work on it.
Student F: Put the external bus.
Student S: How we can know if is is correct?
Student F: Put the external bus.
Student S: This one, we take it off?
Student F: Also the execution time.
Instructor: No, you don't take it off, you put it in parallel.
Student A: What we have to put here? (Students F and A talk each other) What it match with? External bus and execution time are increased both (she shows two up arrows with her hands). The external bus and execution time, the one goes up, what? Me, I can't.
Instructor: Do you understand what this relation means? If you put this relation that means as long as the internal frequency is increased, so much also the execution time is increased
Student F: Yes
Instructor: If you put this relation that means as long as the internal frequency is increased, so much also the execution time is decreased. You just put a relation here. Do you want to put also a relation up there? Put the relation and we see it again later
Student S: Yes, but this is correct now?
Instructor: I don't know. Put also the rest of the relations and we see it again later.
(Is interfered dialogue that concerns choice of relations which is not mentioned)
Student A: Which one is the correct?
Student F: This one.
Instructor: Before put it, think about what happens in real world
Student S: Yes, the processor…
Student A: Me, I don't know
Instructor: Put any relation and we will see it later.

After model's construction by the students it follows a scaffolding process (tlD) between the instructor and them, which focus in the questions of the worksheet. In this phase the grounding does not emanate from the previous (IR) phase, as someone would expect, but it constitutes a supporting activity of common knowledge construction between the instructor and the students that is grounded only by this common knowledge. In this phase, environment's tools and representations are not used.

In episode 2 the educational workgroup tries to construct mutual understanding to answer the question of worksheet that concerns the relationof internal frequency of processor's core with the number of clock's circles that times the processor.

3.2 Episode 2: Internal frequency and number of clock's circles (Workgroup T-Z)

Student T: "When the processor's internal frequency is 800 MHz that means the internal clock…"
Instructor: "Per second, what does it do per second?"
Student Z: "Read it again"
Student T: «When the processor's internal frequency is.."
Student Z: "Yes.."
Student T: "800 MHz"
Student Z: "800 MHz"
Student T: "That means the internal clock does…"
Student Z: "800 circles per second"
Instructor: "Only 800?"
Student T: "No, not 800.."
Student Z: "But they are MegaHertz"
Student T: "Eight hundreds millions"
Student Z: "Eight hundreds millions per second"
Student T: "Eight hundreds millions"
Instructor: "Eight hundreds millions "/"since they are Eight hundreds mega"
Student Z: "Since one Hertz is.."
Student T: "No, since it is MegaHertz"
Student Z: "One MegaHetz is one million"
Student T: "Yes, 800 million per s.."
Instructor: "Isn't true? One MegaHertz is one million, how much are the 800?"
Student T: "Per second"
Student Z: "Eight hundreds millions per second"
Instructor: "That's right, so it does eight hundreds millions circles"

Since the educational workgroup reached in some level of mutual understanding concerning cognitive object, it advanced in the last phase of reconstruction of model (IR). In this phase the students express what they have learned during scaffolding process (tlD) reconstructing the model,selecting again relations between the entities properties. The model's execution constitutes once more teacher's initiative, since students do not have any reason for executing the model that will not confirm their choices. However as it appears in the following episode 3, the instructor has reasons for supporting the dialogue that results from the model's execution.

In episode 3, students, after having discussed with the instructor (tlD), select new relations between the processor's specifications and the system's performance and execute the model after the instructor's initiative. During the model's execution, the instructor supports the dialogue so as to be explained in which way the model's behaviour corresponds in the workgroup's choices and in the real phenomenon that model represents.

3.3 Episode 3: The right relations execution

Instructor: “Let’s try the other ones, let’s run … how we can test the other / open anything of them, open just one”
Student A: “ This one”
Instructor: “Bravo, that’s it / push the button there, very nice, run it!, press the button now / as you like, either step by step or at once / no, this is not the step by step button, next to this is the step by step button / very nice, read now the value, internal frequency 4.77, execution time how much seconds?”
Student S: “55”
Instructor: “55, push again the button, is increased, let’s see now, internal frequency 50 MHz, execution time?”
Student S: “Is decreased”
Instructor: “32 / 90MHz execution time 31 /133 MHz execution time 30 / 200MHz execution time 30”
Student S: “Remains the same”
Instructor: “233 go on/ go on/ is it false?”
Student A: “Yes”
Instructor: “No, it is not false because..”
Student S: “Remains stable”
Instructor: “Do you believe that it is false? There is a relation. As much as if you increase the frequency, some moment the execution time doesn’t…”
Student S: “Goes on”
Instructor: “The execution time is not altered, our computer is a system (mouse) in which doesn't play role only the internal frequency, but also the other attributes / let’s run it a little in order to see / the internal frequency it increased, the execution time some moment is decreased, but some moment it stops, that’s right? This isn't completely, isn't completely false / that’s right? (it runs the representation tools of the relation) the internal frequency is increased the execution time is decreased, you see it? if we choose now a processor that is more modern, that has 3 GHz, that are this here, the execution time goes in the 30, that’s right? But other attributes should also change in order to the execution time is more decreased, that’s right? As long as the execution time is decreased, so much faster the program is, that’s right?”
Student F: “Yes” (Student S shakes the head affirmatively)
Instructor: “So this is right, at least partly, let’s go to the other”

4. Discussion – conclusions

From the short analysis that proceeded, it results that the educational environment in question and the activity’s objectives placed by the instructor as well, shape the educational workgroup’s communication structure. During the dialogue process supported by the instructor, it appears that mutual understanding is constructed between him and the students, having as a mental context their common knowledge.

During this discussion anyone would wait the educational workgroup had used also the recent collective experience with the environment’s tools: the multiple representations of student’s perceptions for the cognitive object, but also the simulation’s execution of real phenomenon. Nevertheless this collective experience was not used for the construction of new knowledge. This is explained by the fact that collective experience was not incorporated in the wider common knowledge of both instructor and so as to support the construction of mutual understanding about the cognitive object [1], [12].

Both representations and simulations of the educational modelling environment user’s interface provide student’s thinking support [4] not only when they are connected optically with what they represent (realistic representations-simulations) but also when this connection is recognized or is possible to be constructed by the common knowledge of the members of educational workgroup (teacher and students). In the particular framework the representations created by the simulation’s execution constituted a symbols’ system, that was not connected conceptually in all the cases of students with itself the phenomenon of processor’s performance trial and test.

Thus the particular educational scenario appears that it did not ground sufficiently the discussion between the members of educational workgroup. Those did not have reason for using the model’s execution tools since this initiative would not support their reasoning. Consequently, the all activity was converted by the instructive action so that it resembles more as conceptual mapping and least as semi-quantitative modelling as were the initial intentions of its designers.

Of course this does not mean that the all activity of using that educational environment’s tools was not incorporated creatively in the instructive process between teacher and students. It did not offer at the level of grounding, but it created that dynamic environment carrying out the educational dialogue, structuring the communication so as a framework of investigation, but also endorsement by the instructor was created.

Simultaneously it gave the possibility of utilisation of alternative systems of symbols and representations, moreover native language and mathematics. Thus, educational workgroup members, under instructor’s initiative, used the model’s construction and execution tools in order that the students appropriate the symbol’s system used by the educational modelling environment. At this point the role of mediation and framing of the educational activity by the instructor were, and it is we would say, very critical, since itself using of modelling educational environment tools it is possible to provide chances for creative discussion that concerns in the real phenomenon that is studied.

5. Acknowledgements

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Use of specially designed Haptic Devices in a Virtual Reality environment for Educational Purposes: Requirements, Specifications, and hands-on experience derived from an IST project

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Abstract. *In this paper the use of haptic interfaces and applications for educational purposes is discussed. The question whether Haptics technology (virtually touching objects and feeling forces), could be implemented fruitfully in the teaching procedure is studied as well as if it helps the understanding of certain scientific concepts.*

The hardware haptics components was designed after careful consideration of the educational needs: the most important parameters of the end user requirements were drawn up, and the functionality of the end product was discussed with selected educational experts (mostly teachers).

These requirements were transformed into specifications for a large scale system, called the Interactive Kiosk Demonstrator (IKD) in the framework of an IST project entitled "Multi-User Virtual Interactive Interface (MUVII)". For the application software design (thinking especially in the context of science education) the educational needs of the end users were painstakingly analyzed and evaluated and, subsequently, some applications were designed and developed. These applications have been used and tested by students of different ages, and their teachers, for more than three months in order to reveal the benefits and the drawbacks of the haptic device as well as the applications.

Some interesting results were derived from the users' feedback, and these support the view that haptic interfaces can be used in education for the benefit of the students.

Keywords. Haptic Interfaces, Science Educational Applications, User requirements, Virtual Reality.

1. Introduction to Haptics, 3D Graphics and 3D Sound

It is useful, to define some terms of *Haptics*, *3D Graphics* and *3D Sound*, since all haptic devices use this kind of technology.

The term *haptics* was popularized in the United States by the philosopher Gilles Deleuze and comes from the Greek verb "haptesthai", which means to touch and to handle. The technology refers to the ability of touching and handling virtual objects. In a more general sense, it is an interface that enables users to understand the weight, the shape, the volume of an object and the forces acting on it. By using *special input/output devices* (joysticks, data gloves, or other devices), users can receive feedback from computer applications in the form of sensations felt on the fingers, the hand, or other parts of the body. The term *"tactile feedback"* refers only to the sensory input on the fingertips of the user.

With *3D (three-dimensional) graphics* we refer to a space where objects (polygons) are made up by a series of dots which are referred to as corners. The coordinates of these corners are specified by three values: x, y and z. The representation of the 3D space on each of user's eyes is always a 2D image obtained through the rendering process. The impression of 3D is created in the human mind after some (quite elaborate) computation, albeit without conscious effort from the part of the user. Many parameters are used as input to this computation, like the different 2D image in each eye, different colouring (hue) of objects as distance increases, common assumptions as to the size and speed of various objects etc.

As far as *3D sound* is concerned, true 3D sound has genuine depth and width to it. Just like 3D graphics, 3D sound can also be recreated by just two speakers and some very advanced mathematics! The use of 3D graphics and 3D sound combined with haptic feedback create a multi-sensory immersion for the users.

2. MUVII project description

The key objective of MUVII project [8] was to develop on the one hand two new Man-Machine-Interface Devices featuring haptic feedback, called Haptic-3D-Interface (H3DI), and on the other hand a prototype of an innovative integrated platform using the device: the Interactive Kiosk Demonstrator (IKD). University of Patras (HPCLab - High Performance Information Systems Laboratory) was responsible for the design and integration of the IKD platform as well as the development of the 3D haptic applications. In cooperation with The Science Laboratory of the School of Education of University of Patras, provided the specifications of the device and carried out the testing of the whole platform with pupils and teachers. The other partners of the project were: Laval Mayenne Technopole (France), CEA - Commissariat a l'Energie Atomique (France), SINTEF - The Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology (Norway), De Pinxi (Belgium), Institut für Kommunikationsakustik – Ruhr University of Bochum (Germany), ONDIM (France), CompuTouch (Norway), Centre PIC (Russia).

The opportunity of having a natural "look and feel" environment for teaching purposes is very promising indeed. The purpose of MUVII IKD was to demonstrate new interactive paradigms in a novel integration of the following modalities as these interfaced interactively with the user: *3D-vision, 3D-audio and haptic (force and tactile) feedback*. The process followed in order to design, implement and test the IKD was:

1. *User requirements and constraints* for the IKD device and applications were gathered and analyzed.
2. *Technically feasible specifications* of the IKD device, applications and platform were defined in detail.
3. Design and development of the *IKD device*
4. Design of the modular architecture of *IKD supporting platform.*
5. Design and development of *IKD Applications.*
6. *Integration of the hardware and software modules.*
7. *Educational Testing of the IKD*, for more than three months, with an adequate sample of more than 300 pupils, and some teachers.

In the present paper the first two steps of this process are described, and some conclusions regarding the issues raised in them are drawn, which can be used as a useful guide for those interested in developing haptic interfaces and applications for educational purposes.

3. User Requirements Gathering

In order to collect the most important user requirements, several discussions with potential users (mostly with teachers and to a lesser extent with students) were held. It is interesting to note that although students normally have a better knowledge of computers than their teachers, they are also "dreamers" and ask for features that are not feasible yet.

During these discussions the concepts behind the current haptic technologies (force and tactile feedback) as well as our ideas were explained. In order to judge the pupils' reaction towards virtual reality environments involving haptic feedback interfaces, some trials were run using both children (of various ages) as well as adults, and utilizing a setup involving commercial haptic interface devices (i.e. Phantom by SensAble Technologies, I-Feel-Mouse by Logitech). The results of those trials were most encouraging, especially considering that these devices have a "feel" which is a lot less natural than the one expected from the H3DI of the MUVII IKD.

Moreover, regarding the tactile feedback, it was demonstrated that the tactile motors of CompuTouch (one of the partners in MUVII project) gave the sensory input expected when they were integrated in a common mouse. The users got feedback on their index while interacting with a windows application and the capabilities and limitations of such tactile motors were studied in detail.

The teachers were fascinated with the idea of using haptics in their classes since this technology gives the opportunity to observe, test and simulate phenomena that could not be performed in a class or in a school laboratory [2]. This is due to several reasons such as safety problems (e.g. it is too risky to use explosives or certain chemicals in an ordinary lab) or too difficult and perhaps impossible experiments ("switch off" friction for instance, driving any type of vehicle and feel the forces of a collision, construct a certain machine etc.).

One of the primary interests during this phase was to specify the best shape and functionalities of the IKD device. The main requirements for the IKD device was the movement independence, the feeling of force feedback independently on each finger, the precision of the movement so that the haptic device could function "transparently" as an extension of the user's hand. Apart from that, users expressed their interest for the use of two devices, one for each hand. Moreover, users wanted a large workspace (i.e. actual space where the device would be active).

As far as the applications were concerned, the potential users wanted to use applications that couldn't be easily performed in a class, but with a high educational value and, of course, to be exciting enough for the students. Many different ideas for applications were offered and discussed, and finally two applications were selected and implemented for the IKD, as specified in a following section.

4. User Requirements Analysis

In the ensuing analysis it was revealed that, as far as the device was concerned, users wanted to use advanced *wearable (not ground-based) haptic interfaces* instead of joysticks. The characteristics most users required involved *grasping, manipulating and throwing objects* in the virtual space, while feeling forces and tactile feedback on as many fingers as possible (but at least on the 2 essential ones: thumb and index). The users required to be able to *investigate and explore* various 3D objects and *feel* their material, surface, size, shape, etc. Another very important characteristic, for the educational use of the IKD was deemed to be its *realism*, (something that is normally ignored by game developers). Special emphasis was paid in support of *accurate hand and finger movement*.

More specifically, users wanted an *"easy-to-use" device* that doesn't require in depth knowledge of computers, robotics or physics in order to use it. Another important factor for them is the *weight* of the device – they want it to be as light as possible so that young children can handle it – and the *freedom of movements*. The users want the device to be a "natural" continuation of their hand which they can freely move and act in the application's environment.

Regarding *3D sound features*, users found very interesting the idea of hearing the various sound cues of the application and being able to easily perceive their direction, distance and volume, while at the same time they can communicate with the other users by using open air headphones. Furthermore, *Haptic related sounds* (i.e. sounds that are produced directly from the interaction of the user's virtual hand with the objects) should also be supported by the sound subsystem of the IKD.

One of the most innovative and challenging requirements was to support two users interacting simultaneously in the context of the same application. The users should be able to jointly manage the common viewpoint, but each user be able to independently move inside the 3D world of the application. The two users should be able to act at the same time either at the same or on different object.

The IKD applications to be developed were selected after the analysis of the requirements and these were: (A) Newtonian Physics, Trajectories and the Solar System (with learning mode, recapitulation mode and edutainment mode) and (B) Virtual Model Assembly – Gears (with learning, training mode and game mode).

5. IKD Specifications

The analysis of the user requirements led to the specifications of the IKD haptic device, the IKD platform and the IKD applications, as described in the next sections and in [3].

5.1 IKD Device Specifications

The MUVII IKD Haptic 3D Interface (H3DI), as the human-interface part of the IKD platform and applications, plays an extremely important part in the final functionality of the applications. Furthermore, the IKD H3DI should respect some specific constraints, regarding the varied ages of the final users (children as well as adults) and some requirements of the specific IKD applications. More specifically, the requirements are the following:

Size of H3DI: How small should the body of the 3DHI be? The main concern is the use of the device by young children (primary school age). As the size of the hand is smaller, we cannot expect young children to be able to handle with ease (or if at all) a device created with a fully-grown male in mind. Therefore, the best possible solution is to create a device that is *adjustable in size,* so it can be used by adults and children as well. This could be achieved by having detachable pads attached to the main body.

Weight: Should be as light as possible approximately 100 - 150 grams. The balance of this weight is of considerable importance, as it should not be very top – heavy, or in anyway out of balance. A top-heavy 3DHI would feel unnatural to use and, therefore, it would present an obstacle to the user to associate with it, and "immerse" in the use of it.

Priorities to be kept in the design: The *balance and fit* are (probably) more important parameters than size and weight. Any inevitable compromises made should keep this in mind.

Type of movements: The users should have the capacity to move their hand (with the device worn) freely in space without strict movement restrictions. Also, the users should be able to use at least two of their fingers (thumb and index) independently. This way, it was observed that they could easily manipulate virtual objects (albeit in a rather unnatural fashion). Taking into consideration that in this trial a new haptic interface was evolved, this is acceptable. It also turned out that the user could easily adapt him/herself to this situation, e.g. the use of only 2 fingers to manipulate objects). Furthermore, the precision of the movement is an important factor, because this allows the user to perceive the haptic device as an extension of his hand.

Type of actions: By exploiting the force-feedback of the H3DI, users should be able to select, pick-up, hold, move, orient, release/place, pull/push and throw objects, while they feel forces acting on their fingers (weight, torque, collisions, etc.). By exploiting the tactile feedback (provided by the tactile motors integrated on the H3DI) users can investigate and explore various 3D objects and feel their surface material, shape, etc.

Force feedback: Users manipulate objects using their two fingers and feel forces acting on them, independently on each finger.

Tactile feedback: Users are able to get tactile feedback on their two fingertips.

Workspace: This is the actual physical space where the device would be operational (its position can be tracked). Minimum requirements are 600 mm (width), 600 mm (length), and 400 mm (height). Obviously, the greater the final workspace is the better it is.

Robustness: A certain amount of robustness is required especially as we envisage children using it. Ideally, it should be able to withstand a drop from 80 – 100 cm height onto a hard floor without breaking or needing adjustment or realignment.

5.2 IKD Platform Specifications

To achieve the best virtual reality immersion for a multi-modal interactive environment like the MUVII IKD Platform the best solutions for each one of the three modalities involved in MUVII (visual, haptic and sound) were integrated. MUVII IKD demonstrates new interaction paradigms in a novel integration of these three interaction modalities: 3D-vision, 3D-audio and haptic (force and tactile) feedback. Innovations of IKD include:

- The multimodality of haptics, 3D-audio and 3D-graphics, to provide an integrated, natural "look and feel" immersion environment for edutainment purposes.
- Integration of two haptic feedback devices (see Figure 1) that support tactile & 3DOF force feedback, thus providing multi-user ability (either teacher-pupil or pupil-pupil) to enhance the teaching procedure and the collaboration among pupils.
- Motion capture / tracking for hand and head of two users.
- Sophisticated 3D-sound: use of open headphones, head-tracking and real-time reproduction of individual 3D sound for each user.
- Innovative Haptic Interaction Metaphors, like visual-haptic and audio-haptic (see next section).
- Rapid application development support, through the customized Virtools authoring environment, the MUVII IKD library of predefined generic objects & behaviours

and the MUVII IKD audio authoring toolkit.
- Innovative Demonstration Haptic Applications: They introduce several innovative features and their primary purpose is to demonstrate the capabilities of the H3DI and to build on its functionality.

The really hard but technically challenging part in IKD is to keep the latency time between visual, haptic, tactile and audio feedback as small as possible in order to achieve a great degree of realism. Very short time latency is also required for the hand tracker that is used for the accurate positioning of the real human hand and the real-time rendering of the virtual hand inside the 3D world of the application. The problem is getting harder, if you consider that these subsystems of the IKD platform are implemented by different pieces of software which they are being executed in different computers and in some cases under different operating systems all connected to form a single system.

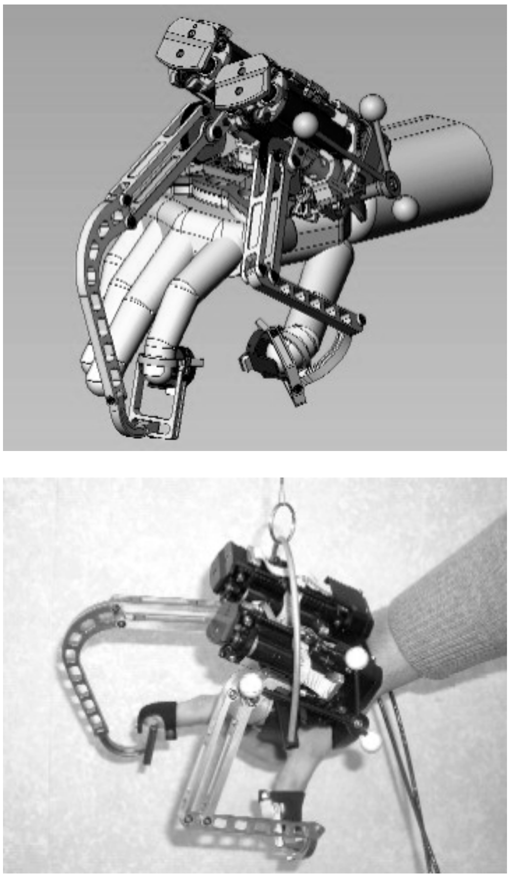

Figure 1: IKD H3DI concept and realization respectively (Courtesy of CEA [1])

5.2.1 Innovative Haptic Interaction Metaphors

To enhance the haptic experience of IKD applications, special visual, audio and haptic interaction metaphors have been specified in order to give emphasis on events that give haptic and tactile feedback to the users. These metaphors include Avatars, Haptic, Visual and Audio metaphors [4, 5]. Moreover, we provided specifications on enhancing haptic metaphors through “real-world” and “non-real-world” audio cues and sound effects, with emphasis on near real-time performance, without loss of user’s perception of immersion in the virtual world.

These metaphors help the users to better immerse in the virtual world and perceive the concepts of the Educational Applications. Moreover, it is possible to turn on/off these metaphors so that we can observe the user’s reactions and verify the metaphors’ effectiveness

6. IKD Applications

Many different applications were proposed and were exhaustibly discussed and evaluated so that finally two applications were selected and implemented for the IKD [6, 9]: (A) *Newtonian Physics, Trajectories and the Solar System*, and (B) *Virtual Model Assembly – Gears* (each one with learning mode, recapitulation mode and edutainment mode).

From the educational point of view, the applications were based on the **constructivist** theory, according to which students are responsible for their own learning. Meaningful learning demands that pupils construct their own knowledge. Some emphasis was also paid in self-directed learning techniques, in that students are left free to decide which part of the knowledge offered interests them most and how much time they spent on it.

As supported by the constructivist learning approach, it is much more fruitful for the students to consciously choose to investigate something (e.g. properties of an object) as opposed to passively watch a science video.

Computer aided learning and virtual reality environments allow students to learn by following his/her own pace, or even according to his/her interest. In MUVII IKD applications, in “active manipulation” mode, the student can manipulate objects after some conscious decisions to do so. Thus, users interact with the objects they choose in the way they choose, and feel the feedback from their actions. This stimulates their interest, and increases their attention. We have reasons to believe that the knowledge remaining to the student after such a learning activity is higher than what is left after teaching the same subject using traditional methods of teaching, where the student passively hears the teacher teach. The control on the objects that the software gives to the user, is recognised as a very important and interesting feature [10].

Within the application of *Newtonian Physics and the solar system*, the user interactively (and virtually) navigates through the solar system, while collecting information about anything that interests him/her. Various elements that our solar system consists of, such as the planets, the satellites, the comets and the asteroids offer tactile, auditory and written information about themselves. The user experiences the effect of the forces when accelerating objects (e.g. tries to throw them off their course) as well as the strength of the gravitational forces applied to objects at different distances from the sun or from a certain planet. Obviously, for the purpose of such an interaction the user is endowed with "super-powers". With the use of haptics the pupils are able to experience, feel and gradually learn the way the laws of simple mechanics are applied at the scale of our solar system. Figure 2 shows a screenshot of the application.

Figure 2: Feeling the gravity
(Planet: Hermes Diameter: 4.878 km)

Figure 3: Assembling a windmill

Regarding the *Virtual Model Assembly - Gears,* the users are offered a lesson in the history of cogs, gears and their applications through the ages. They can also try to assemble some selected applications by combining gears. The users experience the effect of forces like weight, friction, motion, rotation etc. This application can be used to enhance students' understanding of phenomena like the transmission of motion from one part of a machine to another. Figure 3 shows a screenshot of the application.

7. IKD Experimental Validation

IKD H3DI, software infrastructure and applications were tested, against functional and performance issues, in a real-time educational setup situation, during a three-month continuous operation. Moreover, IKD was demonstrated in Laval Virtual 2004 (see Figure 4) exhibition event.

Students responded quite well to the use of this haptic prototype. Students were also pleased and seemed to be amused by their experience. They would wish to repeat their experience and to see the haptic device extend its abilities as well as to see it used in other applications too (more varied applications). For more information see [7].

Figure 4: Laval Virtual demonstration, a young user

8. Conclusions

The multi-sensory environment of a haptic device can offer great improvements to the existing teaching methods, by offering tools of enhanced quality suitable for deeper understanding of the entities taught. Students seem to have adjusted well to the new system and to have liked the experience of using it. Currently there are no other applications with capabilities similar to the ones specified in MUVII project, incorporating characteristics like multi-user collaboration among pupils and teachers, efficient 3D-sound sub-system, targeting children of varied school age, efficient haptic interaction metaphors etc.

This paper outlines some important requirements and specifications for haptic devices, especially for applications that will be used in education. The specifications presented should prove useful as a guide for those that aim to develop haptic interfaces as well as application software for education. On the other hand, the present paper will also help potential users (teachers, pupils) to become better acquainted with the idea of using haptic interfaces in education, to understand the power (and the limitations) of haptically-enhanced virtual reality educational systems, and to start generating some useful feedback in terms of their potential implementation in everyday school practice.

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Web-based Instruction in IT Hardware

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Abstract. *Educational opportunities can be improved by implementing Web-based instruction. A tutorial titled "Methods and Facilities of Information Technology" was conjointly developed as a component of "IT Hardware" undergraduate course and is delivered through the campus networks at three universities in Ukraine and Poland.*

The tutorial content covers the practice of IT in seven modules. Special emphasis is made on the basic concepts implemented in IT hardware. The instructional value of benchmarking and diagnostic/testing tools is also considered, and a practical approach to proper selecting such software is described.

The tutorial was evaluated using data gathered from a post-course survey. A total of 45 questionnaires were returned. Students responded positively to the idea of implementing Web-based instruction and extending it to other courses.

Keywords. Information technology, hardware, Web-based instruction, benchmarks.

1. Introduction

Technology has radically changed the way educational institutions function in an academic environment and the services they provide. However, many universities feel the lack of equipment and limitations of scheduling. Recently Web-based instruction has become a viable alternative to classroom model that may improve educational opportunities and provide great assistance to overcome some of grand challenges to education.

The first challenge is speed. Our universities are simply too slow at what they do. To teach rapidly developing disciplines and IT courses in particular, an educator should, we quote al-Djahiz (an Arabian encyclopedist, the 8th century), "keep pace with time when it flows, and fly with it when it flies". It is obvious that Web-based instruction is a very suitable model to achieve this.

The second problem we face is the commercialization of education. More and more students have to pay for study at universities in our countries. Tuition fee is increasingly growing while universities have no funds to provide financial aid. To respond the needs of busy students working to get money, the instruction should be presented at times and locations convenient to them. Learning needs to be active, self-directed, collaborative, and situated in real-life.

And that is the third grand challenge: how do we deal with students? What is our role and what is our communication style? Most educators were and many of them are rather authoritarians than collaborators to students, their style is more didactic than liberal. Fortunately, introducing new teaching strategies will facilitate liberal changes in an academic environment, because most educational innovations require that students will take a more active role in the learning process. The students taking the Web-based course had to be highly self-motivated and well organized.

Now we come to the final challenge, which is the issue of access. It is very interesting to look back at the recent history of access. Article 19 of the Universal Declaration of Human Rights, which was adopted in December, 1948, states that, “Everyone has the right to freedom of opinion and expression. This right includes freedom to hold opinions without interference and to seek, receive and impart information and ideas through any media regardless of frontiers.” Many new educational models including Web-based instruction are developed to improve access and make the knowledge, a “global public good”, as widely available as possible.

2. Tutorial outline

The mastering of IT hardware is an important component of the IT literacy curriculum. To address some of the hardware-related skills, a Web-based tutorial, “Methods and Facilities of Information Technology,” was developed as a collaborative project with the faculty of Ternopil State Technical University (TSTU, Ukraine), Lviv Polytechnic National University (LPNU, Ukraine) and Rzeszow University (RU, Poland).

2.1. Access policy

The tutorial was designed as a component of “IT Hardware”, an undergraduate course, and is delivered through the campus networks (Fig. 1).

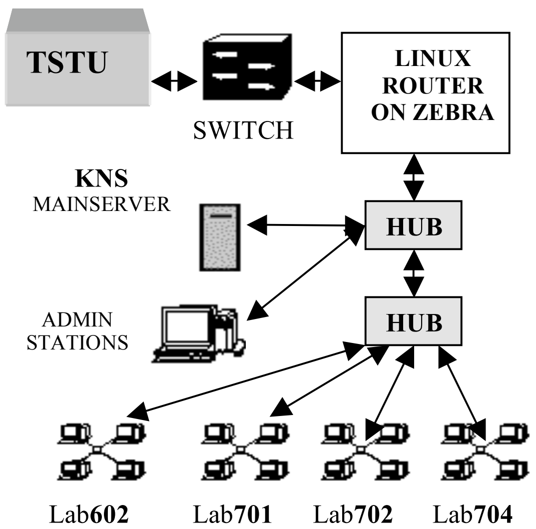

Figure 1. Access to courseware in TSTU network

Users are administered by Microsoft Active Directory and are sorted in three groups: Administrators, Teachers and Students. Courseware is stored on KNS (main server) working under Apache Web Server software. By courseware [1] we mean the collection of coordinated materials and tools specifically produced and used in education as instruments of instruction and delivery of curriculum. Administrators and Teachers can change all educational materials locally or by using hidden SMB shares. Students’ files, such as home-directories, are organized as DFS shares to be accessible from any point of TSTU network. Non-Students’ documents (i.e. educational materials) are available to Students in read-only mode.

The router works under Debian GNU/Linux Woody 3 or 4; rooting software is Zebra, Cisco’s alike system. Two 100 Mbit/s cards are used.

Software installed on the KNS main server includes Windows 2003 Server, Apache Web Server, and FTP-Internet Information Service. One 100 Mbit/s card and two 120 Gb HDD are used.

2.2. Content of the tutorial

The class was presented as a traditional 30-hour classroom course. The content covers the practice of IT in seven modules. Each module includes lecture notes and other information on the topic, recommended reading list, and assignments to reinforce comprehension or to practice skills. This course allowed for gradual but in-depth learning of concepts and principles in information technology. The seven sections of the course are arranged so that students progress from basic subject knowledge to the ability to overcome a particular IT-related challenge through proper selecting, using and adjusting IT hardware.

The first two modules include data compression methods and image formats. Students complete assignments to construct a redundancy-reduction code using the Huffman method and analyze the properties of an information source allowing data compression. They are also offered to draw pictures to understand which one of image formats (.gif or .jpeg) is more effective depending upon picture properties (for example, number of colors). The next three modules include CPU architecture, memory technologies and HDD storage devices. In the last two modules, students summarize their knowledge acquired during the course. They study the motherboard structure to understand the over-all architecture of PC and use monitoring tools to explore PC performance.

3. Introducing the past into the present curriculum

We strongly believe that learning and understanding the processes of IT hardware evolution should occupy an importance place in the process of study IT technologies in order to make the link between the past and the present meaningful for students. When history of one or more hardware components or technology is directly tied to class activity, some positive changes in perception happen. But simply offering the students to go through the chronology of IT hardware (processors, memory, storage devices etc.) would not work, and every educator knows from own practical experience that requests which are not required formally pass unheeded.

Therefore we have made a special effort to indicate the basic concepts implemented in IT hardware (i.e., parallel processing, pipelining or pre-fetch) and show that, in many cases, today's IT solutions are based on the same basic approaches hidden by new names. This will help students to keep pace with IT progress and recognize well known ideas implemented in new-generation hardware that will appear after they complete their formal education.

4. Benchmarking and diagnostic tools

We also consider benchmarking and diagnostic/testing tools to be of great instructional value, especially since necessary software, online help, tips and reference searchable databases are accessible online. However, there is a certain danger, because, as indicated in FOLDOC Free Online Dictionary of Computing [2], "in the computer industry, there are three kinds of lies: lies, damn lies, and benchmarks".

To interpret the relevance of benchmarking and diagnostic/testing tools and then to select proper tools accordingly to the educational needs, a teacher has to check requirements regarding:

- operational system;
- RAM and HDD space sufficient to install and run an application;
- user profile (some test applications can be run only by network administrators);
- availability of special chips providing the information to be analyzed by the application;
- duration of testing (too long tests may be ineffective);
- report modes, both test and graphic options are desirable;
- native language interface if possible.

The reasons to integrate benchmarking and diagnostic/testing tools into the tutorial and other IT-related courses are very pragmatic. Students can see the structure of PC, determine parameters of its components, analyze how well these parameters are coordinated, explore PC performance under different loads, and reveal PC problem areas.

The availability of too many benchmarks may become a problem because they often produce conflicting results when measuring performance characteristics of the same PC components. It is important to realize that this results from software implementation. The simplest solution would be selecting a single application to get comparable results with different hardware. However, the comparison of different benchmarks may allow noticing unusual details provided that specifics of software implementation are taken into account.

Benchmarking and diagnostic/testing tools are available at many Web-sites, but only few of them provide validated and refined information put all in one spot. The role of such resources is that they make possible top-down approach [3] to software selecting. For instance, an extensive archive is supported at **BenchmarkHQ** (*http://www.benchmarkhq.ru/english. html*).

General-purpose toolkits and device-specific applications serve different educational needs complementing each other (e.g. **SiSoft Sandra,** *http://www.sisoftware.co.uk,* and **HD Tach,** *http://www.simplisoftware.com*). The latter ones provide extensive data on individual PC components that makes them effective when students study these same components. In contrast, general-purpose toolkits help to summarize the knowledge of PC at large.

5. Tutorial evaluation

The tutorial was evaluated using data gathered from a post-course survey. Questionnaires were completed by 45 students so that we could learn of beliefs and attitudes towards the Web-based instruction and materials developed during the project. Our analysis of questionnaires shows that overall participant attitude has been positive regarding the Web-based instruction in IT hardware. Observations made through this project include:

- Most students, 43 (95.6%), prefer Web-based access to assignments, and 2 students (4.4%) indicated that printed materials are more convenient to them;
- 44 (97.8%) students prefer to submit assignment reports in electronic format, and only 1 students (2.2%) printed his reports;
- Most students, 42 (93.3%), have responded positively to the idea of extending Web-based instruction to other courses; 3 students (6.7%) were indifferent.

Table 1 shows the survey results for why students preferred the Web-based instruction

Table 1. Advantages of Web-based instruction

Advantage *	Number and percentage of responses
Allows me to choose when and where to complete assignments	21 (46.7%)
Helps me to meet deadlines	11 (24.4%)
Decreases time to prepare reports	37 (82.2%)
Convenient access to educational materials	22 (48.9%)
Quick feedback to a teacher	25 (55.5%)

* Respondents could check more than one item.

Since any student was allowed to view current results on completing assignments by all students, they were also asked to comment on this "open" reporting. 34 (75.6%) respondents strongly agreed that being informed about all students' accomplishments is very useful, because this makes them to compete. Students answered objective questions but also were given sufficient space to "explain" their responses. These responses have been essential in helping us learn more details. For example, many students indicated that they would like to have an authorized access to Web-based courses via the Internet.

This general course evaluation was considered to be the best way to determine whether this "experimental" project was a good learning experience, what changes to consider, and whether the project should be repeated in subsequent semesters or extended to other courses.

6. Conclusions

The students were very satisfied with the course and with the Web-based instruction and support provided. We believe that this can be credited to three important attributes of Web-based instruction: more time for learning and reflection is available, individual attention stimulates learning, and motivation enhances the learning process.

We debate the quality of new teaching strategies versus existing classical models daily. It is too early to say about possible outcome of those debates. But, when we intervene in the existing system, we need be careful not to damage something that has actually worked rather well. Then the sensible approach, we think, is to experiment, be reasonably skeptical and adapt educational models to the particular field, to the particular discipline. The overemphasis on either classroom or technology-based models seems to be a mistake. It is an issue of choice, the way we teach, the way students study.

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Conceptual Learning of Science and 3D Simulations

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Abstract. *The paper explains various approaches to present natural phenomena and technical examples by means of simulations accompanied by 3D visualisation. The background of the article is the experience with development and deployment of highly interactive didactic material concerning technical science by means of most advanced information technologies. Particular attention is given to interactive simulations in physics, chemistry, electrical engineering and computer engineering. Such research is conducted within international CoLoS consortium and the achievements are verified in various educational environments. Such test-beds are also schools and some faculties in Slovenia. The learning population was represented by university students but also by secondary school teachers of informatics. The article is focused on the interactivity and realistic 3D visualisation of the natural and technical concepts, the integration of such topics in interactive tutorials, and the dissemination alternatives offered by the information technologies.*

Keywords. Didactics, multimedia technologies, simulations, 3D visualisation

Introduction

CoLoS (COnceptual Learning Of Science) is a consortium founded in 1988, composed of research teams from 18 universities. Fields of interest of various CoLoS research groups are: physics, chemistry, electrical engineering, mechanical engineering, and computer science. The major goal of this consortium is to encourage and co-ordinate the development of teaching methods and to improve the knowledge and understanding of fundamental concepts with a special focus on intuitive and qualitative approaches. One of the methods that has been developed by CoLoS is based on the mimicry of nature and its fundamental principles. The computer is used for the visualisation of the molecular or atomic behaviour. The teacher or students can interact with the simulated system and in such a way obtain a better understanding. From the technical point of view this is achieved through 2D or 3D visualisation of simulated world, equipped with the needed control buttons, sliders and other possible interacting components.

3D Simulation of particles and non-rigid bodies

One of the most significant CoLoS authoring tools is xyZET [1], which was developed at IPN Kiel (Germany). This is an interactive, graphically oriented simulation tool that permits the presentation of objects and structures in 3D space. The basic building elements of these objects are particles that are defined by their mass, charge, and initial position and velocities. These particles can be connected with springs. In such a way more complex, non-rigid bodies can be presented. Different internal and external forces influence the particles in the system. Their behaviour can be observed during the animation. The basic phenomena from the domain of mechanics and electricity can be explored (kinematics, conservation of energy and momentum, Hook's law, gravity, charges, field lines and equipotential planes).

The conceptual learning of the particular phenomena can be achieved by incremental building of the first simple and then increasingly more complex bodies and structures, and by experimentation with various physical parameters. The teaching scenario can be included in accompanying and interacting hypertext. In such a way complete courses in the domains of mechanics and electricity have been created.

The figure 1 displays a screenshot with the experiment comparing a mathematical and a physical pendulum. The 3D world with the experiment is visualized in a separate frame. Besides this the accompanying control frame and hypertext based tutorial is presented.

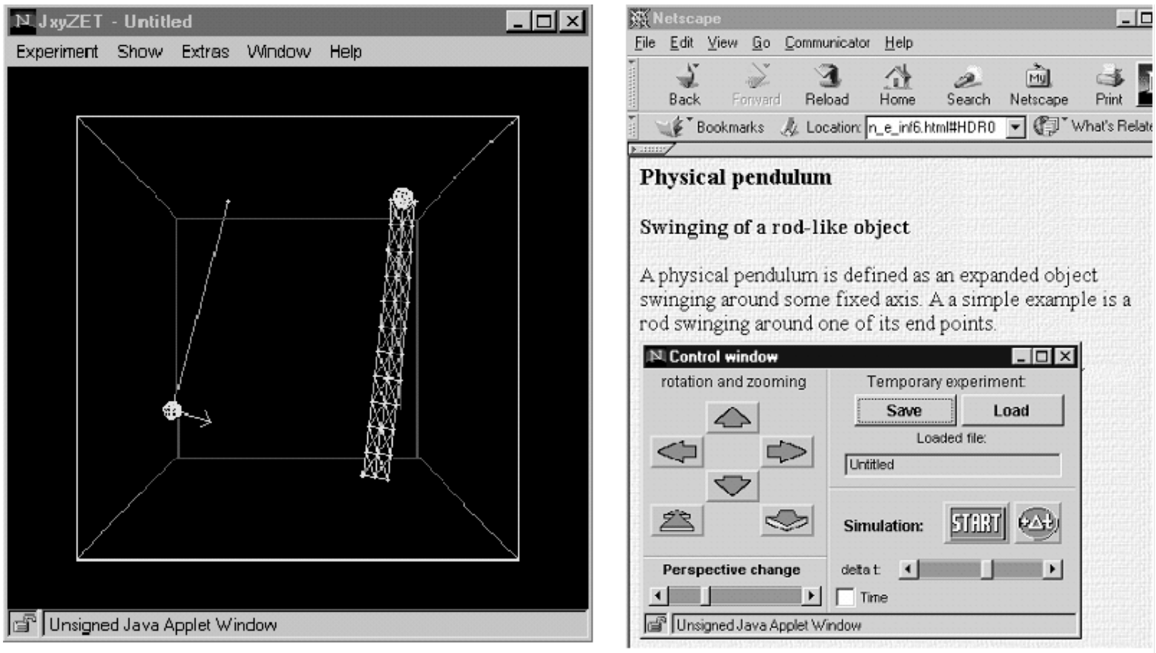

Figure 1: A screenshot with a mathematical and a pendulum

The gallery of several hundreds experiments includes some extremely complex examples with bodies consisting of more than 100 interconnected particles. Most of the experiments were integrated within the tutorials covering mechanics, resonance and electricity.

xyZET is an authoring tool running in MOTIF environment. Besides this, some additional platform independent java applets were developed at Ljubljana University. The final version was entitled JxyZET. The user interaction with experiments is achieved through buttons, menus, sliders and checkboxes that are I ntegrated in the tutorial. Several tutorials in the domain of physics, mostly written by H. Haertel and some by CoLoS group from Murcia (electricity, resonance), were adapted.

Flexibility of JavaScript Controlled Simulations

The next chapter presents the advantages of using JavaScript functions in interaction with scriptable applets. Very good results were obtained by the so called Physlets, which were invented by Wolfgang Christian [3]. Physlets - Physics Applets, are small flexible Java applets designed for science education. They can be used in a wide variety of WWW applications. The graphics of physlets is simple and without details that could be more distracting than helpful. This keeps Physlets relatively small and very flexible. All Physlets can be set up and controlled with JavaScript, which means that they can be used for several application problems with small changes in the JavaScript. Data gathering and data analysis can be added when needed, through the use of inter-applet communication. Since Physlets are scriptable, the experiments can be modified just by editing the HTML.

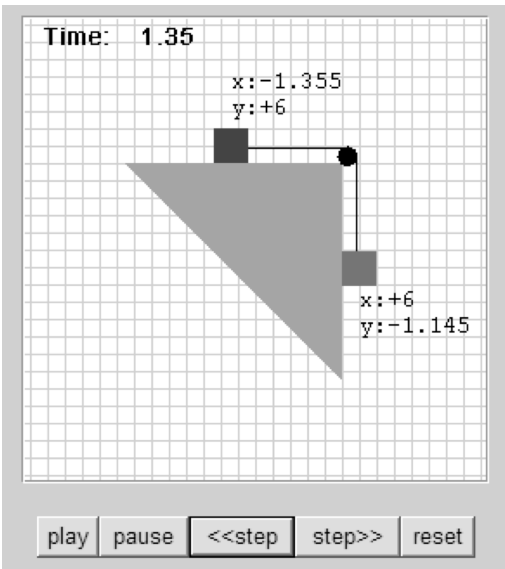

Figure 2: Physlet presenting 2 connected bodies

Christian's concept of scriptable applets influenced further development of JxyZET simulation applet. The original JxyZET was expanded with some scriptable functions. This permits the definition of more complex elastic bodies built from several hundreds or even thousands of particles and springs. These bodies can be easily modified just by changing some parameters within the JavaScript code included in the parent hypertext. The usage of JavaScript permits the interaction of an user defined algorithm with the simulation tool, in our case JxyZET. Further research of JavaScript capabilities permitted some additional improvements and increased flexibility of this simulation tool, which was completely redesigned and renamed in Animator3D.

The achieved flexibility of Animator3D applet permits the development of experiments in different scientific domains because we can put the simulation algorithms in externally defined JavaScript and are not limited with the algorithms incorporated in the original applet. The following example is a simplified 3D simulation of the known nuclear fission process.

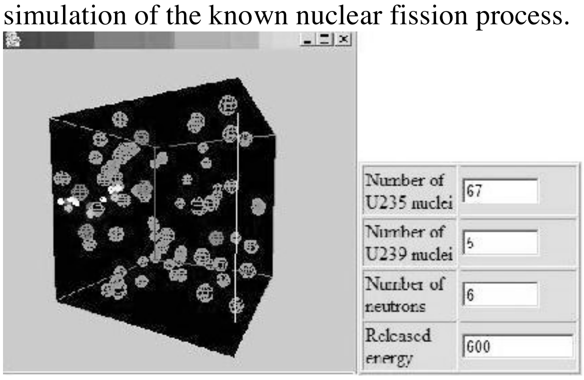

Figure 3: Simulation of a nuclear fission process.

The experiment consists of putting a quantity of U235 nuclei, some U239 nuclei and one neutron with a predefined velocity in a container. Every time a neutron collides into a U235 nucleus the later is split in two smaller nuclei (waste product) and two additional neutrons are created. In addition some new energy is released. U239 acts as an absorber. Every time a neutron collides into a U239 nucleus it is absorbed by the later. The experiment aims to find a balanced number of U235 and U239 nuclei so that the chain reaction neither dies because of disappearance of all neutrons nor it becomes too rapid (as in uncontrolled fission).

4. Photorealistic visualisation in 3D

One of the problems of such simulations is that the students have sometimes problems with understanding abstract visualisations even if they are presented in 3D space. The problem is how to decrease the gap between the real world which surrounds us and the abstract models which are used in simulations. One of the possible solutions could be to use a more realistic visualisation and to approach the abstract presentation stepwise. The interactive programs can be even more attractive if written in some more realistic 3D visualisation environment. There are several WEB technologies, which permit such visualisation. Considering the needs of interactivity, the focus of the research was oriented in Java3D.

The interactivity of the hypertext user with these demo programs can be easily achieved by means of JavaScript routines that interact with public functions within applets. The problem of such demonstrations is that the client computer should have installed corresponding Java runtime environment (for java3D) and therefore such courseware is less platform independent as is the case with usual interactive applets. Such approach is therefore more appropriate for classroom demonstrations during lectures.

The next figures presents the possibilities of such visualisation and shows a complex 3D model of a steam engine.

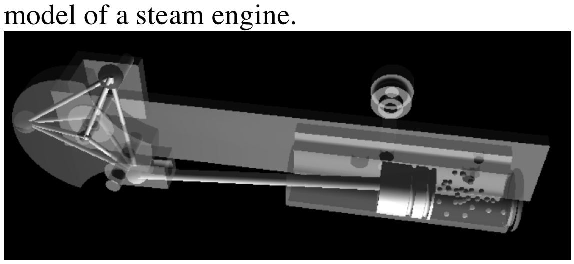

Figure 4. A 3D model of a steam engine

The transparency of the parts of this complex 3D model can be changed as shown in the figure. The figure shows the superposition of this 3D model with its abstract physical equivalent. In the cylinder a container with monoatomic gas is introduced. The length of the container (its volume) changes due to the pressure of this gas. The position of the piston in the cylinder depends on the volume of the container. The inertia wheel is substituted by several particles interconnected with springs. One of the particles of the wheel is connected with another spring to the piston.

Another interesting approach was used in the simulation of the already mentioned nuclear fission reactor. This simulation can be made more impressive by means of the following approach: The model of the nuclear fission reactor is represented by a 3 dimensional container which includes a quantity of U235 nuclei and one neutron with a predefined velocity. Besides this it includes two moderator rods (containers with some U239 nuclei), which can be moved up and down, thus controlling the reaction.

In order to give a more realistic view the background of the experiment is presented with a textured plane along with a picture of the reactor, scanned from a textbook. By changing the transparency of this picture we can gradually move from the realistic to the more abstract view.

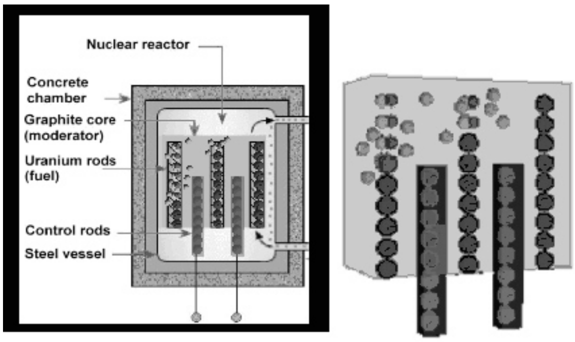

Figure 15: Example with nuclear fission reactor

The same technology can be used for a realistic presentation of the simulated physical phenomena and permits also education through play and fun. In fact such experiments resemble the well known computer games. The next figure shows such simulation of two colliding 3D bodies. The cars on the picture are in fact 3D models with corresponding masses and velocities. A student can study the fundamental rule of energy conservation by changing the physical properties of the visualised objects.

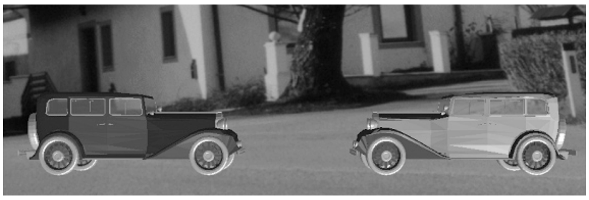

Figure 18: Realistic visualisation of the collision between bodies

The presented visualisation technologies are not limited to teach physics and the same approach was tested in other domains, in particular chemistry, biology and even computer graphics and computer programming.

6. Conclusions

The interactivity of the hypertext user with Java based demo programs can be easily achieved by means of JavaScript routines that interact with public functions within applets. The problem of such demonstrations is that the client computer should install the corresponding Java runtime environment. When more advanced 3D examples (for java3D) are implemented such courseware is not platform independent, as is the case with usual interactive applets. Such approach is therefore more appropriate for classroom demonstrations during lectures.

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A Teaching – Learning Sequence Concerning Dynamic Interactions: The Need for Appropriate Software

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Abstract. *In this study we describe the underlying rinciples we took into consideration in order to design a teaching-learning sequence to teach dynamic interactions to student - teachers. Specifically, we describe the pedagogical dimension, namely, students' basic conceptual difficulties in this subject, as they are derived from literature and an empirical research. Moreover, we refer to the epistemic dimension, namely the issues dealing with the didactical transformation of content to knowledge suitable for the specific target group. We particularly focus on the reasons that led us to design proper software to support teaching and learning.*

Keywords. Dynamic interaction**,** Newton's 3rd Law, software, teaching-learning sequence

1. Introduction

This research concerns the design, development and implementation of a teaching – learning sequence (TLS) for student - teachers. The core content of the TLS is the revealing of the concept of force as the measure of the strength of the interactions, in the context of the 3rd Newton's Law.

The design of our research program includes three phases: a) the elicitation and classification of student conceptions about dynamic interactions, as well as the study and analysis of the content of the corresponding subject matter b) the design of a TLS about teaching dynamic interactions for student – teachers c) the pilot and the main application of the TLS and its evaluation.

Many students meet difficulties in understanding the different topics of Physics. A common difficulty among topics is the creation or translation of the representations, as well as the comprehension or the use of mental models about a physical system. According to Christian and Belloni [1] computer simulations can help students to understand Physics in different ways, that is making sense of translation among representations or building mental models of physical systems. For this reason, we decided to exploit simulations' potentiality in the TLS in order to enable students to comprehend the concept of dynamic interaction. In literature, we can find a limited number of studies developing software regarding Newton's 3rd Law [2], in contrast with the big number of studies dealing with the 1st and 2nd Law [3].

In this paper, we focus on the need to design and implement proper software in order to teach a part of the TLS content. Specifically, the research question we are concerned about is: "Which are and why the underlying principles we need to develop software in order to teach dynamic interaction in the 3rd Newton Law context?"

In another paper in this volume [4] the structure and the content of this software are explicitly described.

2. Research Design of the Teaching-Learning Sequence

2.1. Literature

TLSs are currently considered to be powerful tools for improving teaching and learning in Science. According to Meheut and Psillos [5] TLSs comprise small-scale curricula and their designing can be represented with the didactical rhombus, which is set up by two interacting dipoles. The first is the connection between scientific knowledge-material world (epistemic dimension) and the second is the connection between a teacher and his/her pupils (pedagogical dimension).

The pedagogical dimension is usually placed into a constructivist context. This fact points to the need to acknowledge the differences between the scientific view about the content and the alternative conceptions of pupils' target group. The epistemic dimension combined with the pedagogical one leads us to the didactical content transformation, namely, to knowledge suitable to be taught to a target group [6].

In literature, there is a big number of studies both on learners' problems to comprehend the concept of force and the ways to teach it. These studies ascertain that force constitutes one of the primary concepts children face in everyday life, while the corresponding conceptual models they develop are usually in contrast to the scientific ones [7, 8, 9, 10, 11].

With respect to the 3rd Newton's Law and the concepts of force and interaction, recent studies systematically deal with the differences between the alternative learners' conceptions and the scientific view. The results of these studies point to three general aspects of pupils' typical views of the force concept and the science to be taught. a) Students consider that force is an acquired (or innate) property of objects, while in science force is a measure of an interaction between two objects [12]. b) Students find it difficult to accept that an inert or an inanimate object can exert force, while the scientific view is that interaction always comes in pairs between two objects independently of the nature of the objects [12]. For example, Greek students (11-16 years old) believe that interaction exists only when motion exists. c) Students don't use the Newton's third law in every situation, while the notion of symmetrical interaction between two objects is applicable to all situations [2, 12]. E.g. in Australia, research results show that the majority of pupils recognize two forces between a spring and a book on the spring correctly, while they find it difficult to indicate forces between a table and a book on it [13]. In literature, the term contextual coherence is used to evaluate the extent pupils "can apply a concept or a physical principle in a variety of familiar and novel situations" [12].

2.2. Empirical Study

Taking into consideration the literature outcomes [14] and a few semi-structured interviews, we developed a questionnaire to study the 1st year students' conceptions about dynamic interactions in a number of Schools of Education in Greece. Specifically, we surveyed the conceptions of 260 first year teacher-students about the concept of dynamic interactions in three different contexts, namely, the gravitational, the magnetic and the electrostatic one. The questionnaire, which will be presented elsewhere [15], comprises ten questions. Three of them deal with gravitational interaction, four questions deal with the magnetic one, and the last three look into electrostatic interactions [15]. Each question has the same structure, including three sub-questions and drawings. In each question, there is a system of two inert objects (the only exception is the pair of Earth-Moon), which interact e.g, two inert wooden cubes, two charged bars, a magnet and an iron object e.t.c.

The results of our empirical study seem to be corresponded to the related literature results about pupils. Following, we refer only to those related the software development.

a) We ascertained that students support that interacting entities "give" rather, than exert force; namely, they perceive force as an innate property. This perception is symbolically expressed when they are asked to represent force by an arrow. Students place the arrow on the object, which exerts the force.

b) Students seem to perceive the dynamic interaction between inert magnets and inert charged objects easier than the one between inert bodies. Specifically, between two charged bars or between two magnets, they recognize that the objects exert force on each other. With respect to the gravitational forces, the students recognize the interaction between celestial bodies (Earth-Moon) easier than between celestial-terrestrial ones (Earth-apple) and between terrestrial ones (two inert wooden cubes). We interpret this as a lack of contextual coherence [16].

c) A limited number of students support the scientific view that the magnitude of the forces each body exerts to the other are equal. On the other hand, many students have a strong idea that the bigger the entity the greater the force exerted while they are interacting. For example, Earth exerts a bigger force to the Moon because it has bigger mass. A bigger magnet exerts bigger force to a smaller one, e.t.c.

3. The need for appropriate software

3.1. Epistemic and Pedagogical Principles

The basic principles for developing the TLS will arise from combining the two dimensions (epistemic and pedagogical) we described earlier. Namely, from a) the literature review results and from our empirical research on learners' alternative conceptions (pedagogical dimension) we analytically referred to and b) choosing the proper content, so that trans – phenomenological approach of the dynamic interactions (epistemic dimension) will be promoted.

The aim of the present TLS is to enable students to acquire a unified perception about dynamic interaction in three different contexts, which are the gravitational, the electrostatic and the magnetic one, using each time the corresponding entities, namely, mass, charge and magnets. This way, the trans – phenomenological character of interactions is revealed [17] and splitting of knowledge is avoided. The general aspect we want students to acquire, applying the TLS is: when entity A acts on entity B, simultaneously entity B acts on entity A. The interaction between them has the same magnitude and can be either attractive or repulsive.

3.2. Designing appropriate software

Based on the principles described earlier, we decided to develop software a) to cover a wide range of dynamic interaction application contexts b) to take into account the three general aspects of students' conceptions about force, interaction and the 3rd Newton's Law and c) to bear an interactive, still guided teaching - learning character.

The trans - phenomenological approach of dynamic interactions becomes especially difficult when designing lab exercises, since it is hard to pick up real objects or observable things in order to help students construct their own knowledge [18]. Actually, if we compare the three dynamic interactions – the gravitational, the electrostatic and the magnetic one – we ascertain that studying the two first with real objects and observable things is particularly difficult compared to the magnetic one. How is it possible for students to observe the gravitational interaction between two inert bodies and even the Earth – Moon interaction? Regarding electrostatic interaction, it often becomes difficult for the objects to attain or sustain charge for some time. Additionally, it is impossible for the students to carry out activities and know the charge of two different bodies both quickly and accurately. On the other hand, using magnets to study the interaction between them is rather simple.

Therefore, we decided to design software, which would include gravitational and electrostatic interactions in various cases either classic (the Earth – Moon effect) or novel (the effect of a big charged sphere on a small one, equally charged, in an imaginary situation). The very nature of the software allows us to use various situations, either real or simulated ones. E.g., we can study the action of a "space watermelon" on Earth or the action of a watermelon on an apple in a room or on the beach. We assume that students' practice in the lab in two distinctive contexts can actually help them acquire contextual coherence. This speculation has led us to the development of two units regarding the software. The first comprises five labs about gravitational interaction and the second one includes six labs about electrostatic interaction [4]. We decided that magnetic interactions would be studied with real lab work, similar to the activities students carry out in the other two contexts.

The outcomes of the literature and our empirical research prove that the three general aspects of pupils' conceptions are widely spread among learners and it can be very hard to change them to the scientifically accepted ones (see above). That's the reason we decided to include features of these aspects in every lab exercise of the software and present them in the same pattern so that the students can easier conceive them.

Specifically, in the 1st step of each activity we negotiate the general aspect that force is an innate property. We ask students to depict the action of an entity (entity A) on another one (entity B) with an arrow and then check if they have placed the arrow correctly. Thus, the students have the chance to speculate in various cases both on their view that an entity "gives" force than exerts force on another one and the way they depict this action. In the 2nd step of each exercise we focus on the concept of mutuality. We ask students to draw the arrow that shows the action of the second entity (entity B) on the first one (entity A). In this way, students have the chance to find out that in every case forces are exerted from both entities. Moreover, except the Earth-Moon case, the entities are always inert. In the 3rd step of the exercises, we ask students to check the magnitudes of the forces. That is, to predict and check if the magnitudes of the actions each entity exerts on the other are equal (aspect c). In the last step of each exercise, we thought it would be important to persist on the concept of mutuality that characterizes every dynamic interaction (aspects a-c). Specifically, students can remove or get the two entities closer to each other (e.g., an apple and a watermelon on the beach) and observe that the two arrows change in magnitude simultaneously and always pointing one against the other.

The use of the software has the advantage of the pedagogical dimension compared to the real lab, since it can include a substantial number of different alternative conceptions in its context. We studied the students' answers of our empirical research, we sorted them out and we placed them among the software context. Thus, the students, while talking in their group, had the ability to check various parameters in the software, as well as to compare their own answers with their colleagues' ones. For example students checked the magnitude of interactive forces between two entities with unequal mass and equal charges, or equal mass, equal and unequal charges, e.t.c.

4. Discussion

In this study we focus on the development of the software designed for an innovative 10-hour TLS. This software was designed to support the first three lessons of the TLS. During the software application discussions between the teacher and the students, teacher's recommendations and some classical experiments (magnetic dynamic interactions) occurred.

In the pilot phase, we implemented the TLS in two groups of 8 primary student – teachers and 8 pre-school student – teachers. The initial results show that the students have easily overcome some of their conceptual difficulties. This was the case when they were confronting the «give force» model. After the first 2-3 activities, it seems that the students overcome it placing force on the body it is exerted to, instead of the body exerting it. With respect to other aspects, change was not so easy. E.g., students found difficult to understand why the magnitudes of interacting forces are equal, though the size of the interacting entities are not. This problem seemed to be overcome when we mathematically introduced the law of the inverse square. The students saw that the magnitudes of both entities contribute to the formation of the magnitude of each force.

Generally, from the pilot application results, it seems that the software contributes to students' overcoming difficulties. Nevertheless, "it does not make sense, to ask about the effectiveness of lab work in general" but "we need to ask about the effectiveness of specific lab work tasks for achieving specific learning objectives" [18]. The learning objectives in our software are divided in two categories: the content and the process [18]. In the first category of the learning outcomes (content) our aim is to help students to understand the concept of dynamic interaction, across different contexts. That means to understand that two entities interact mutually and the strength of interaction is the same independently of the amount of entities (mass or charge). In the second category of the learning outcomes (process) our aim is to help students to understand the process of scientific representation of interaction. This means that each action of the interaction is represented with an arrow, which has a specific point it is applied on and a specific direction.

At the beginning of this paper, we mentioned that we transformed the content to make it suitable for our target group. This fact sets some limits to the epistemic dimension of the software. Specifically, in the software we introduced only inert entities, which interacted from a distance. We did not discuss the interaction of entities in motion or in touch.

5. Acknowledgements

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Newton-3 : A Software For Teaching Dynamic Interactions.

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Abstract. *The educational software presented in this work, is a web-based application, designed for the topic of 3rd Law of Newton. The software covers a series of several cases from gravitational interaction to electrostatic. The software sets a series of 11 "Lab" activities, and in each Lab, students are given a problem of interaction and are asked to place the forces. The software is structured on an interactive dialog-basis, where a pictorial "expert" changes faces and makes comments upon students' response. Cases examined in the "Labs" and expert's comments are selected on the basis of students' conceptions. Each "Lab" consists of subsequent steps, where students are gradually introduced from the concept of "one body exerts force to the other" to the concept of "mutual action". In this work we present the design of the educational software developed. Some preliminary results on the logging capabilities of the software are also presented and discussed in brief.*

Keywords. Educational Software, Newton's 3rd law, Teaching, Web application

1. Introduction

The 3rd law of Newton and the concept of interaction between objects are two key points of prime significance to the construction of concepts related to situations of objects' motion, equilibrium and change of kinetic state [1,2]. Despite the significance of the topic, and even though advances in ICT have been widely acknowledged to promote a more efficient teaching and learning, very little attention has been given in the development of appropriate software in the case of Newton's 3rd Law. In the majority of software available, the topic of Newton's 3rd Law is covered as a part in a larger piece of software, usually connected with kinematics and free-body diagram representations. In most of the cases, interacting forces can be shown as arrows on the click of a button. In other, yet fewer, cases of educational software, the user (student) is given with a picture of "interacting" bodies and pairs of forces, as pairs of arrows of similar size and opposite directions, and is asked to "place" them on bodies [3]. Though either of the approaches –visualization of both arrow-forces on the click of a button or placement of a pair or arrow-forces– might be advantageous in many cases, however, they may hardly elucidate the essence of "interaction" in the sense of a mutual relationship and a mutual action between two bodies.

The educational software presented in this work, is a web-based application, designed for the topic of 3rd Law. The software covers a series of several cases from gravitational interaction to electrostatic. The design is based on a recent literature review[4] and empirical research[5] which reveal that students usually consider force to be either an internal or acquired property of a body rather than an outcome of the interaction between the bodies; for example student-teachers still tend to share the opinions of a "give" rather than "exert" force model [4].

The software sets a series of 11 "Lab" activities, and in each Lab, students are given a problem of interaction and are asked to place the actions. The software is structured on an interactive dialog-basis, where a pictorial "expert" changes faces and makes comments upon students' response. Cases examined in the "Labs" and expert's comments are selected on the basis of students' known alternative conceptions. Each "Lab" consists of subsequent steps, where students are gradually introduced from the concept of "one body exerts force to the other" to the concept of "mutual action".

2. Visual description and use

Newton-3 application runs on a simple web browser with Macromedia Flash plug-in installed. The main screen looks like a notebook page, and is divided into two main sessions. The left-most part is the actual application, called a 'Lab'. Each 'Lab' consists of different activities-tasks, as described below. The right-most session (see Fig.1) is text area, which contains brief instructions for 'Lab' activity, to run. Text is kept to a minimum and briefly describes the tasks that the student (user) has to do in each 'Lab' activity. User (student) may select among a total of 11 different 'Lab' activities from the menu-like buttons at the bottom of the html page. User instructions appear as a pop-up window, on the click of 'instructions' link.

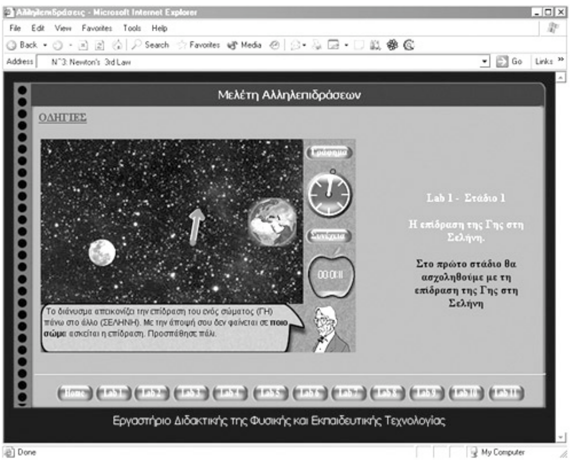


Figure 1. Main screen of the application.

A typical 'Lab' stage is shown in Fig.2. The stage is divided into 3 parts; the main part is devoted to the visual representation of the interaction addressed in the 'Lab' activity. The right-most part is a tool-box, and the bottom part is the 'experts comment' on student's actions. A photo-realistic representation both of the background and of the interacting bodies is adopted, to help the user (student) to get a clear view of the problem presented. In figure 2, the case of 'earth' and 'moon' is presented, while background is set to represent the 'universe'. User is asked to pick and place the action that one object (ex. the 'earth') exerts onto the other (the 'moon'). The action exerted, is represented by a vector (arrow). The arrow -force vector- is initially placed at the 'empty space' between the two interacting bodies and the user is prompted to set the vector at the 'proper' place. Student may place the force vector by direct manipulation on the arrow representation (drag and rotate). The angle of rotation is set on the 'Rotation-disk' (abstract representation of a protractor) in the toolbox.

Figure 2. Typical 'Lab' stage : the case of the Earth and the Moon.

Visual representation of the 'Lab' can run into two modes: either in a photo-realistic representation, or as abstract schematic (Fig. 3). The 'schematic' button in the toolbox does toggle between the two modes of representations.

A time indicator located within a schema of an apple-like outline displays the time elapsed since the start of 'Lab'. It serves as a visual indicator for the student to monitor the time required to makes his/her choice and place the arrow-vector. Then, student should press the 'check' button to get a comment on his/her choice. The 'expert' at the bottom part of the screen, changes faces as a visual indication to his satisfaction on student's try out, and gives a prompt on what student should take into account to get a better result. The apple-like outline is gradually filled up on incorrect answers.

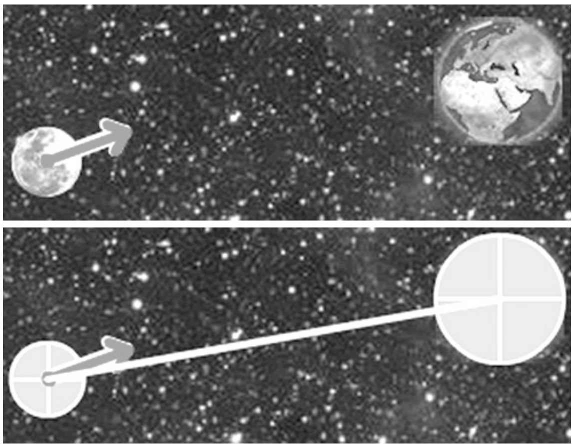


Figure 3. Photo-realistic and schematic mode of representation

2.1. Interactive dialogs

One of the most important parts of this software application is the feature of the pictorial expert that can serve as a virtual "teacher". On one hand this feature is used to supply the student with the initial (kickoff) instructions regarding the task at hand and what must be done. For example:

"In this Lab we shall study the action that the Earth exerts onto the Moon. You should place the action (vector) of the Earth on the correct spot."

On the other hand every time the program goes through a check on student's answer (by a click on the "check" button) the system feedback appears in the "expert respond" area. The responds are not just a simple indication of error but aim to help the user to understand the problem and, at the same time, to prompt for the right direction of thinking. For example in the case that the student has placed the tip of the arrow-vector on the surface of the correct body (i.e. moon), the 'expert' will respond by:

Or, in case that the student has placed the vector in the correct spot but pointing to the wrong direction/angle, the "expert's respond" would be:

"The vector depicts the action of the one body (Earth) on the other (Moon). You have placed the tip of the vector on the surface of the Moon. Remember that the vector is applied on the centre of mass to the body that acts upon. Try again."

"The vector depicts the action of the one body (Earth) on the other (Moon). You have placed the vector's point of application on the centre of the moon. Remember that force is a vector, and direction is one important element to a vector. Try again"

2.2. Program feedback and checks

Several cases of possible student's answers in placing the arrow-vector are examined. Cases setup a dataset in the form of a look-up table, based on known students' alternative conceptions on vector representations, force as a vector, and on interactions on the 3rd Law of Newton [4,5,7,8]. The program runs the checks starting with the vector's base (point of application). The several cases examined are outlined in Fig. 4:

In reference to fig. 4, the following cases are examined:

I. The force-vector is applied on neither of the bodies but on the 'empty space'
II. The force-vector is applied on neither of the bodies but is much closer to one, the wrong one.

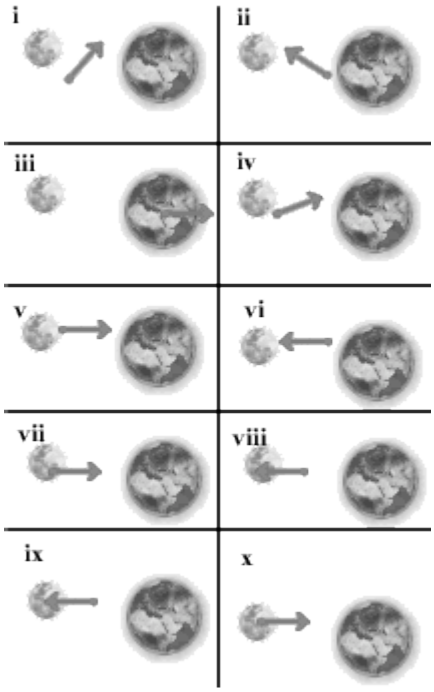


Figure 4. Check on different cases representing the action of one body (Earth) onto the other (Moon)

III. The force-vector is applied on the wrong body.
IV. The force-vector is placed close to the correct body.
V. The base (point of application) of the force-vector is placed on the surface of the correct body.

VI. The tip of the force-vector is placed on the surface of the correct body.
VII. The base of the force-vector is placed somewhere on the correct body but not on the center of mass.
VIII. The tip of the force-vector is placed somewhere on the correct body.
IX. The tip of the force-vector is placed on the center of mass.
X. The base of the force-vector is placed on the center of mass, and this case the direction of the force-vector is examined.

3. Description of the Lab activities

Each 'Lab' activity is divided into four sessions, as outlined bellow. Each session follows the previous one, upon successful completion. The first two sessions, deal with the problem of <u>*one*</u> body acting onto the other, while the last two sessions deal with the bodies interacting. The essence of "interaction" in the sense of a mutual relationship and a mutual action between two bodies is introduced, after students have thoroughly examined the concept of 'action'. In more detail,

i) On the first session (Fig.5a) the student is asked to place the <u>*action*</u> of the one body (right) to the other (left). Much emphasis is given on the student's understanding on the representation of the action as <u>*force*</u>, and the vector characteristics of force.
ii) Second session (Fig.5b) is similar to the first one. The term of <u>*reaction*</u> is introduced, as the action on the other body exerted onto the first. Again, the main focus is on the student's understanding on the characteristics of force as a vector. Students are asked to deal with a similar problem (as in the 1st session) and this similarity is believed to help them set the basis for the understanding the mutual relationship between <u>*action*</u> and <u>*reaction*</u>.

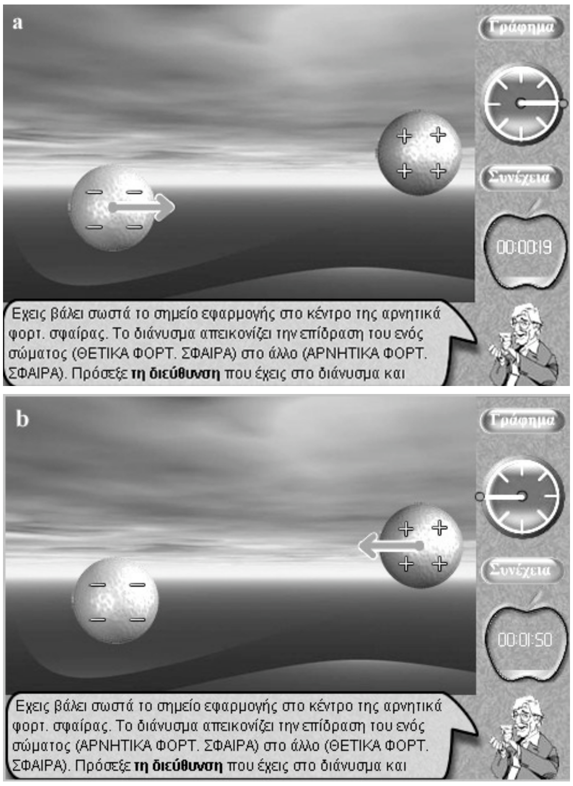
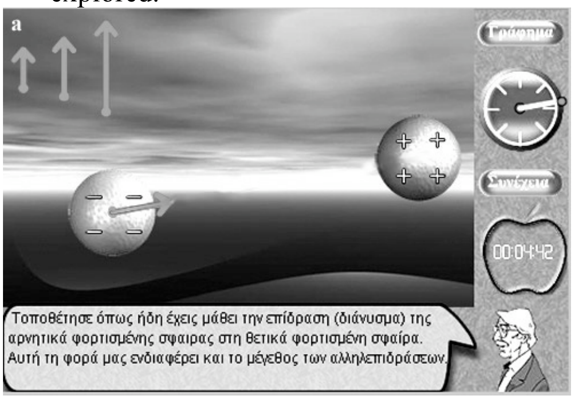


Figure 5. Action and Reaction in the case of two charged bodies: student tryouts to place the *action* (a) and the *reaction* (b).

iii) Third session (fig. 6a) explores the concept of "mutual relationship". The session summarizes the activities of the previous two sessions into a unified set. The student is asked to place both forces on the two interacting bodies. The concept of *"equal in magnitude but opposite in direction"* is explored.



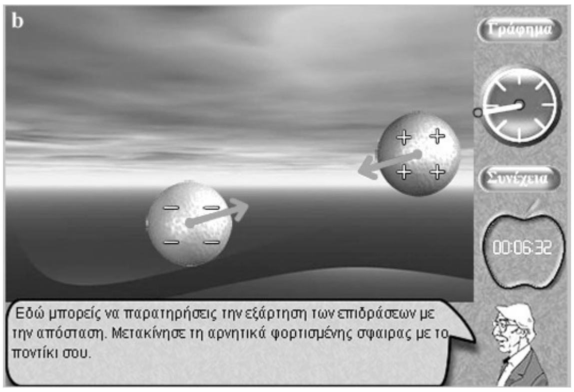


Figure 6: Action and reaction as mutual interaction. (a) Student is asked to place the reaction on second body and (b) to move one of the bodies and observe the mutual change in action-reaction vectors.

iv) The concept of mutuality is further explored in the final (4th) session. The session is an interactive simulation (fig. 6b), where the two bodies are shown interacting, and the force-vectors appear on each of the bodies. The students are asked to drag one of the interacting bodies all over the screen and observe the two force-arrows, changing in magnitude simultaneously and always pointing one against the other (opposite directions).

3.1. Lab activities in different fields

This application consists of 11 'Lab' activities grouped into two general categories of objects' interactions: gravitational and electro-static. The general structure of each 'Lab' is the same with the one we described above. The choice of these two general categories and of the specific labs was based on the step-by-step progress of the examples from the more familiar to the more complicated. The aim is for the user to be able, after the competition of the series, to appreciate the generalization of Newton's third law. The cases examined are based on students known learning difficulties, where students tend to explain the interaction between two bodies by adopting a 'dominance principle'; i.e. the greater mass the body has, the greater the force it may exert[4,5,9-11]. The 11 'Lab' activities are listed bellow:

1. Gravitational interaction between two celestial bodies: the case of Earth and Moon
2. Gravitational interaction between an object of everyday use (ex. apple) and the Earth. Both are considered as free in the space
3. Gravitational interaction between two objects of everyday use, as two free objects in the space
4. Gravitational interaction between two objects of everyday use when they are close to the surface of the earth
5. Gravitational interaction between two objects of everyday use, when they are inside a room
6. Electrostatic interaction between two metallic spheres that have the same positive charge but different size
7. Electrostatic interaction between two metallic spheres that have the same negative charge but different size
8. Electrostatic interaction between two metallic spheres of the same size and opposite charge of equal value
9. Electrostatic interaction between two metallic spheres of the same size and opposite charge of unequal value
10. Electrostatic interaction between two metallic spheres of different size and opposite charge of equal value
11. Electrostatic interaction between two metallic spheres of different size and opposite charge of unequal value

4. Activity Logging

Newton-3 application is capable of activity logging. Activity logging takes place when application runs in a client-server mode. Activity logging is a text file, comma delimited, so it can be easily processed and analyzed. An extract of a typical Activity logging file is presented in fig. 7. Figure 7 shows the activities of a student in the case of two spheres interacting electro statically (Lab 8). The student is prompted to place the vector indicating the *action* of one sphere onto the other (Serion_1 in Lab8). Student's recorded actions are indicative to his/her conceptions and could elucidate his/her pattern-of-thinking. The first steps in the Fig.7 could show a 'give force' thinking model, rather than 'exert force'; the student tries to place the vector (action) on -or around- the body which, as quoted in the text, is the acting body. Next steps elucidate the student's conceptions on force as a vector representation; the student, in his/her successive trials, places the arrow-vector pointing to the center of mass, or to the surface, sets the vector inside the body but not on center on mass, etc.

```
Lab_8,  Session_1,  00:00:22,  Action:  The
vector is on the free space.

Lab_8,  Session_1,  00:00:26,  Action:  The
vector is set on wrong body.

Lab_8,  Session_1,  00:00:33,  Action:  The
vector is set on wrong body.

Lab_8,  Session_1,  00:00:38,  Action:  The
vector is set close to the wrong body.
. . . .
Lab_8, Session_1, 00:01:46, Action: Correct
body, arrow points to CM

Lab_8, Session_1, 00:01:49, Action: Correct
body, arrow points to surface

Lab_8, Session_1, 00:02:09, Action: Correct
body, arrow is inside the body
 . . . .
```

Figure 7. Extract of Activity log file

Thus, using *Activity Logging* one may educe valuable conclusions regarding the original students' views on interactions, how views may develop as the student advances from Lab activity to another, whether student might develop a strategy from one activity to another, etc.

5. Concluding remarks

The *Newton-3* application is a Web based application, accessible through any typical browser with the Macromedia Flash plug-in. The applications sets a series of 11 'Lab' activities, based on students' conceptions on the 3rd Law of Newton. User-friendly principles taken into account [12], easy of use and sound pedagogy make it a useful tool for the introduction of the concepts of "mutuality" and the essence of "interaction".

The application design is fully modular, adaptable and expandable (fig. 8). Comments and 'expert' prompts are not hard coded in the program but they are found in a single external text file, which acts as a source. This way, even an individual instructor can adapt and also translate *Newton-3* without any programming knowledge. The application is easily expandable to other types of interactions (eg. magnetic interactions), since pictures are also external graphic objects assigned to program internal variables. Program functionality, feel-and-look and even the activity logging option and data formatting are also defined in external text-files.

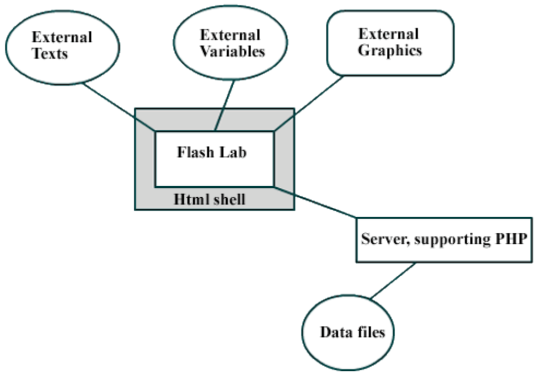


Figure 8. The structure diagram of the application.

Though *Newton-3* can run as a stand-alone web application in a typical PC, a client-server scheme is required for *Activity Logging*. Modern USB and mini-server technology can make *Newton-3* run at full activity logging functionality, in a typical school computer-lab, through a low cost USB-stick, on which a php-supported http minimal-server set running. These capabilities open new dimensions in the evaluation of students' responses to the 'Lab' activities. It would be quite interesting to investigate the development of patterns-of-thinking on individual user-student basis. This work is currently in progress.

6. Acknowledgments

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Techno-Sciences and Mathematics: Vehicles for a Sustainable Future and Global Understanding

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Abstract. *Although, we do and teach sciences and mathematics, we seldom "look behind and beyond the class". Techno-sciences and mathematics can, and should, serve as vehicles for a sustainable future and global understanding. It has been found that the potential of using mathematics and science as languages that can convey meaning and evoke emotions which could raise learners' social consciousness and social responsibility is ignored. This paper discusses this finding and provides cross-curriculum teaching examples of restoring this neglected social aspect.*

Key words: global understanding, mathematics, social meaning, sustainable development, teaching methodology, Techno-sciences.

1. The problem

Today the development of social responsibility for sustainable development and global understanding has gained a renewed concern among educators. It is often debated that techno-science (technology and science) and mathematics, although they have generated enormous positive developments across all societal spheres, they have also brought world-wide problems, some of which are irreversible. This is largely due to the positivistic ideology that over the last three centuries has objectified and reified both people and the natural world, seeing them as separate and inanimate, rather than affectively interconnected. School curricula and teaching methodology are mainly used in the context of instrumental rationality and technical interest in knowledge, which does little to develop human self-realization and critical discourse [1, 2]. Indeed, educators are finding themselves increasingly dissatisfied with the distance between school curriculum and life outside the school as skills learned in school are rarely applicable to problems in the real world [3, 4]. Instruction that is confined to a limited range of contexts leads to inert knowledge in which facts and procedures remain isolated and are not activated in different problem-solving situations [5]. In the International Conference on Education, organized by the International Bureau of Education in Geneva, 1994, 102 ministers of education noted the urgent need to include global/international understanding in school curricula and in teacher-training courses [6]. Global understanding has been also connected with the quest for an education that is geared towards a sustainable future and social responsibility [7]. It is no longer considered enough merely to transfer knowledge to "empty vessels". A new philosophy of education is thus needed, which should aim at developing self-determination, judgment, solidarity, desire to action, and critical thinking. When pupils learn to make judgments and decisions, it seems likely that this process will have application outside of school and later in their lives. Science and especially mathematics curricula seem to be treated from a decontextualized perspective without social meaning [3]. If this happens, then science and mathematics are disassociated from social reality and do not serve as vehicles for better global understanding and sustainable development. The approach that has been adopted in this paper emphasizes the importance of anchoring or situating knowledge and practices in science, mathematics and technology in meaningful, real-world, problem-solving contexts. Our thesis is that knowledge is useful and meaningful to the extent it emancipates human minds, and not just satisfying material needs and wants. We should provide youth and future citizens with the capacity to re-establish the unity between people and nature as well as knowledge and praxis. We should also provide to future generations the right of choice to develop their understanding and capacity to tackle many of the problems they inherit from previous generations. In this context, educators and researchers should raise questions such as:

- What aspects of ourselves can we see through techno-sciences and mathematics?
- How can we look into the future through techno-sciences and mathematics?
- Do sciences and mathematics have social meaning and constitute a critical factor for social change?
- How can, for example, new technology helps: to integrate science and mathematics with other subjects; to promote more cooperative learning, to encourage the transfer of science and mathematics process skills to everyday life, and to improve student attitudes towards science and mathematics?
- How do science and math teachers help the kids make meaningful social meaning out of science and math problems?

Educating young learners for the development of social consciousness and responsibility towards sustainable living means also posing a set of self-reflective questions such as:

- What is my vision of what I would like our world to be?
- Are my actions consistent with the way I would like the world to be?
- What does the way I lead my life mean for the lives of others?
- How can I contribute in creating a more just, peaceful, and ecologically sound world?
- What can we do together as a local community, as a country and as a global community to promote sustainable development and global/international understanding?

2. Research framework

Based on the previous assumptions and positions, we set the following three research questions:

1. To what extent the Greek primary school curriculum in mathematics and sciences enables teachers to reconstruct their visions and practices of teaching in more emancipatory ways?
2. Are there any differences between young learners' interests in tackling issues of social concern and the contextualization of school knowledge in sciences and mathematics with issues of global concern?
3. How could sciences, mathematics and technology serve as vehicles for developing a sustainable future and increase global understanding?

To study these questions we were based on the following taxonomy of 10 global issues related to sustainable development used in a previous study of ours [8].

1. Population (population growth, overpopulation, infertility, population management and control).
2. Poverty and economic progress (the gap between North and South, East and West, aid, debt).
3. Environment (pollution, ozone depletion, acid rain, green-house effect, global warming, deforestation).
4. Human rights (social justice, self-determination, gender equality, language rights, the right to freedom, health and education, equality).
5. Peace (armament, disarmament, international conflict management, conflict resolution, peacemaking-peacekeeping).
6. Food and hunger (malnutrition, food as a basic human need and right, world hunger, consumerism).
7. Resources (use of natural resources, waste of resources, renewable resources, recycling).
8. Biodiversity (protection of nature and wildlife, endangered species, animal rights).
9. Cultural diversity (multiculturalism, racism, xenophobia, minorities).
10. Science and technology (biotechnology, bioethics, positive and negative aspects of science and technology).

We carried out a content analysis of all mathematics textbooks of the six primary school grades and the two science textbooks of the 5th and 6th grades entitled "Research and Discover". The number of mathematics textbooks amounted to 12: two volumes in each grade, with a total of 1650 pages. The two science textbooks entitled amounted to 623 pages. We also elicited primary school pupils' visions of what they would like their world to be. This question was addressed to 164 primary school pupils in one school in the city of Rethymnon, Crete and 137 primary school pupils in selected classes of six schools in the metropolitan area of Athens. Schools' selection was based on convenience and not random sampling.

3. Research results

Tables 2 and 3 indicate that although primary school pupils have informal knowledge related to issues of sustainability, the knowledge mathematics and science school textbooks transfer to them does not reflect the curriculum results presented in Table 1. As found in other works referring to the United Kingdom "the instruction learners receive in a decontextualized manner does little to guide them in relating their prior knowledge to formal knowledge in a meaningful web of information" [9].

Table 1. Integration issues of global sustainable concern to mathematics and science curricula.

Global Issues	Mathematics				Sciences	
	Grades				Grades	
	1-3	4	5	6	5	6
Population	-	-	-	-	-	-
Poverty	-	-	-	-	-	-
Environment	-	1		1	2	2
Human rights	-	-	1	-	1	-
Peace	-	-	-	-	-	-
Food/Hunger	-	-	-	-	-	-
Resources	-	-	2	2	1	2
Biodiversity	-	-	-	-	-	1
Cultural diversity	-	-	-	1	-	1
Science & Tech	-	-	-	-	-	-

Table 2. Pupils' visions of what they would like their world to be (Rethymnon).

Global Issues	Grades						
	1	2	3	4	5	6	T
Population	-	-	-	1	-	-	1
Poverty	-	-	3	9	2	-	14
Environment	1	3	20	-	9	7	40
Human rights	-	-	-	3	2	-	5
Peace	-	3	3	14	3	14	37
Food/Hunger	-	-	-	2	-	1	3
Resources	-	-	-	1	4	1	6
Biodiversity	-	-	4	9	4	1	18
Cultural diversity	-	-	1	6	-	3	10
Science & Tech	-	-	-	-	-	-	-

Table 3. Pupils' visions of what they would like their world to be (Athens).

Global Issues	Grades				
	2	4	5	6	Total
Population	-	-	-	-	-
Poverty	2	-	18	10	30
Environment	8	20	32	30	110
Human rights	-	-	46	40	86
Peace	-	25	50	30	105
Food/Hunger	-	-	10	7	27
Resources	8	30	5	5	48
Biodiversity	1	4	10	-	15
Culturaldiversity	-	9	10	10	20
Science & Tech	-	-	5	4	9

More specifically, the results summarized in Table 1 show that the primary school curriculum in science and mathematics is decontextualized and lacks a connection to the issues that society is confronted. In mathematics curriculum the very limited global issues found concern those of forestation (twice), recycling (twice), water saving (twice), the right of land to non-land owners and a statement about the numeric systems developed by Arabs, Greeks and Romans. All the issues, besides the last one were integrated in arithmetic problems.

In the science textbooks "Research and Discover", the global sustainability concepts found refer to a simple statement that certain animals are related to the ancient Egyptian and current Indian cultures. There is also a statement that many animals are in danger in Greece and that human beings are the main cause of their possible extinction. Air pollution is introduced along with a reference to the concept of Ozone, both with very simplistic approaches. In the Unit dealing with Water, there is a statement about water pollution and the problem of water scarcity. Waste is also mentioned in the Unit dealing with Environment Protection with particular reference to recycling. The picture does not change in the corresponding 6th Grade science textbook. The sustainability global issues found concern the concept of blood donor in the Unit dealing with the Respiration System, the concept of Acid Rain in the Unit about

Mixtures and the concept of recycling again in the Unit dealing with Energy.

It is also surprising that not any kind of technology (e.g. multimedia, Internet, spreadsheets and audio-visual means) has been integrated in mathematics curriculum and in the two science textbooks examined. It is a contradiction that science textbooks entitled “Research and Discover” do not integrate practices that learners can use tools of data manipulation, analysis, and presentation as well as resources and realistic episodes that could engage primary school learners in discovery and problem solving learning. One could expect from such textbooks to integrate new information and communication technology, giving the potential to young “explorers” get involved in investigative activities, raise questions, collect primary and secondary data, interact with peers and experts, take virtual field trips, visit museum virtually and so forth.

The results of this study show that beyond science and mathematical literacy, unfortunately, almost all mathematics and science lessons consist of content that is divorced from any significant understanding of social processes and realities. Accordingly, school does not engage learners in experiences that are relevant to life and their development as socially responsible and critically thinking citizens. Besides a mere statement about different number systems, mathematics is used from an ethnocentric perspective, totally associated with the Western culture. There is no material in school mathematical and science texts relating to the mathematical and scientific achievements of the “Others”, such as Arabs, Indians and Chinese. Added to that, content and practice are fact-oriented without any notion of critical constructivism espoused by critical social theory and pedagogy. It is thus assumed that the potential of using mathematics and science as languages that can convey meaning and evoke emotions which could raise learners’ social consciousness and social responsibility is ignored.

4. Cross-curriculum didactic implications

In light of the above findings, teaching global sustainable issues requires teachers to be creative, critical, resourceful and informed on these issues. Science and mathematics textbooks tend to be limited in their coverage of these issues and, even the ones integrated are tackled on the surface both in terms of breath and teaching method. Therefore, teachers must turn to more recent sources of information for designing lessons and for engaging learners in this process. There is a need to teach young learners to become responsible and participating members of their communities and develop their social consciousness and critical thinking through reflection, cooperation and inquiry. The contextualization of science and mathematics towards an education for a sustainable future and social responsibility implies that teaching integrates a reflective learning approach that engages learners in a continuous discourse and action. Critical discourse that leads to action, which in turn leads to discourse and so on, is firmly connected to political literacy. This is also related to cross-curriculum and inter-disciplinary approaches to teaching and learning. In this context, what would be same examples which show how to merge technology, science and mathematics with sustainable development and global understanding?

For example, the concept of air pollution could be introduced in connection to the concepts of global warming and greenhouse effect. There could be a scenario in which learners are asked to consider what may happen in the future if certain current trends continue. Cause and effect sentences contextualized with issues of global concern can be introduced in writing along with reading and speaking as well as in combination with other subjects. In the subject of language, the cause and effect relationship is both a way of thinking and an approach to teaching writing skills. Either through brainstorming and/or certain information elicited from various sources about global warming and the greenhouse effect, pupils could be asked, first, to think of all the causes of global warming, and then think of the effects. When, for example, a pupil makes a statement such as: “if global temperatures rise, the level of the sea will rise and this will cause disaster”, the teacher should encourage discussion through search for evidence. Discussion could be based on the following questions: What will happen to the polar ice caps? What will happen to the world climate? Will that influence food production? Will the population migrate to avoid problems of food, famine and temperature? Where will they go? What will happen to the species? What could be some positive strategies for dealing with the problem? Assisting learners in searching the Internet can lead them to find various sources, facts, and tools dealing with global warming. For example, by visiting the address http://www.ncdc.noaa.gov/ there is the world's largest active archive of weather data. Also at http://www.ncdc.noaa.gov/ol/climate/stationlocator.htm one can find weather data from specific locations.At http://www.epa.gov/globalwarming/ there is information about the greenhouse effect and what can be done to cope with this problem. If there is interest to connect this issue with the issue of animal endangerment, then at http://www.worldbook.com/fun/wbla/earth/html/earth.htm one can have in-depth look at global changes brought about by humans and examine the growing problem of species extinction. There is also an interview with one of the world's leading biologists on the importance of preserving Earth's species and a multimedia presentation on the problem of global warming. A useful guide and various resources for teachers and learners on global warming can be found at http://www.pbs.org/wgbh/nova/warnings/ Using technology learners can thus research real-time and historic temperature data locally/nationally and/or world-wide, analyze the data using mean, median, and mode averages, graph the data and draw conclusions. Learners can use a calculator or electronic spreadsheet such as Excel to compile their statistics and then represent the results graphically. The graphic representations provide good resources for summarization, interpretation and discussion as well as a means for communicating information.

Another example which shows that technology provides a powerful tool within the classroom both as an information resource and a means of communication is the Web-based project entitled "Passport to Knowledge" http://quest.arc.nasa.gov/livefrom/passport.html. This project concerns an ongoing series of "electronic field trips" via interactive television and the Internet. Scientists are available to provide help and guidance to young learners as they collaborate to do real world science research in real time. In that sense, learners become co-investigators with field researchers and experts, as they engage in problem solving which has direct application to real life. GLOBE accessible at http://globe.gov/fsl/html is another worldwide project dealing with hands-on cooperative learning concerning environmental issues. Activities involve learners in taking measurements, analyzing data, creating maps and graphs and reporting their data through the Internet.

It is generally assumed that one of the critical aspects of education for a sustainable future is the integration of culture, environment and peace. In bringing this integration, there is a need for developing a better understanding and interaction among cultures, especially by encouraging respect for and acceptance of cultural diversity [10, 11]. An example for the connection of mathematics with culture can be appreciated in the consideration of foreign artifacts with geometric design. Textile patterns and configurations in folk art reveal cross-cultural connections for geometric design and the principles of geometric symmetry. If for example learners explore the African, Indian or Islamic decorative art, they can find a lot about mathematical theorems [12]. Folk art design may thus serve as an attracting starting point in the mathematics classroom. In terms of teaching methodology, the use of traditional cultural design in the mathematics classroom provides alternative approaches to teaching, while at the same time promotes global understanding. Such considerations do not only relate to mathematics and global understanding, but also foster an integral approach to learning by incorporating a knowledge of history, geography and social-anthropology as well as developing a cultural and aesthetic literacy.

5. Concluding remarks

Greek primary school curriculum in mathematics and sciences does not enable teachers to reconstruct their visions and practices of teaching in more emancipatory ways. There are also considerable differences between young learners' interests in tackling issues of social concern and the contextualization of school knowledge in sciences and mathematics with issues of global concern. Accordingly, science, mathematics and technology as they have been introduced and practiced in primary school cannot serve as vehicles for developing a sustainable future and global understanding.

This study and the teaching examples provided indicate that if technology, sciences and mathematics are contextualized with issues of sustainable concern and global understanding, learners should take an active role in the learning process. This means giving the learners the right to take a share in the responsibility of acquiring skills, knowledge and personal meaning. Active participation requires the teacher and learner to be involved in negotiation, discussion, decision-making, teamwork and other skills that are valued by society and in the world of work. It is a move away from the teaching model in which the learner is viewed as an object who passively receives knowledge that is solely externally instilled. The notion that people and young learners can do very little to change the way the world is today has been generated by an educational philosophy which separates education from political literacy and action. There is, thus, a need to restore the link between the school and society and contextualize science and mathematics with real life problems, supported by new information and communication technologies. The school can no longer be regarded as a sanctuary where students are protected from the social ills of the larger society [13]. It seems that when we suspend our preconceptions of what young people should know and how they should demonstrate this knowledge, we find that children can deal with complex issues in surprisingly sophisticated ways [14]. Exploring issues of global concern within the classroom and especially through sciences, mathematics and technology is a means of recognizing and validating the social, cultural, and political experiences learners bring with them to school. The early school years constitute an important time to lay the foundation for the development of an education geared for a sustainable future and global understanding.

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Optics and Pool: Play the Game

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Abstract. *The objective of this work is, with the use of a pool table, to apply and demonstrate the laws of reflection to students of the early ranks of basic school.*

The idea of associating the use of a pool table to the teaching of geometric optics is based on the need to make the teaching process more appealing on behalf of the students; being pool a popular and appealing game, it would be possible to teach physics concepts in an apparently informal context. This assembly is also simplified due to the fact that only day-to-day materials are used, reducing it's final cost (for that effect we only need to perform a few reversible changes to the pool table).

Associated to the poll table (in an early stage) is a flat mirror system, that is placed along the table borders, and laser markers which allow us to visualize the incisive and reflected beams' path, making possible the prediction of the ball's path by applying the laws of reflection.

In a subsequent stage, the used mirrors will be spherical concave and convex, associated to it's equivalent and adapted pool table, being the calculations preformed similar to those of preformed with the flat mirror system.

With the implementation of this system, it is meant for students to take conclusions about the laws of reflection by comparison to the ball and luminous beam paths.

Keywords. Non-formal learning, Science Education, School, Hands-on experiments, Optics, Mechanics.

1. Introduction

In this communication we will present an experimental work to be carried out by students, from even the early ages of basic school, in a non-formal environment. Using a pool table (a game well know to many students) students will perform a series of experiments learning and demonstrating the laws of light reflection.

The idea of associating the use of a pool table to the teaching of geometric optics is based on the need to make the teaching process more appealing on behalf of the students. Being pool a popular and appealing game it would be possible to teach physics concepts in an apparently informal or non-formal context. This assembly is also simplified due to the fact that only day-to-day materials are used, reducing it's final cost as we only need to perform a few reversible changes to a pool table.

2. How to bring together pool and optics

To a regular (or especially designed) poll table is attached a flat mirror system, that is placed along the table borders. Laser pointers aligned over the table will allow us to visualize the incidence and reflected beams' path, as it is shown in figures 1 and 2.

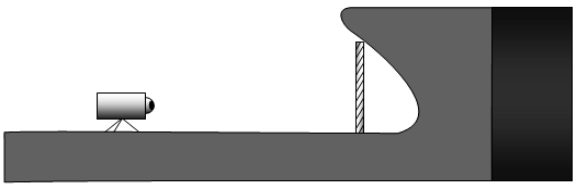
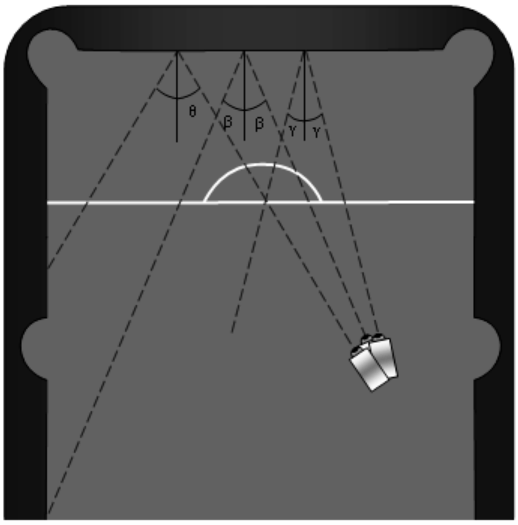


Figure 1: Adaptation of a mirror to the pool table walls

This way, it is possible to predict the ball's path by applying the laws of reflection, as it is shown in figure 3.

In a subsequent stage, the used mirrors will be made spherical concave and convex, and adapted to the pool table, being the experiments and calculations preformed in a similar to those preformed with the flat mirror system, as shown in figure 2.



Figures 2: Scheme of the application

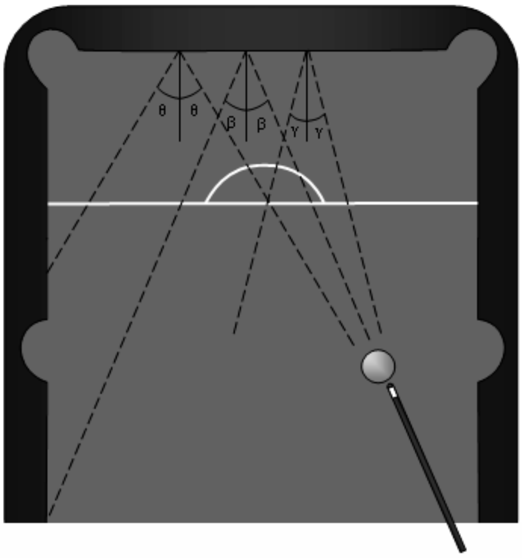


Figure 3: Prediction of the ball's path

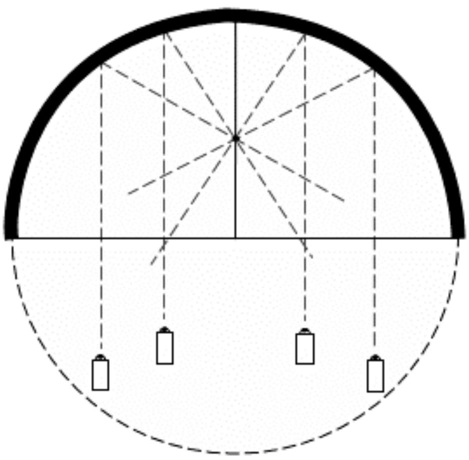


Figure 4: Adaptation of spherical concave mirror to the pool table

As it is possible to see, in a pool table with this shape, all the balls moving through a trajectory parallel to the straight sides of the pool will always enter the hole made on the table, if it is positioned in the focus of the analogue mirror (figure 5.).

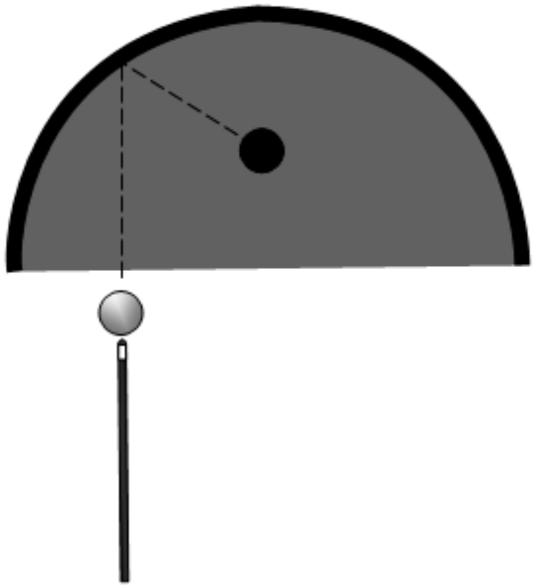


Figure 5: Prediction of the ball's path in a spherical concave table border

At the time of the curve mirror experimentation we can also explore geometry related concepts like, for instance, the determination of focal lengths.

3. How to achieve the activity' objectives

With the implementation of this system it is meant for students to take conclusions about the laws of reflection by comparing the ball and luminous beam paths.

Other of our goals is to raise the interest of the students to a subject like optics, using a well know and always fashionable game, played from youngsters to older people, in every contexts of the society.

Using this popular game, with the proper adaptations, it is also possible to use this equipment in the study of many other concepts, like:

- the reflection laws (as it was shown above);
- the optical fibers – as it happens in the optical fibre, the ball will move in the pool table, bouncing along the borders, as the light beam reflect along the fibre.

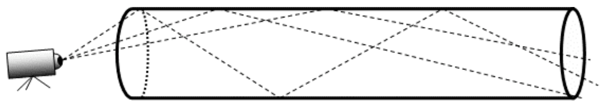


Figure 6: Scheme of light propagation in a optic fiber.

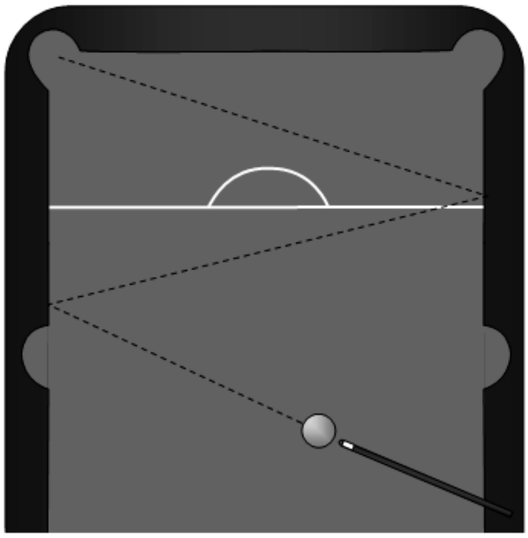


Figure 7: Adaptation of the pool table to optical fibres study

- mechanical energy conservation -using a spring to push the ball it is possible to relate the ball velocity with the force applied to the spring resulting in different total trajectories of the ball (number or re-bounces that will be intuitively related to the energy lost during the bouncing and re-bouncing process).

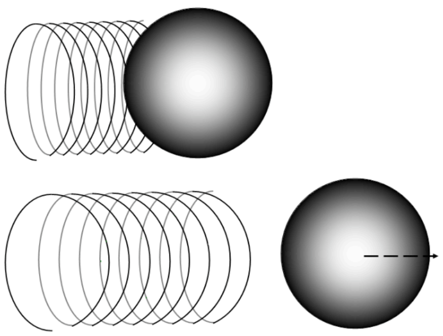


Figure 8: The use of springs allows the adaptation of the pool table to the study of energy conservation

- linear momentum conservation. This is surely one of the first ideas we may have when thinking about a pool table. However the previous observation of the light reflection process will help the full understand of this process - using several ball's students will study and understand linear momentum conservation in collisions.

One of the advantages of this equipment is that it is possible, with small adjustments and a bit of imagination, to create new combinations that may allow the exploration and study of many different concepts.

In a more developed stage of the experimentation of this system we can create more challenges such as making the pool ball reach a certain position, after a given number of hits (an equivalent to the same number of light reflections).

The objective can be the conception, by the students, of systems (including adaptations of the pool table) or procedures to study some defined phenomena with the establishment of the correct strategy: the elaboration of the strategy for the study of a subject implicates a good knowledge of it.

7. Conclusion

Learning in a non-formal or informal context often is easier and more effective, specially if the activities involved relates to former knowledge or experience from the students. Furthermore it is essential that the fun side of it is complemented by serious analysis that should always lead to the establishment of clear conclusions.

8. Acknowledgement

This work enrolls in the frame of activities of the Hands-on Science network.

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Robots at School. The Eurobotice project

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Abstract. *The pedagogical usefulness of robotics in Science and Technology education is being proved in different contexts and approaches.*

In this communication we will present a Comenius 1 school education project named Eurobotice where it is intended to combine the study of the basics of robotics and of its applications with space science and space exploration.

The Eurobotice project involves around 300 students, ages 12 to 14 on average, from 10 schools of eight EU' countries.

Teams of school students are established and work cooperatively in order to solve a number of challenges under the theme of space exploration. The space topic will be researched discussed and explored and several robots or robotic' artefacts are build and programmed in other to fulfil a number of task in a final robotic competition at the facilities of the European Space Agency in Holland.

Keywords. Robotics, Science Education, School, Hands-on experiments, Comenius 1 projects.

1. Introduction

Hands-on experimental activities have long time proved to be one of the most effective ways to drive the students to a successful learning of science and technology [1,2].

Robotics is a topic rather challenging and appealing to our young students.

On the other hand robotics and automation is also very and ever increasingly important in science and technology, in a vast number of industries and even in our every day life. Robotics will certainly have a major role in the current and future development of our economies and society.

2. Eurobotice - *Mission Mars*

At the 1st International Conference on "Hands on Science, Teaching and Learning Science in the XXI Century" we introduced the topic of the learning and use of robotics in school education [3]. This time we are going to report on a European cooperation project centred in this in-school' robotics topic.

The Eurobotice project is Socrates/Comenius School project involving 10 schools from 8 European countries (France, Portugal, Austria, Belgium, Denmark, Norway, Sweden and UK) and promoted within the frames of the Hands-on Science European network.

The main objective of the project is to promote the learning and the dissemination of new technologies, with special focus in robotics, motivating and involving all the school members, as well as the whole community they are inserted in. In particular Eurobotice aims to improve the teaching of science and technology through the use of robotics and space research dealing with both subjects in an integrated and interdisciplinary way. Students from all countries find the challenges of space exploration stimulating. The project wishes also to encourage an exchange of ideas between members of the European Union and to promote the study of science, engineering and technology.

The activities of students teachers and schools will be driven towards the preparation of a final major activity. It is a robotics competition or festival on the theme of Robotics and the European Space Exploration research. In particular the main topic will be the exploration of Mars, a topic of great actuality. Students will design build and program a robot or a set of robots built to perform a series of different but interrelated tasks. The robot teams will than, at the festival, be exhibited and run against other robot' team from other schools and countries.

For this competition there are two main preparatory activities that will take almost a full school year: the Robot Game and the Research Assignment.

Figure 1. The students present their work to the other teams the jury and visitors the results of their research work on space exploration.

During the development of their Research Assignment the students will understand more fully the significance to the real work of the scientific and technological research being conducted by scientists around the world in this specific science and technology subject. In the context of Eurobotice the subject is space exploration. In particular the students must to, by them selves, learn more about space, space exploration constraints and missions. They are asked to learn about the industries and research activities in their own country.

Reports shall be produced namely in the form of multimedia presentations and webpages or sites.

After this preparation phase (that in fact takes place throughout the all duration of the project' activities) the students enter the Robot Game phase. Here the students must design develop build and program a robot to solve a series of missions on a playing field. Specific rules are associated with each one of the different tasks presented. The different missions will take place in a specially designed playing field (figure 3.) that intends to simulate a Mars' ground. The eight chosen missions are named: Exit the Tetrahedron base; Launch the sample canister; Clear the solar panel; Connect the 180° and 90° habitation modules; Free the rover; Move ice cores to base; Move boulders into the launch circle; All terrain vehicle test.

The ensemble of missions intends to reproduce actual activities that need to be fulfilled in a space exploration program. Furthermore each activity focus on tackling the learning of a specific competency (programming, building,…) or knowledge (kinematics and dynamics, friction, mass and volume, resolution and accuracy,…).

Figure 2. The winning robot?... result of several months of intense highly motivated work.

The project was integrated into the normal curricular activities of different and diverse disciplines: foreign languages – used to assist in the exchange of information between participating European countries- namely english and french; ICT, of great importance in the processes of learning how to program the robots but also on how to exchange information between the different teams and schools from the different European countries involved, through email and internet; physics, in all that relates to mechanics but also optics and electricity for instance as support to the understanding selection and use of the different robotic sensors; technology – on the construction of the robot's propulsion and manipulation systems; art and design – in what concerns the "look" of the built robots, and to enhance the presentation of the pupils' research reports to an international audience.

During the project students have to locate sources of information, select appropriate materials and organize it in a logical efficient and appealing way.

With these activities we will achieve to develop an awareness of the organisation of Europe's space industry and research, to encourage students to consider a science or technology based career and increase the awareness of the links between theory and practice. The project was also used to facilitate and induce exchanges between students and teachers from diverse

European countries increasing the sense of European citizenship.

Teachers learn how to work with colleges of schools from other European countries sharing experiences and best practices.

Individual schools learn how to benefit from European fellowships by developing links with other European schools and institutions

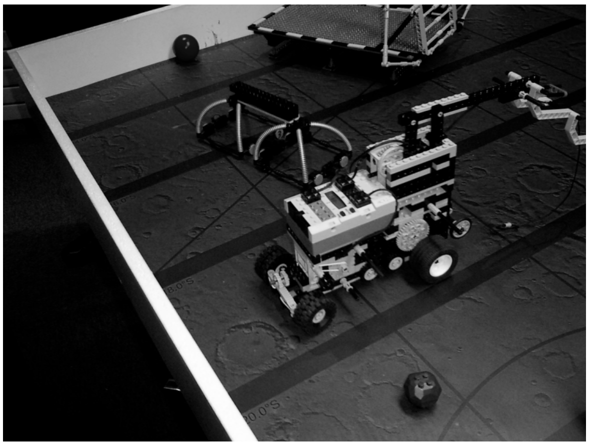

Figure 3. The Mission Mars' playing field.

At the end of the project the students are capable of:

- perform tasks methodically individually and in teams;
- to put in practice their theoretical knowledge concerning the programming of their robots;
- use the theoretical knowledge obtained in the solution of practical problems;
- increase their aptitudes and competencies of use of the technologies of information and Internet, elaboration of critical and logical reasoning, the ability to validate and to use all the obtained information towards a goal.

At the end of the project the students' teams and the schools will produce and exchenage a DVD with the conclusions of their work, their multimedia presentations, films and pictures of the accomplished work and the participation in the competitions. These products will be used in demonstrations to motivate other students to the study of robotics and other areas considered traditionally difficult as physics and mathematics.

More information concerning these projects can be found in the websites created by the project students: http://robos.no.sapo.pt and www.eb23-joaomeira.rcts.pt/indexeurobotice.htm.

3. Conclusion

In-class hands-on experimental activities have a very positive impact in the large majority of the students involved.

Space exploration and robotics are appealing and challenging topics that students from early ages work with in an enthusiastic and committed but very responsible way.

The students, their teachers and schools gain a series of new competencies and knowledge invaluable in their educational development. The most important outcome of this type of projects is the self-confidence and responsibility our students developed and well as an excellent posture towards science and technology.

4. Acknowledgements

The authors and in name of the Hands-on Science network would like to acknowledge the support of all schools members of the Eurobotice project and of all National Socrates Agencies of the countries involved in the project.

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Using Physics to Innovate Practices in Family Type Firms

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Abstract. *One of the major causes that contribute to the increasing withdrawal of students from the education institutions is the lack of application of the studied subjects in the daily routines. There is a great gap between what is described in most of the compendiums and the request of the normal practical and technical works practiced in our society.*

Another frequent complain of our pupils is the fact that teachers always explain the theoretical fundaments, describe the development of motivating projects, but they never apply or concretize anything. This causes, frequently, a complete discredit of the teacher among the students and contributes to the growing abandon of school in order to search technical skills in the work market.

The objective of the project, here in presented, is to create a bond between teachers, students and their family by using hands-on experiments. This was achieved with a triangulation involving the clarification of the most interdisciplinary approach basics of light and optics and electricity focusing on the design and construction of simple technical devices such as a periscope, a solar oven or electric building equipment. These sets of experiences were useful to improve practices which are of common use in the workshops traditionally implemented in this disregard geographical area the school serves. The goal is to apply the in a widest range of traditional jobs creating more efficacy and profits.

Keywords: Electricity, Hands-on experiments, Light, School and Technical careers.

1. Introduction

This communication presents a project that aims to promote the creation of an educational space where the students can have an active role. At the same time, we pretend to improve the technical skills, the apprenticeship of our students and create the supports to employ this knowledge in their future labour. It was also our interest call the family to participate actively, in a way to show the importance of school and all the benefits that this cooperation could bring.

In the area where our school is settled there are great opportunities of employment in sectors relational with plumber, carpentry, electricity and bakery. Once there is a baker' professional course implemented in the school, we decide to turn our attention to other areas more related to our expertise in Physics and Chemistry. Since the beginning we thought that areas like light, optics, electricity and thermodynamics were ideal to our target students, in a way they could practice with the materials readily available in their parent's jobs.

The desire triangulation between teachers, students and parents was obtained. Every part had a desirable common interest. We had the teaching/learning process facilitated; the pupils have direct contact with practice and hands-on experiments, start to do the science on their own and contact with new instruments and science resources; and finally the local family firms obtain directly from their sons the capacity to submit an application of high-tech in their jobs and receive a better prepared and reliable workforce.

2. Student's Social Environment

The basic school of São Torcato is settled near Guimarães and it's inserted in a rural environment in the outskirts of this big industrial and historic town that belongs to the UNESCO's World Heritage Places.

The family aggregates are essentially constituted by small farmers and industrial workers. There is also a great percentage of unemployment and domestics. This fact, strongly affect school's activities and results, because the pupils are generally not or residually motivated for study and even abandon school before the end of the minimum frequency of study defined by law in Portugal, which is high school.

Most of the times, this abandon is a result of major economical needs and aim to help their parents in their familiar small enterprises, normally, directed to service areas. Therefore, in Guimarães surrounding's we have a great amount of factors that contribute to school failure which is aggravated by the parent's disinterest to follow their son's school career.

3. Target Group

The set of experiments and its applications in the daily jobs was planned for pupils with ages between thirteen and sixteen years old that are in the 8th and 9th grade of the basic school. In the overall were involved more than seventy students coordinated by Physics/Chemistry teachers and with the cooperation of teachers from other different such as Mathematics, Informatics and English.

We also try to capture the attention of the whole community to be involved, by promoting a Hands-on-Science fair, included in the Science Week that concludes the study year.

Finally, it's also our intention to give a future seminar on our results to other colleagues, mainly, those related with Physics, Chemistry, Mathematics, Natural Science, Drawing and Informatics.

4. Brief Description of the Experimental method and experiments

In the beginning there were constituted two groups of students, one from the 8th grade that dedicate to build some devices based in optics and light properties and another group constituted by their 9th grade students which worked in electricity and magnetism applications.

In the final, booth's experiences were crossed and their results were shown in the science fair that take place, each year, in June. The purpose of this dynamic workshop is to exhibit the school projects and demonstrate the local society the most important achievements obtained in the educational establishments of the area. About seventy students participated directly in this physics projects but about two thousand were, and still are involved in several activities that were requested because of the student's investigations. All devices that were produced were presented and explained by the students that point out their observations, analyzes, critics, and major obstacles in the processes.

The first stage was the motivation of the 8th grade students because the project implicate, not only work in the classroom but also dedication outside the timetable hours. We don't have a science club, so all the extra-curricular work was made in volunteer spirit and it was necessary to captivate the student's attention to science and technology.

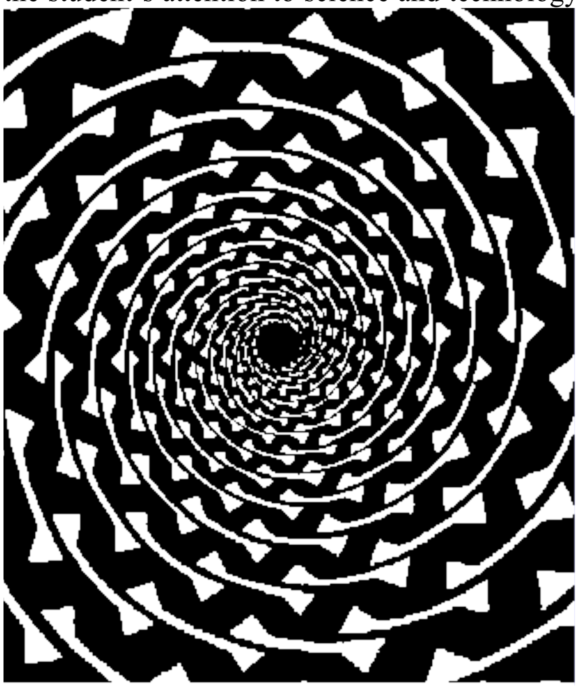

Figure 1 - Optical Illusion (Fraser's Spiral)

This motivation was achieved with a great success, by making an entertaining but educational work about large number of optical illusions (Fig. 1). The students worked in group and their task was to research in the web some light phenomena's and to explain them, in a critical and logical way, with the teacher's assistance. It was clear that our visual perception can deceive us because it's a reconstruction of the reality in our mind. The retina's stimulation suffers from inertia at the beginning and some luminous persistence in the final that can trick our examination (Fig. 2). These facts are crucial to explain the important role played by observation in the scientific process and to the potential of ambiguity of our inspection and the numerous and distinct errors that we are subjected to.

We gather up countless peculiar images that contribute to stimulate and to enthusiasm the pupils and also to explain the errors that we commit when we evaluate the size of circles, the high of squares, length of lines, the end of movements and the sensation of profundity.

Figure 2 - Optical Illusion (The Appearance)

Also to captivate the 9th grade student's attention and interest we help them build two types of electricity generators (Fig.3), one using the magnetic action, a dynamo, (introducing a magnet in movement in the interior of a coil) and the other with a chemical fundament (putting thin plates of zinc and copper in a few lemons).

Figure 3 – Chemical and Magnetic Generator

They were delirious with the facility to put electric charges in movement. An ordinary trick that experienced teachers use to capture the awareness of students is using experiments with an enormous visual outcome, some calculated risk and spectacular effects as possible, so we provoke a short circuit with iron straw at the terminals of a battery.

Another motivation factor is the fact that the most interesting and successful hands-on experiments are described in the school's newspaper with the photograph of the authors.

This favourable climate helped us to lead the students into some more complex tasks. The students were now left with total freedom so they could implement the hands-on experiments that most seduce them and were useful to their future career according to the family business.

The older students built an electric scheme of a house with large sort of components like, disjuncture, fuse, interrupter, lamp, commuter and so on (Fig. 4).

Figure 4 – A phase in the construction of a house's electric circuit

An electromagnet was also manufactured with the objective of being used as an electric derrick and other devices to expose the self-induction. They also, create am electric transformer with the specification needed to charge an old cellular phone.

Our desire was also introduce some high-tech materials that normally lack in the Portuguese school laboratories. So we made an effort and start to teach some basic contents about electronics that usually are never focused because they are at the end of the school physics program.

We use materials completely unknown to our students like diodes, LEDs, termístors, condensers, LDRs or transistors to assemble circuits assure automatic illumination, amplify the sound or constitute alarms that prevent fires or thefts (Fig. 5).

Their pawning was total because the goal of working and the competences acquired are of a vital importance in a wide range of subjects they could apply in the future family job and also they were working with components that they never had access to.

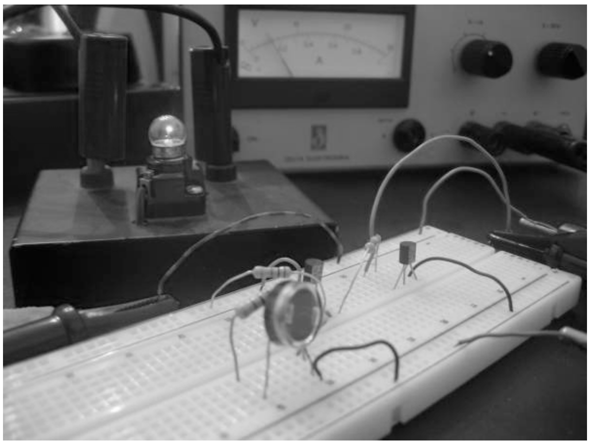

Figure 5 – An electronic circuit that assures automatic illumination.

The other group, with the younger students turn their attention to light and optics properties. They thought in an independent and autonomous way their procedures. The 8th grade pupil's imagination, creative spirit and the practical skills were put in the set of experiments. All the material were bribe by the students in their parents jobs and they use freely their imagination, creativity and the practical skills to conceive and design their.

They build a periscope that was used to explain the reflection laws and to do a little of spying.

Figure 6 – Analyzing the construction of the Periscope

They built also a solar collector that could be used to heat water and make a lot of experiments and measuring with it to understand subjects so different like the light waves, the sun orientation, the thermal material conductivity, the radiation absorbance, the heater effect. It was needed a great interdisciplinary work between Chemistry, Geography, Physics to explore all the potentiality of this collector.

Finally the two groups with students from different ages and school grades worked conjointly to share their knowledge's and to make an instrument that apply both electric subjects from the 9th grade with optical subject's from the 8th grade. The final result of this cooperation was the construction of an optic device that allows effectuating an analysis of the human visual system, namely, observing the iris behaviour, with the assistance of a lamp regulated by an electric circuit that contains a rheostat.

The labour and devotion evidenced by the students, the availability and time dispensed, the necessary tasks and diligences required and all the difficulties that they to pass over, gave them an enormous confidence and sense of responsibility. It has also revealed the teacher hided work that is necessary to present an interesting lesson and to prepare a set of hands-on experiments. In order to achieve the pretended results in a practice it is needed a lot of preparation time and the analysis of several factors that may influence the progression of the experience. For the pupils involved it's now evident all the factors that we have to account to reach to successful results and brilliant outcomes.

4. Conclusion

The students that were involved acquired special competencies in the focus areas and developed a critical attitude and the taste for study and the school space. The predisposition to observe the situations, analyze the problems, search for the solutions and implement the resolution process was increased.

Thanks to this program, now we dispose from vast panoply of pedagogical resources acquired by the school to fulfil the needs required for the project. Most important of all, we also create a large amount of didactic means that are used with very careful and proud because they are the fruit of the student's labour and imagination.

The most rewarding conclusion, from the statistics treatment of the inquests, is that science careers are now more desired. Sixty three per cent of the inquired reveal that science is now a part of their interests and priorities for the future. Having in account, that only eight per cent of the students followed natural-scientific area, in the last year, this is a promising notice and an inversion in the decline of the interest for science studies and careers.

Forty one percent of the students show improvement in science knowledge on the 8th grade optics subjects. The parents were also unanimous in accepting that this could be the right trail to explore in school. The bridges established between the educational system and the workforce brings to school there most important role and function in the society, creating exemplar citizens and excellent professionals and technicians for labour.

Finally, all the inquired were unanimous in reveal that the role of the sciences teachers is very important in their formation, because it's the area that gives them more technical skills and divulge the most important advances and applications useful to innovate the local business and small industries.

We can resume all this achievements by translating the words of an important Portuguese writer, António Nóvoa, "Education it's done in the production and not in the consumption of knowledge".

5. Acknowledgements

I acknowledge my colleagues in Portugal Paula Fernandes, Renato Silva and Sara Costa, who helped me in the elaboration of the experimental activities and Dr. Manuel Filipe Costa, who organized the Hsci 2005 Conference and assisted me in the elaboration of this paper.

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Hands-on Science in Romania, Act II

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Abstract. *The paper describes our results obtained during the last year as we coordinated the "Hands-on Science" network in Romania. A diversity of activities will be addressed: the promotion of the use of virtual instrumentation experiments; the set-up of a science club in Bucharest; the implementation at national level of a science fair; a web-based research on science literacy; the promotion of experiments based on training kits available on the market, as well as the experimental set-ups built by students; the start of a activity related to a "mobile" science demo laboratory.*

Keywords. Experimental mock-up, science club, science fair, science literacy, virtual instrumentation.

1. Introduction

During the second year from the starting of "Hands-on Science" project we focused on the development of the Romanian network, on the diversification of the activities run under the project umbrella, and on the improving the visibility of the project achievements. New associate members joined the team, and meanwhile the groups involved into science teaching small projects spread across the country. The paper exemplifies the main results, underline the experience gained in this period and points out to the plans we have for the next year. For some specific results see the papers of some Romanian teachers contributing to this volume.

2. Activities and outcomes

Considering the success of the previous year as it concerns the use of the graphical programming environment LabVIEW in building real and virtual experiments for physics teaching we continued our efforts in spreading this practice. The new schools were enrolled into this programme, and, apart of the teachers who take master courses and have the possibility to study the programming, we encourage teachers from other towns to start a self study campaign and we are offering consultancy when needed. Additional results in using virtual instrumentation in classrooms are also reported at this Conference (e.g. Mrs. Garabet and Mrs. Ruset reports). Our pragmatic approach in using this software tool was to complement the programming facilities with training kits and dedicated sensors, to assist teachers in building real experiments. Following this line, training aids for mechanics and electricity were purchased in the project frame and were offered to partner schools (Fig. 1).

Figure 1. Training kits and special sensors offered by the project to the "Grigore Moisil" Theoretical High School in Bucharest

A team of two high school teachers, leaders in using LabVIEW for both real and virtual experiments, made two trips in less developed area in Romania (Valea Jiului county where, after mines closing, a high unemployment rate is registered, and Ramnicu Valcea county in a rural region) in order to introduce the philosophy of the "Hands-on Science" project to interested school teachers. In the mean time, they presented the results they have using virtual instrumentation and PC-base data acquisition. The most remarkable fact concerning this initiative was their demo visit to a village with a dominant rromani population (Fig. 2). The interest of the audience was astonishing. We expect to be able to promote more such exchange visits in the near future.

Figure 2. Demonstrating hand-on experiments at a rromani school in Ramnicu Valcea County

The interest towards the project is demonstrated also by the organization of science contest for secondary school students in the Slatina town, where young people participated with great enthusiasm in building their own small experiments (see Mrs. Vladescu' paper). The contest focused the interest of a great number of very young and innovative students, and their work was rewarded both at the national science fair organized in Bucharest (Fig. 3), and at the local level as they were invited to "perform" during the celebration of the Europe' Day on May 9.

Figure 3. Innovation and technical skills proved by secondary school student

from Slatina

In order to make as accessible as possible the demonstration of advantages of the PC-controlled experiments, we started to build a small portable demo laboratory based on a National Instruments data acquisition board, operating over the USB connection. This approach coupled with a set of sensors can be used for on site training sessions. We have to thank to National Instruments Company for its generous support of this endeavor. The team from "Grigore Moisil" Theoretical High School demonstrated also this teaching aid to a teacher's conference in May 2005.

The same dedicated team organized by the end of April a science fair at national level. More than 160 students participated at both secondary degree and high school level from almost all regions of Romania. Microsoft Romania generously sponsored the travel of students and teachers in Bucharest and offered awards. The science fair "Hands-on science@moisil.ro" included the developments of real and virtual experiments, design of web pages with science related content, experimental mock-ups, live demonstrations. In Fig. 4 is presented the experiment developed by a group of high school students, set-up used for the investigation of microscopic objects by coupling a CCD camera to a PC. Very simple but educationaly efficient mock-ups were presented by school children having a great interest in science. In Fig. 5 a simple electrical motor built with trivial materials was demonstrated. The study of hydrostatic pressure was demonstrated by a team from Slatina town (Fig. 6), while their older colleagues report an investigation of the drinking water quality in various wards of Bucharest (Fig. 7).

Figure 4. Investigation of an insect morphology with a PC-controlled microscope

Figure 5. A simple and efficient electrical motor

Figure 6. Demonstrating pressure in liquids using trivial components

Figure 7. Young chemists answering questions on the drinking water quality in Bucharest

During the last year, most of the activities carried out in Bucharest were centered on the newly created science club. The Club gathers several high schools having different structures (i.e. theoretical high schools, vocational training centers) and focuses (natural sciences, economics, etc.). The Club was initiated by the Tudor Vladimirescu High School, but soon other educational units joined the stream (Fig. 8). In this way, as the participation grown up, we are organizing almost every month a meeting, having different hosts and centered on specific subjects. More information can be found in Mrs. Pausan’s paper. What is very interesting is the fact that each participant brings his experience and “culture” and various means of expression are encouraged. So, a complex, very non-formal interaction is established between teachers and students. The way they approach science teaching is extremely complex starting from reports on a selected theme, experiments, debates, poster sessions (Fig. 9), exhibitions, and finishing with small peaces of poetry on science written by students or even short plays with scientific message. The most exciting think was that some of the performances were played in foreign languages.

Figure 8. The open of the “Science Fun Club” at Tudor Vladimirescu High School in Bucharest

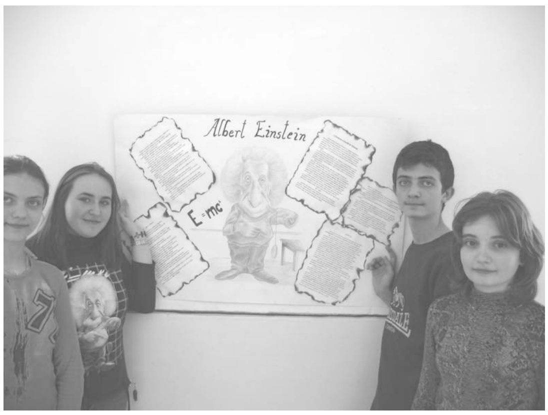

Figure 9. Participants to the poster contest having as subject the “life and activity of Albert Einstein”

An interesting experience was delivered by the club activities at the High School “Kiritescu” in Bucharest where the central theme of the activities run was consumer protection. Within this frame, groups of school students demonstrated chemical tests used for the quality certification of food stuff (Fig. 9). A second subject was pollution of the environment. We have to highly appreciate such an approach as it proved very pragmatic and from the educational point of view oriented towards community needs.

Figure 9. Students from a high school on economics concerned about consumer protection by scientific evaluation

In some cases live experiments were carried out targeting basic phenomena. In Fig. 10 the line forces of the magnetic filed are beautifully materialized.

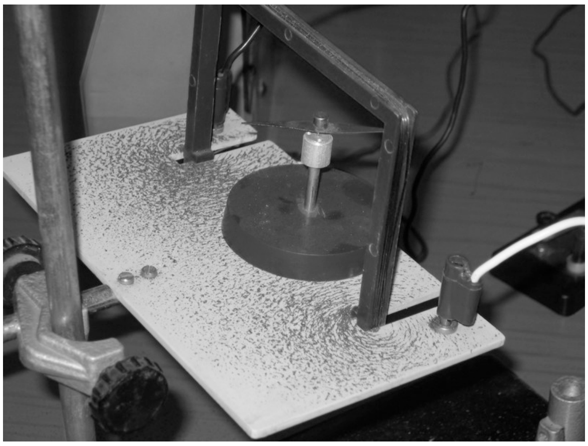

Figure 10. Visualization of the magnetic field through a classical experiment

As the experimental kits available to an average ranked high school are quite in a short supply in Romania we took the opportunity to organize in the frame of some science club sessions some demo exhibition with classical experiments (Fig. 11). In this way, students from different high schools had the possibility to access some experiments not available in their respective schools.

Figure 11. Exhibition of laboratory experimental kits

The operational capabilities of the Romanian network were strengthen by a generous donation received from EXFO, Canada, a manufacturer of testing equipment for the optical communication industry. The instrumentation received includes both emitters and powermeters, operating at two wavelengths which will be used to diversify the activities of the “mobile” demo laboratory, by including training sessions on optical fiber communications principles and the most important tests carried out for such systems. We expect that in the next year more on site training sessions will be performed in different parts of Romania, mainly in regions with economic problems, to give a chance to a pool of less privileged students.

During the last year we tried to encourage also the production of written training aids both in a print form (Mihaela Garabet and Ion Neacsu – “Experiments in the Physics Laboratory”, printed in Romanian) and in electronic format (“Papers of the First National Science Fair”, also in Romanian). Both materials were distributed for free to schools or during conference presentations.

As our efforts were also directed towards the dissemination of the project results we deliver a talk at an international conference on education held in Romania, and which was published in the conference proceedings [1]. On the same line, an interview with the Hands-on Science network

Professor Manuel Costa was published in a well known Romanian magazine dedicated to science issues – “Stiinta si Tehnica”.

Our interaction with media diversified as D. Sporea delivered a presentation on the project at a local TV station in Bucharest. The training sessions run by Mihaela Garabet and Ion Neacsu in schools from the Jalea Viului Country were also extensively covered by the local television.

Our policy included also the development of local and regional links on science teaching. Within this frame, we participated with a paper to a NATO/UNESCO sponsored Advanced Research Workshop held in Hungary [2]. Following this meeting our Institute, which is coordinating the network activities in Romania, applied and became a member of the Network of Youth Excellence - NYEX. In the same context the author took part to the “Science in Society Forum 2005”, organized by the European Commission in March 2005, where new contacts were established. In June 2005 the author was also invited to attend an international workshop on science education in primary schools in Serbia. On this occasion a review of the Romanian achievements in teaching science in schools is planned. This meeting also will be an opportunity to establish regional links and start some forms of cooperation.

Another direction of our work is related to an extended web-based research we carried out concerning the “meanings” and “the ways of implementation” of science literacy. The paper was presented at the workshop organized by the “Hands-on Science” network in Malta, in January 2005 [3].

In order to support the network efforts and to promote its results a proposal was sent in May 2005 to the European Commission asking for approval of an exhibition booth at the November 2005 Conference on communicating European Science. According to our strategy the booth will include presentation of the network achievements in various forms (posters, multimedia presentations, mock-up, printed material and e-materials as training aids, short films, etc.).

3. Acknowledgements

The author wishes to acknowledge the contribution of the Romanian “Hands-on Science” network members for their support in organizing and running the mentioned activities. Special thanks go to Mrs. Mihaela Garabet, Mrs. Emilia Pausan, and Mr. I. Neacsu, high school teachers in Bucharest for their enthusiasm and competence.

The support we received through donations from EXFO, Canada and National Instruments, USA is also gratefully acknowledged.

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Methods Used in Romanian Schools to Increase Students' Interest in Learning Physics

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Abstract. *This work presents a few of the methods that are used in Romanian schools in order to increase the students interest in learning phisics.*

The merhods consists in teaching , learning and evaluation.

The students work with the help of educational computer programs , real experiments , crossword puzzles and didactical movies.The evaluation is performed in modern way , the students are given tests that include various sorts of items , portofolios.They also present playworks , poetrys , drawings.

By using these methods we assure the development of numerous practical and intellectual abilities of our students.

Key words: computer, creativity, experiment, teaching methods.

1. Introduction

Modern education must base on creative learning and on using certain methods to make learning attractive to the student.

Therefore , within the project called "Hands on Science Network Romania" we tried to combine the traditional teaching , learning and evaluation methods with the modern ones , so as students acquire both knowledge and practical skills.

Evaluation is performed in such a manner as to avoid stress , as it happened with traditional rating methods , and to create permanent competition among students.

There is also emphasis on accomplishing interdisciplinary links as well as team work which develops students'responsibility , their receptivity to novelty and innovative behaviour , based on attempt-error , success-solution.

In the present paper we would like to emphasize a few work methods that have been tested with the students in "Elena Cuza"National College in Bucharest , Romania.

2. The use of real and virtual experiment during physics class

Society of the future will be a computerized one.That is why computer and education software are more used in schools , as they enable students to perform experiments that are difficult to carry out in laboratory , to check the solutions to various problems , or to identify the optimal conditions to perform a new experiment designed by students themselves.

The use of computer also enables students to go over provided materials in their own rhythm , to select information and to understand theory faster.

Education software allows students to get involved in learning process through differentiated appreach of knowledge depending on each student's level.

Yet the use of computer may lead to a loss , in terms of practical , calculation and reality investigation skills as well as to a decay in human relationships.Moreover , education software cannot answer all unpredictable questions students might ask.

These drawbacks make it clear we cannot possibly give up live observation and lab experiments.

The students in "Elena Cuza" National College have performed both real and virtual experiments.

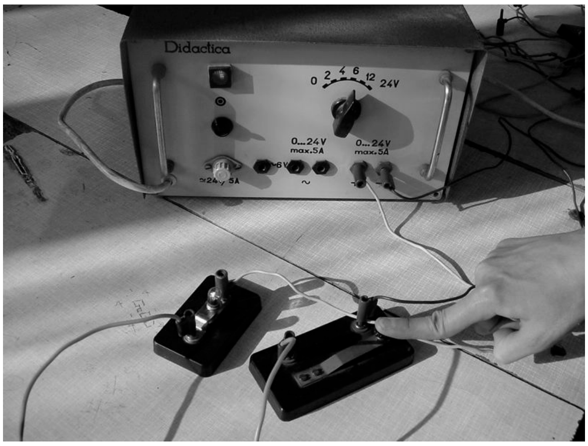

Figure 1. Real experiment-Simple electric circuit

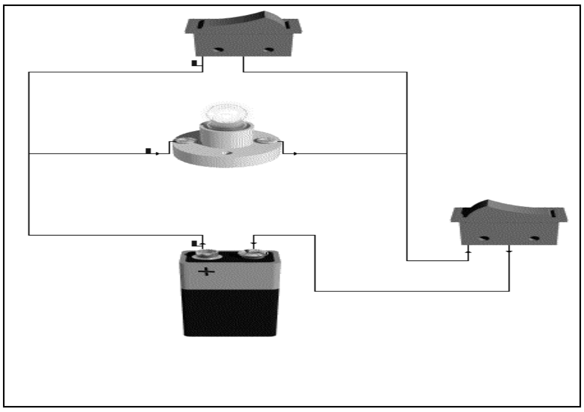

Figure 2. Virtual experiment-Simple electric circuit

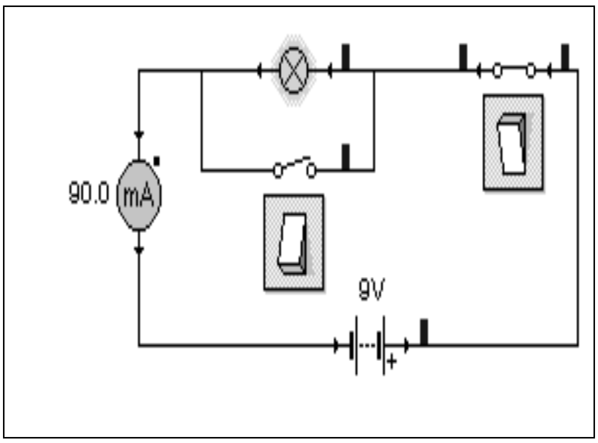

Figure 3. Virtual experiment-Simple electric circuit-symbols

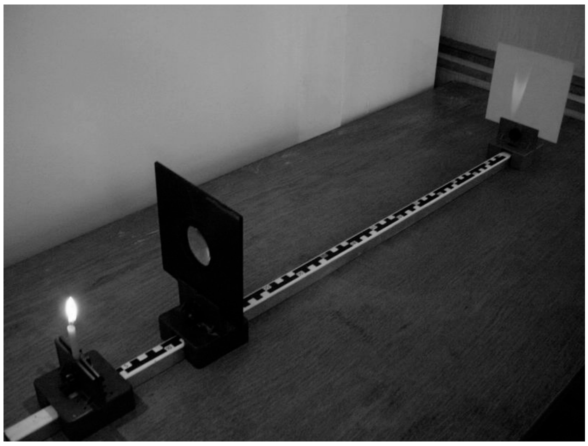

Figure 4. Real experiment-The image of an object through a lense

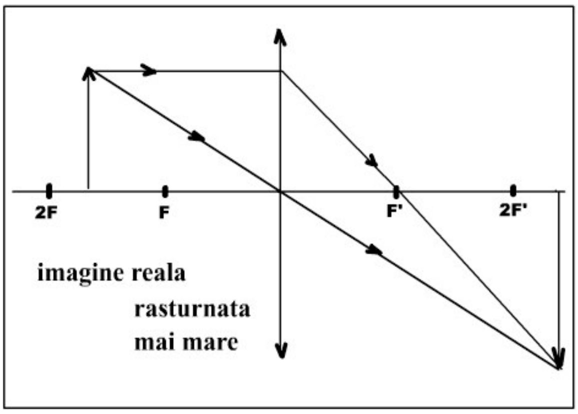

Figure 5. Virtual experiment-The image of an object through a lense

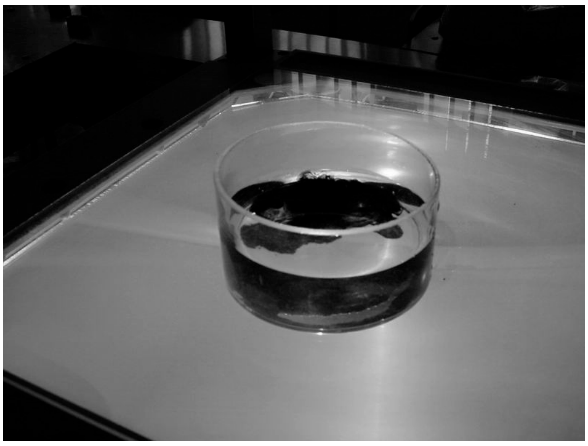

Figure 6. Real experiment-Diffusion

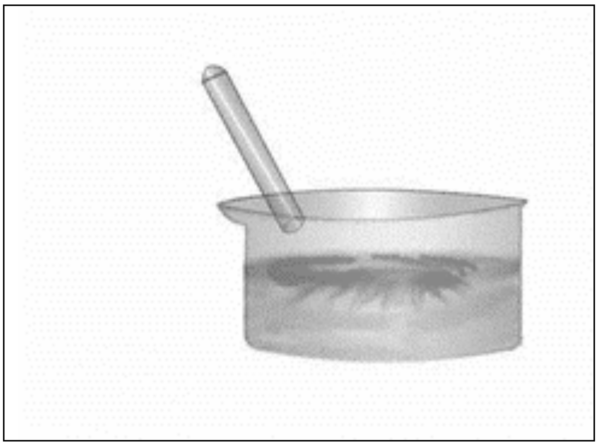

Figure 7. Virtual experiment-Diffusion

3. Creativity in theaching and educational process

Students creativity occurred even when they were suggested to make their own experimental devices to study physics using simple materials found in any household.

We hereby present some of our students'works:scales , dynamometer , electroscope , electric power generator and electrolysis device.

Figure 8. Handcraft electroscope

Figure 9. Handcraft dynamometer

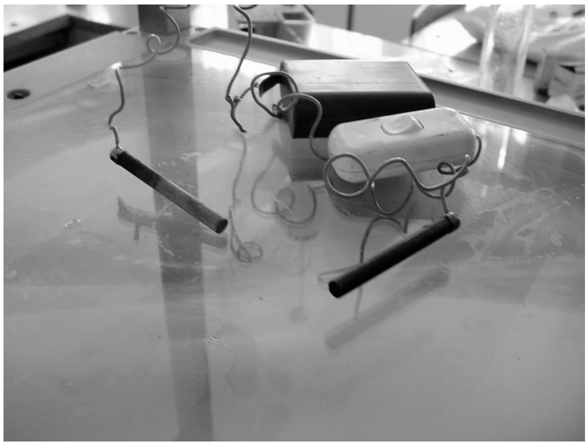

Figure 10. Handcraft electrolysis device

By means of their hand-made devices , the students were able to perform various experiments as well as to check out laws of physics.They have checked electrolysis laws using a device built with coal electrodes taken from an exhausted battery , wire , a glass , some $CuSO_4$ solution and a charged battery.

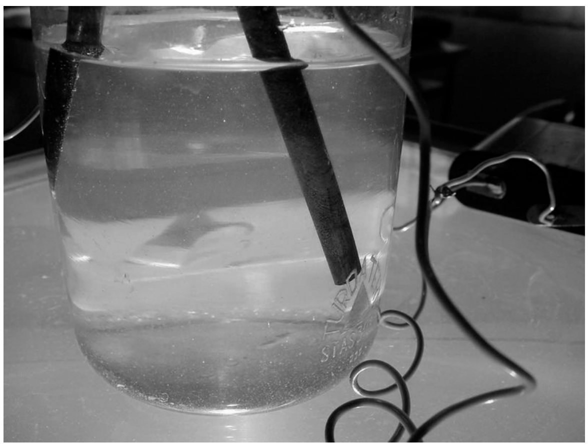

Figure 11. Verifying electrolysis laws with a handcraft device

The gains of such laboratory work consisted in enabling poor students to actively participate in the lesson , to ask questions and to acquire some practical skills .The students also realized that a lot of work and determination were necessary , as effort , information acquiring and experience are crucial.

Having encountered some difficulties in making their devices , the students started doing research and consequently their interest in physics has increased considerably.

Another way to revire students'interest in studying physics consists in acting in play with scientific backgraund.

Thus , the 6-th grade students in our college acted in the play "Archimedes and emperor's crown".The script of this play was based on an episode recorded in the history of physics.The main idea of this play is eliciting the notion of body density , the starting point being well-known physical notions such as:weight , volume , inertia , body , substance , characteristics.

Figure 12. Students acting in the play "Archimedes and emperor'crown"

Figure 13. Students acting in the play "Archimedes and emperor'crown"

Besides its scientific value this play also has an educational dimension with an emphasis on the daily role of physics and on the fact that man is supposed to learn all his life.

4. Evaluation process in physics class

Evaluation is based on tests consisting of various items, crossword puzzles, games, drawings, posters, projects and portofolios, essays and graphs.

The students are divided into groups , each group having a leader.As soon as the topic is announced , the students are allawed some time to look for information.

When time is up, a round-table is organized and each group leader presents all participants'opinions , findings and results.The debates arise questions , create new ideas and estabilish interdisciplinary links.The theacher's intervention occurs whenever necessary without trying to impose his/her own ideas and opinion.The atmosphere is thus relaxed , and nobody is tense or nervous.The most original ideas are rewarder with high grades.

We hereby present some of our students'accomplishments:

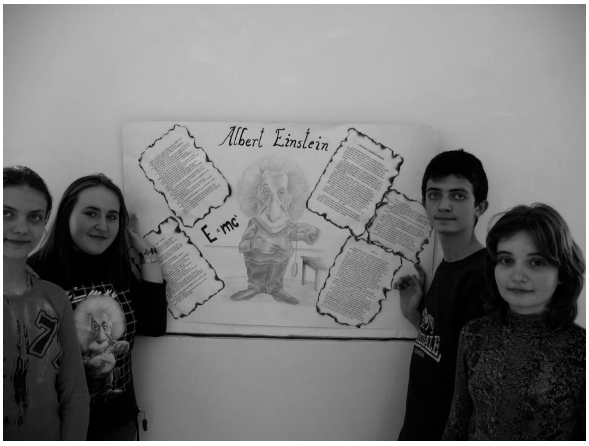

Figure 14. A poster made by our students

Figure 15. Poster exhibition organized by our students

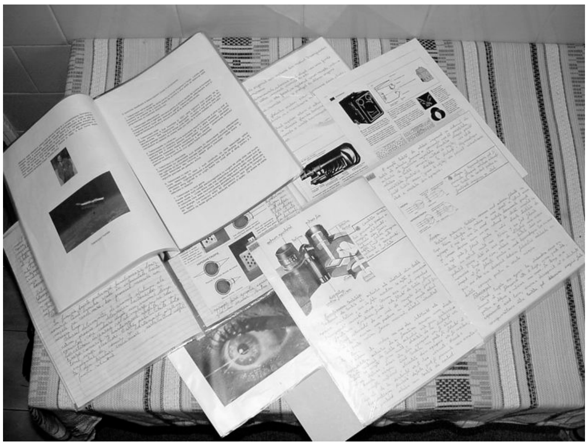

Figure 16. Students projects

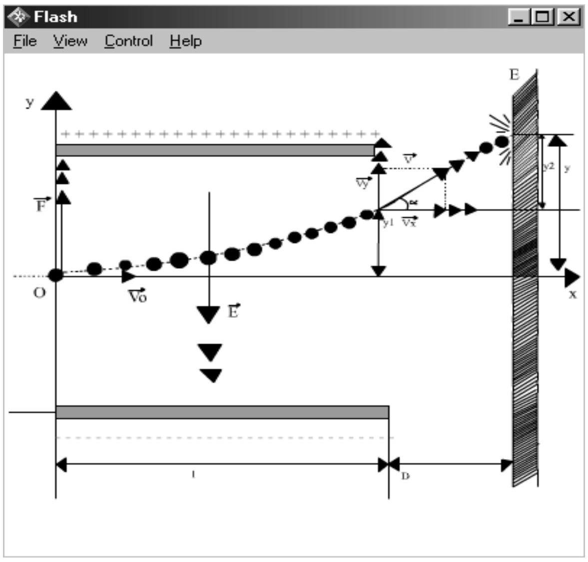

Figure 17. Education software devised by students

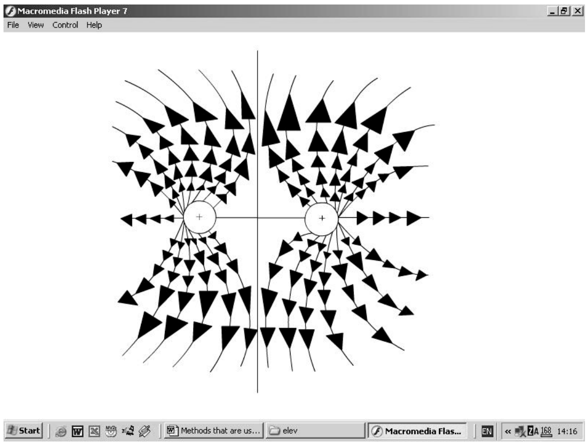

Figure 18. Graphs made by students

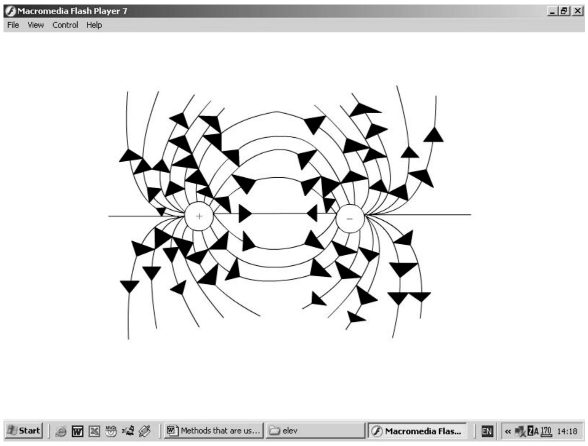

Figure 19. Graphs made by students

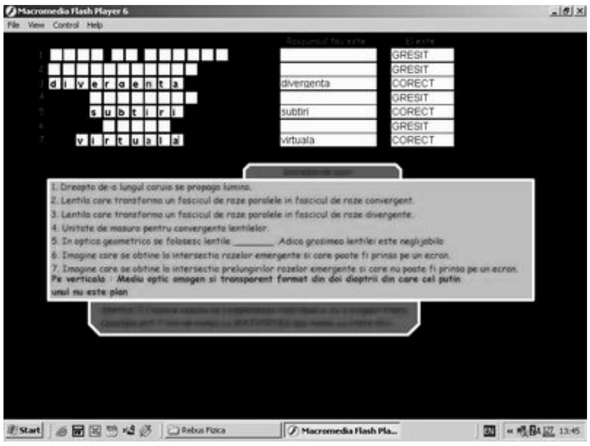

Figure 20. A crossword puzzle

5. Conclusions

The use of these methods in class has caused an increase in students'knowledge of physics, which has also been confirmed by their results in various school contests.

At the same time this approach has positively changed students'attitude towards school, study, towards moral , cultural , and scientific values of society.

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Introducing Concepts of Physics into Primary School

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Abstract. *A project was initiated with the aim to introduce some concepts of physics to schoolchildren of 8 to 10 years old. The experiments were made with three lessons: Matter; Substances and Bodies; and Transformations of Substances. It was tried to introduce not so easy to understand concepts such as: (i) Matter and the way to divide it, living bodies and lifeless ones, (ii) the difference between body and substance and (iii) the transformation of substances under heat. To make school children to understand them, diagrams, photos and experiments were used. The result was very encouraging*

Keywords. concepts of physics, matter, substances, transformation of substances, primary school

1. Introduction

The year 2005 is a year dedicated to physics and to Albert Einstein. Taking this fact into consideration, a project aiming to introduce some elementary notions of physics, to the 8-year-old children was initiated. Three class lessons containing elements, which are usually more difficult to understand, have been selected. These were "The Matter", "Substances and physical objects" and "Transformations of substances".
Together with the schoolmistress, the teacher of physics has been involved in teaching these notions. For a better understanding, schemes, photographs and experiments have been used.

2. Project development

For the lesson "Matter", the pupils were presented the scheme shown in Fig. 1. All categories of matter, together with their specific features, have been explained. Then the children have been asked to give examples from the surrounding reality. At the end of the lesson, they received a test where the task was to arrange a number of words, like flower, horse, stone, water, book, car, butterfly, sun, cloud, boy, ice, apple, land, tiger, etc., into two columns: "living matter" and "lifeless matter".

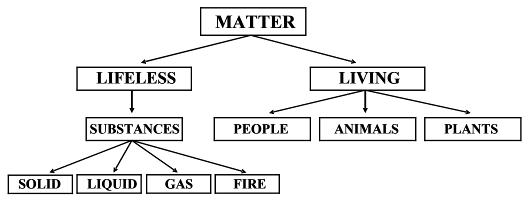

Fig. 1. Categories of matter

The result was the following:

- 20 pupils answered correctly
- 6 pupils answered partially correct
- 1 pupil incorrectly.

This result was considered to be quite good and demonstrated that the children understood the notion of matter with its main categories.

For the lesson "Transformations of substances" the pupils was presented the scheme shown in Fig. 2.

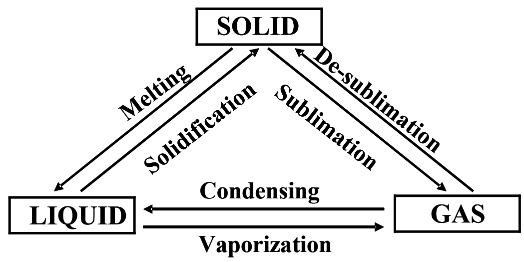

Fig. 2. Transformation of substances

The lesson was run as an experiment. The pupils made themselves heating sources using alcohol. They also brought test tubes, and mirrors (Fig.3). The aim of the experiment was to demonstrate the transformation of the ice into water, then of the water into vapor by heating and finally of the vapor into water

Fig. 3. General view of the class room

again by condensing.
The children have been given small pieces of ice. They introduced the ice into the test tubes and heated them. The ice melted and transformed into water. By continuing the heating the water transformed into vapor (Fig.4).

Fig. 4. Melting and vaporization

Then, they positioned the mirrors above the test tubes and observed the condensing of the vapor and its transformation into water (Fig.5). All these transformations have been explained using the diagram from Fig.2.

For evaluation, the pupils were asked to recognize the name of transformation in a multiple-choice test. For example: the transformation of a substance from a solid state into a liquid state is called: a) solidification, b) melting, c) condensing.
The result was the following:
- 21 pupils answered correctly
- 4 pupils answered incorrectly
- 2 pupils didn't answer at all

Fig. 5. Condensing of the water

2. Conclusions

- The result of this project was spectacular. The pupils were receptive and eager to participate in these lessons.
- The result analysis has shown that the age is not an impediment (a barrier) in understanding of more abstract and complex phenomena from our environment.
- This is the reason why the project will continue with lessons concerning explanations for other notions like energy, power and energy sources.

Appliances of First Degree and Second Degree Mathematical Equations in Solving of Some Physics Problems

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Abstract. *Mathematics is not only an abstract object. It had many appliances in Physics, Chemistry, Astronomy or Biology. I want to reveal that more problems in Physics are solved with mathematical equations of first and second degree.*

The classics unknowns x, y from Mathematics are substitutes in Physics by velocity v, time t, acceleration a. If you know to solve these equations on Mathematics, you must know how to apply them in others sciences too. You must be careful that in physics phenomena not exist negatives sizes (in Mathematics first degree and second degree equations can have positives and negatives solutions).

Keywords. Equations, Mathematics, Physics.

1. Introduction

For solving any problem of physics, you need know mathematics, like first degree and second degree equations. If you want to apply math formula in physics, classical unknowns x, y, $x_{1,2}$ and $y_{1,2}$ must be substituted with speed v, time t, distance x, l, d, or acceleration a.

From the first school years, we learned to measure time and distance. In expressions like “break between courses is ten minutes” or “after two hours I will meat my friends”, on observe that time measures represent only positive numbers. We’ll never hear someone who tell “- ten minutes” or

Each lesson was followed by a test in order to verify the understanding level of the given notions. In addition, the pupils have been asked to make portfolios where they should identify from their environment (house, school, street, etc.) the notions they had just learnt.

“-two hours”. Also we say “the distance from home to school is 1 km” or “distance between two cities is 200 km”, but no “-1 km” or “- 200 km”.

When we drive the car, we see that the speed recorder begin from 0 to high speeds (300 km/h and over 300 km/h) if we have a race car!

We will never hear to distances by “-150 km”, for example.

All these examples give to us differences, between mathematics and physics, very important. A physics problem not must tackle like some mathematical problem. This means, among other things, that the values for physical measures can be only positive numbers. When we will find these values, we must add the unities for measure.

In Romania, the Mathematics curricula is very extent and the teacher, generally not have the time to accentuate the parallel between Mathematics and another sciences, so students know to solve equations from mathematic point, but they don’t understand very well the physical significance.

2. Examples

1.An object of mass $m_1 = 0{,}1$kg is thrown upwards with a velocity of $v_0 = 15, 5$ m/s. After $t_1 = 1{,}2$ s, it meet another body of mass $m_2 = 0{,}3$ kg in free fall from H = 150m high. The second body was dropped after T = 0,5 s from the upwards thrown of the first body. Calculate:

a) the velocity v_1 of the first body after a time t_1;

b) the vertical distance h_1 of the first body after a time t_1;

c) the total energy of the first body when it meet the second body;

d) the vertical distance and the velocity of the second body at the meeting time;
e) the total energy of the second body at the meeting time.
Solution:
a) To lift an object to a high h above the ground, works has to be done against the force of gravity. The acceleration of the first body is a = -g, because the first body is thrown upwards and the acceleration of the second body is a = g, because the second body is in free fall. g is the gravitational field strength, g = 9,8 m/s^2. Objects are represented in Fig. 1.

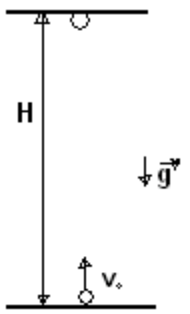

Figure 1. Objects for problem 1

The velocity law for the first body is:

$$v_1 = v_0 + a\,t_1 \qquad (1)$$

and because the acceleration of the first body is a = -g,

$$v_1 = v_0 + (-g)\,t_1$$

$$v_1 = v_0 - g\,t_1 \ .$$

The distance law is:

$$h_1 = h_0 + v_0 t_1 + \frac{at_1^2}{2} \qquad (2)$$

$$h_1 = h_0 + v_0 t_1 + \frac{-gt_1^2}{2}$$

$$h_1 = h_0 + v_0\, t_1 - \frac{gt_1^2}{2} \ ,$$

The Galileo's equation for the first body is:

$$v_1^{\ 2} = v_0^{\ 2} + 2ah_1 \qquad (3)$$

$$v_1^{\ 2} = v_0^{\ 2} - 2gh_1$$

If use equation (3) and put in numbers, we have:

$$v_1^2 = 15 - 9{,}8 \times 1{,}2 = 15 - 11{,}76 = 3{,}24$$

$$v_1 = \sqrt{3{,}24} = \sqrt{\frac{324}{100}} = 1{,}8 m/s$$

b) Put in numbers equation (2) and known that h_0=0:

$$h_1 = 15{,}5 \times 1{,}2 - \frac{9{,}8 \times (1{,}2)^2}{2}$$

$$h_1 = 18{,}60 - \frac{9{,}8 \times 1{,}44}{2}$$

$$h_1 = 18{,}60 - \frac{14{,}112}{2}$$

$$h_1 = 18{,}60 - 7{,}556$$

$$h_1 = 10{,}044 \text{ m.}$$

c) When the first object meets the second object, it had both kinetic energy and gravitational potential energy.
Formula for kinetic energy first:

$$E_c = \frac{m_1 v_1^2}{2} \qquad (4)$$

then numbers

$$E_c = \frac{0{,}1 \cdot 3{,}24}{2} = \frac{0{,}324}{2} = 0{,}162 \text{ J}$$

Formula for gravitational potential energy is

$$E_p = m_1 \cdot g \cdot h_1 \qquad (5)$$

then numbers

$$E_p = 0{,}1 \cdot 9{,}8 \cdot 10{,}044 = 9{,}843 \text{ J}$$

Total mechanical energy for the first body is

$$E_t = E_c + E_p \qquad (6)$$

and in numbers

$$E_t = 0{,}162 \text{ J} + 9{,}843 \text{ J} = 10{,}005 \text{ J}$$

d) The velocity of the second body at the meeting time is calculated using velocity law for it. Knowing that v_0=0 and it reached h_2 after t_1 + T:

$$v_2 = g\,(t_1 + T) \qquad (7)$$

Put in numbers

$$v_2 = 9{,}8(1{,}2 + 0{,}5)$$

$$v_2 = 9{,}8 \times 1{,}7 = 16{,}66 \text{ m/s}$$

Distance travelled by the second mass at the meeting time is calculated with the Galileo's equation:

$$v_2^{\ 2} = v_0^{\ 2} + 2ah_2 \qquad (8)$$

Knowing that v_0=0 and a=g, equation (8) is

$$v_2^{\ 2} = 2\,g\,h_2$$

$$h_2 = \frac{v_2^{\ 2}}{2g}$$

$$h_2 = \frac{277,55}{19,6}$$

$$h_2 = 14,16m.$$

This is the meeting high.

e) For the total energy of the second object at the meeting time we must calculate the kinetic energy and the gravitational energy for him and use equation (6):

$$E_{c2} = \frac{m_2 \cdot v_2^{\ 2}}{2} = \frac{0,3 \cdot 277,55}{2} = 41,632 \text{ J}$$

$E_{p_2} = m_2 \cdot g \cdot (H - h_2) = 0,3 \ \ 9,8 \ \ (150 - 14,16) = 399,36$ J

$E_t = E_{c\,2} + E_{p\,2} = 41,632$ J + 399,36 J = 440,992 J

2. An object with mass m_1 = 2 kg, descended on an inclined plane with α = 30 ^{0}, from a vertical height h = 3 m. His initial velocity is v_{0_1} =15 m/s and the friction coefficient is μ = 0,1. After a distance x = 4m, to a horizontal plane, it meet another object m_2 = 1 kg, who is at rest. Between them is an inelastic collision. On horizontal plane the friction coefficient is μ = 0,1 too.

Calculate:

a)Slope's length and first object velocity v_1, at the base of the slope ;

b)Velocity v_2, of the first object before collision ;

c)Velocity v of both objects, after collision.

Solution:

Objects are represented in Fig. 2.

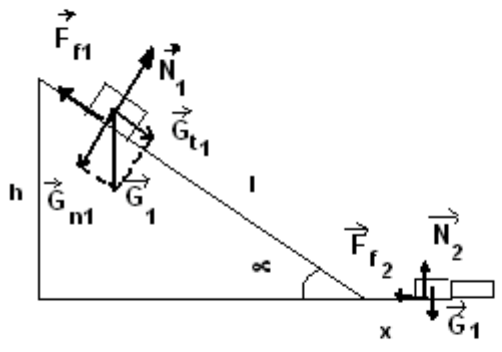

Figure 2. Objects for problem 2

a) Knowing the high from which the first object is going down, h = 3 m, as well the fact that the inclined plane is a rectangular triangle with α=30 ^{0}, we can use the formula

$$\sin α = \frac{h}{l} \Rightarrow l = h \sin α \qquad (9)$$

In numbers:

l = 3 sin 30 ^{0}

$$l = 3 \times \frac{1}{2}$$

l = 3 × 1,5

l= 4,5 m who is inclined plane's length.

From Newton's Second Law of motion

$$\vec{G}_1 + \vec{N}_1 + \vec{F}_{f\,1} = m_1 \vec{a}_1 \qquad (10)$$

$$\text{Ox:} \quad G_{t1} - F_{f1} = m_1 \cdot a_1 \qquad (11)$$

$$\text{Oy:} \quad N_1 - G_{n1} = 0 \qquad (12)$$

The second member in (12) equation is 0 because the object has no component of acceleration to Oy axis.

But we know that

$$G_{t1} = G_1 \sin α \qquad (13)$$

$$F_{f1} = μN_1 \qquad (14)$$

$$G_{n1} = G_1 \cos α \qquad (15)$$

$$G_1 = m_1 g \qquad (16)$$

With equations (11) - (16), we obtain

$$m_1 g \sin α - μ m_1 g \cos α = m_1 a_1 \qquad (17)$$

$$a_1 = g(\sin α - μ\cos α) \qquad (18)$$

In numbers

$$a_1 = 9,8(\sin 30 + 0,1\cos 30)$$

$$a_1 = 9,8 \cdot \left(\frac{1}{2} + 0,1\frac{\sqrt{3}}{2}\right)$$

$$a_1 = 9,8 \cdot \left(0,5 + 0,1 \cdot \frac{1,73}{2}\right)$$

$$a_1 = 9,8 \cdot (0,5 + 0,1 \cdot 0,86)$$

$$a_1 = 5,74 m/s^2$$

This equation represents object's acceleration. Also we know his initial velocity and Galileo's equation

$$v_1^{\ 2} = v_{0_1}^{\ 2} + 2 \cdot a_1 \cdot l \qquad (19)$$

In numbers

$v_1^{\ 2} = 15^2 + 2 \times 5,74 \times 4,5 = 276,66$

$v_{1,2} = \pm\sqrt{276,66} = \pm 16,63.$

As we know, in Physics negatives measures doesn't exist, so the solution is v_1=16,63 m/s.

b)To calculate velocity v_2 of the first object before collision, we must use Newton's Second

Law of motion, that's mean equation (10), to find out its acceleration a_2 on the horizontal plane. Also equations (11) and (12) becomes

Ox: $-F_{f_2} = m_1 \cdot a_2$ (20)

Oy : $N_2 - G_1 = 0$ (21)

or $N_2 - m_1 g = 0$

so from (20)

$-\mu m_1 g = m_1 \cdot a_2$

$a_2 = -\mu g$ (22)

Galileo's equation on the horizontal plane is

$$v_2^2 = v_1^2 + 2 \cdot a_2 \cdot x$$

$$v_2^2 = v_1^2 - 2\mu g x$$

In numbers

$v_2^2 = 276{,}66 - 2 \times 0{,}1 \times 9{,}8 \times 4$

$v_2^2 = 268{,}82$

$v_{2_{1,2}} = \pm\sqrt{268{,}82}$

$v_2 = 16{,}39 m/s$

From same reasons like point a) we choose the positive solution with physics significance.

c)To find out velocity v of both objects, after collision we use The Principle of Conservation of Momentum in an inelastic collision:

$$m_1 v_1 + m_2 v_2 = (m_1 + m_2)v \quad (23)$$

But the second object is at rest, so $v_2=0$. Equation (23) becomes

$$m_1 v_1 + 0 = (m_1 + m_2)v \quad (24)$$

$$v = \frac{m_1 v_1}{m_1 + m_2} \quad (25)$$

In numbers

$$v = \frac{2 \times 16{,}39}{2 + 1}$$

In conclusion, the velocity v of both objects, after collision, is

$$v = 10{,}92 m/s$$

3. Conclusions

Like we know, the movement of natural objects is a complex movement. In these problems I wanted to reveal that is not enough to know only some chapters of Physics, but to resolve problems of synthesis. When we will finish resolving the problem, by mathematic point, we must to put in evidence the pure physical sense, in that context. The "Hands on Science" network provides a frame to improve in-school scientific education.

4. Acknowledgements

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Hands-on science activities for the teaching and learning of mechanical energy with 6th grade primary school children in Greece

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Abstract. *This is an inquiry about the teaching and learning of mechanical energy with a class of 35 children in the 6th grade of primary school in Greece. It is a classroom research approach aiming to provide insights into a particular teaching and learning environment throughout a certain period of time and to understand and describe aspects of conceptual change about mechanical energy.*

A 12hour teaching intervention has been designed and implemented on the basis of the "Model of Educational Reconstruction" with hands-on science experiments, activities and project work. Sixteen out of the 35 children in class have been interviewed using particular instances depicted on cards. The interviews were conducted in three phases: before and after the teaching intervention and 6 months later with a different set of cards. The findings indicate that the children have developed their conceptual understanding on mechanical energy, modifying and changing their initial conceptions within a framework of "energy change and energy degradation".

Keywords. Teaching and learning about mechanical energy, hands-on science activities, conceptual change, primary science education.

1. Teaching and learning about energy

A teaching and learning approach of the "energy" concept in science education is considered to be important because it constitutes a fundamental process, which allows predicting and interpreting the behaviour of a wide variety of physical systems, referring to diverse branches of physics and/ or other areas of science (*inter-phenomenological character of energy*). Moreover, the understanding of socio-scientific issues, such as energy supply and use within a sustainable development approach, appears to be of equal importance nowadays (*socio-cultural character of energy*).

Within the context of "school science" or science curriculum "energy" is treated as a rather compulsory topic for secondary science. Nevertheless, it constitutes a disputable and controversial issue for primary science education, mainly due to its abstract nature, which is difficult to become concrete or even reified to a certain extent for the age group of 10-12 year-old children. There appears to be a lack of consensus in primary science education with respect to the developmental appropriateness of the concept and the "correctness" of possible "simplifications" and/or approximations (Trumper, 1990). In most cases energy is associated with sources or properties of certain objects e.g. batteries and fuels rather than concepts like heat and light (Duit, 1984). There appears to be a tendency to conceive energy as a property of living organisms commonly associated with motion or a physical endeavour, which seems to be strongly linked with the meaning ascribed to the word "energy" (*energetic*) in every day situations (Solomon, 1992). Moreover, "energy" is often used as a label to attribute different meanings to different contexts e.g. "something happening" "something going on", "giving-taking energy", "make something go or stop" etc. (Brook, 1986).

It is often claimed that energy seen as "*the ability to do work*" and the focus on the conservation law, have not been very successful in the promotion of a substantial and functional understanding of the "energy" concept (Duit, 1986). It has been claimed that even when secondary students are taught and somehow recall the second law, they often fail to answer questions which require deeper conceptual understanding of the law (Solomon, 1992). Furthermore, learners tend to avoid referring to the conservation law when they analyse the behaviour of given physical systems (Driver & Warrington 1985). This lack of understanding with respect to the law of conservation is often attributed to the fact that it is counterintuitive, in the sense of being inconsistent with everyday experience (Solomon, 1992). In other words, it appears that learners have difficulties in conceiving the idea of "closed energy systems", and if that is the case for secondary science, perhaps it can be equally considered as an "epistemological obstacle" for the teaching and learning of "energy" in a primary science context.

Nevertheless, there appears to be a shift in the emphasis from teaching about forms and transformations of energy *per se*, to the analysis of systems depicting a process, based on the idea of energy transfer and change (Chisholm, 1992). It is also claimed that an approach of "energy degradation" should be present in association with the conservation law (Duit, 1986) and that could be started at the last two grades of primary school (11-12 year-olds). This is based on the premise that understanding energy degradation might enhance the development of understanding about the conservation law (Duit, 1986; Solomon, 1992) or at least it can create a sort of a fruitful foreground. In this inquiry, "energy" is seen through a context of "change-degradation", providing foreground hints for energy conservation, within a primary science education approach.

2. The teaching intervention approach

In the design of the teaching intervention, the *"Model of Educational Reconstruction"* has been taken into account, in an attempt to balance approaches that pay attention to the science subject matter structure with those that mainly focus on learners' perspectives, abilities and needs (Kattmann *et al.*, 1995; Duit, R. & Gropengießer, 2004). It is claimed that the overall aim of the model is *"to identify the connections between scientific knowledge and the students' alternative frameworks in every day life and also to re-construct meaningful relations which may get lost in the course of scientific and teaching activities"* (Kattmann *et al.*, 1995). The most valuable feature of the model appears to be the intimate interaction of its three main components: a) *the analysis of content structure*, b) *the empirical investigations* and c) *the construction of instruction*. Thus, science subject matter appears to be a reference position in order to understand the learners' perspective, but also the latter may constitute a reference position to facilitate more adequate understanding of the science point of view and vice versa (ibid.). In the course of development of the teaching intervention several teaching and learning strategies have been employed such as: extension of existing views and application in new situations, development of scientific understanding in parallel with existing notions or even recognition of appropriateness and/or applicability of explanatory frameworks in various situations (cf. Scott *et al.*, 1992).

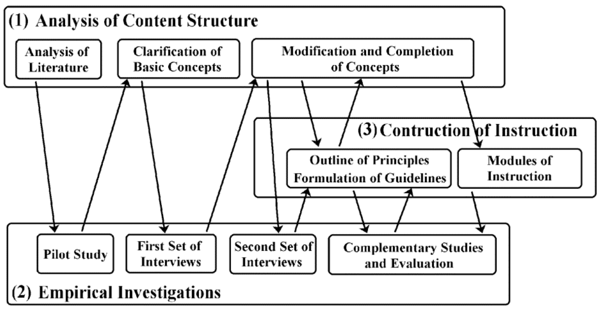
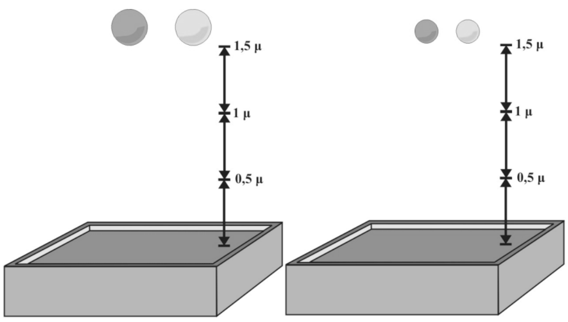


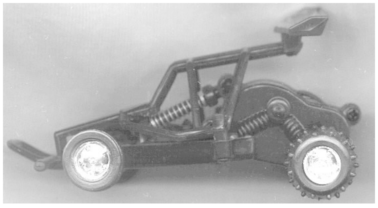
Figure 1. The Model of Educational Reconstruction

The teaching intervention about mechanical energy lasted for a series of 12 teaching hours and dealt with concepts like *work*, *dynamic energy*, *kinetic energy*, *wind energy*, *energy change* and *energy degradation*, within a context of practical investigations such as the following:

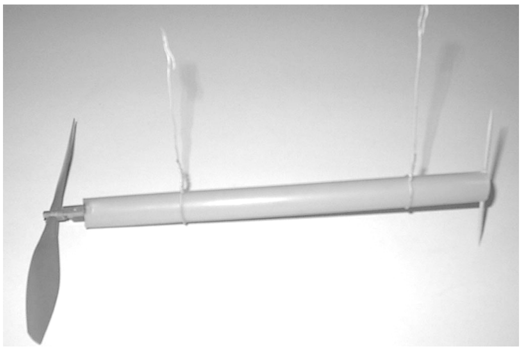
- dropping balls on wet sand, of various weights and from different heights, study the craters they create in the sand and make inferences about dynamic energy and its relation to weight and height



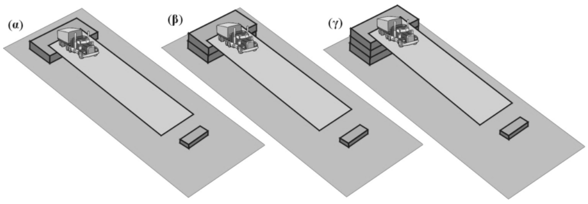
- examination of everyday toys (e.g. jumping toy frogs with elastic tails, moving toy cars and wind up toys, which have been deconstructed studied in class, investigating elastic and metallic plates that "store" dynamic energy and "change" it to kinetic energy)

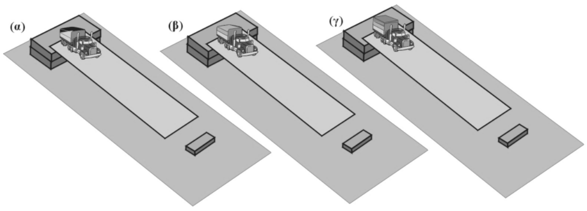


- construction of toys as project work (e.g. aeroplanes, catamaran boats and toy cars moving with "rubber band energy") (cf. Taylor, 1998; Tsagliotis, 2005)

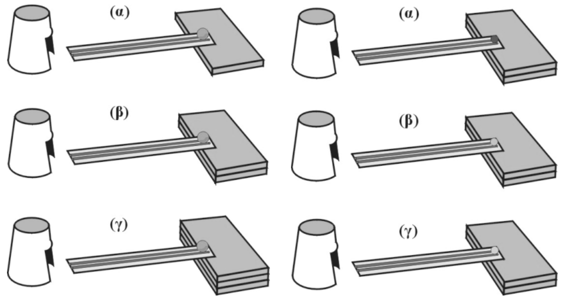


- studying kinetic energy with lorries rolling down the slope at different heights and from the same height with different masses

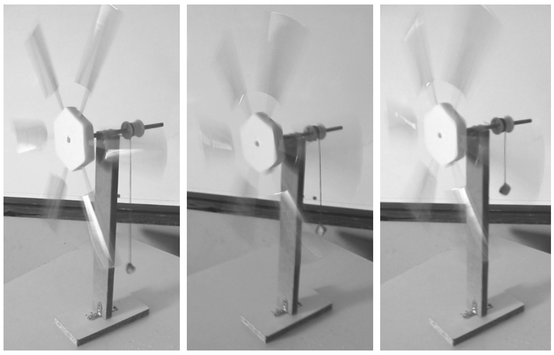




- similarly, studying kinetic energy with a marble rolling down the slope at different heights and with marbles of different masses from the same height, moving a paper cup at a distance



- "*wind energy*" in the case of sailboats and wind mills (constructed in class to lift up weights) was discussed as an "application" of mechanical energy and as an example of energy change and degradation.



3. Research approach

From a practitioner-researcher's standpoint (Schön, 1983), research has been carried out in an educational setting of a 6th grade of primary school with 35 children, divided into two classes (18 and 17 respectively). The over all aim is to provide insights into a particular teaching and learning environment throughout a certain period of time and to understand and describe aspects of conceptual change about mechanical energy with 11-12 year-old children in a primary science classroom. In other words, according to Niedderer *et al.* (1992), this inquiry aims to describe *"selected states"* of children's ideas and conceptions before, during and after a teaching and learning process, in order to understand the variety of these conceptions and the ways they evolve and change.

More specifically, the research questions of this inquiry are the following:

- What variety of conceptions or ideas do children have about mechanical energy?
- What kind of changes in children's ideas and conceptions about mechanical energy can be pointed out?

- To what extent does a conceptual framework of "energy change and energy degradation" enable children to understand aspects of mechanical energy?

Sixteen (16) out of the total of 35 children, selected to be of mixed ability, have been interviewed before and after the teaching intervention with the *Interview-About-Instances* technique (Gilbert *et al*., 1985), using the same set of interview cards. The instances depicted on the set of 10 interview cards for mechanical energy came from everyday activities (i.e. man pushing a heavy box), children's playground (i.e. children playing on the seesaw, swinging, going down the slide, child throwing a tennis ball bouncing on the floor), sports (i.e. weightlifter), natural phenomena (i.e. a stone going down a hill slope) and human constructions for the use of mechanical energy (i.e. a water mill, a wind mill and a sailing boat). The same children were interviewed again six months after the completion of the research episode using a second set of 4 interview cards, which depicted both similar but also differentiated instances from those of the earlier set.

The interviews have been fully transcribed and are analysed in three levels. At *first level* the *Pre-Intervention Interviews* and the *Post-Intervention Interviews* are analysed separately, in order to elicit a variety of qualitatively different conceptions about the depicted instances before and after the teaching interventions on mechanical and solar energy. At *second level* the elicited conceptions are to be compared within the context of each depicted instance, in order to identify conceptualisation differences, in an attempt to reveal the dynamics of conceptual change. At *third level* the conceptions of particular children-cases are considered across the interview cards, both in pre and post intervention interviews, in an attempt to obtain deeper insights in children's evolution of conceptions and conceptual change. The post-interviews, taken 3 months later, will be considered separately and in combination with the 2nd and 3rd levels of analysis. The *NVivo* software from *QSR* has being used in the coding and analysis of the interview data (cf. Gibbs, 2002).

4. Findings and discussion

Findings indicate that *before the teaching intervention* mechanical energy appears to be seen as an "action", an "activity" or a "human endeavour", strongly associated with motion and "pace", whereas things that are not moving "have no energy". *After the teaching intervention* mechanical energy appears to be seen as "stored energy" (dynamic energy) when "things are high up" or when they are "stressed", "pushed down" or elastically deformed, but also as "energy of motion" (kinetic energy) which is related to the "speed of objects" or to the "pace they have while moving". *"Energy change"* appears to be discerned in the card-instances as dynamic-kinetic-heat change [e.g. rock rolling down the hill slope], whereas *energy degradation* is seen though "energy change to heat" due to "friction" [e.g. swing, seesaw, wind mill, sailing boat,] and "crashes" "fading" [e.g. rolling rock, water crushing on the water wheel]. In this sense *energy degradation* is seen as energy which "is put out of use" or is "incapacitated" for a useful cause or result, "turned into heat", which cannot be easily used further.

Such aspects of change on children's conceptions about energy from the pre and post-intervention interviews can be seen through a framework of multiple *variations* of conceptions about energy, discerning different aspects of situations and phenomena, which come into focus, are thematised by reflection and appear to be context dependent. Within a *dynamic approach* to conceptual change, children appear to experience and discern some varied features of mechanical energy, in terms of characteristics and aspects that come to the fore and remain into focus, within the particular context of the depicted instances of the interview cards. As Marton (1990) has argued, *"within the internal dynamics of a conception of something, a restructuring is taking place and one meaning develops into another"* and that appears to be a gradual and on-going procedure.

The notion of *multiple varied conceptions* can be seen as a challenge to a theory of conceptual change, which assumes *conceptual stability* and does not focus on the dynamics of awareness (Pong, 1999). If multiple, varied conceptions are context dependent, it appears more important to be able to recognise a context, discerning some of its features into focal awareness, and in this sense evoke an *appropriate* conception, in terms of *conceptual appreciation*, delimited by the particular context (cf. Linder, 1993).

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Boring but Vital – How Should We Teach Our Students about Chemical Safety?

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Abstract. *One of the most important considerations in the operation of a science laboratory is safety. This paper discusses why an understanding of safety issues in the laboratory is as vital as a knowledge of the science itself, and suggests a number of ways of promoting an appreciation of safety issues among students.*

Keywords. Accident, chemical, chemistry, hazard, risk assessment, safety.

1. Introduction

Safety should be an influence on every aspect of the way that science is taught, both at school and in College or University. However, while this is easy to state, it is not always easy to put into practice.

All competent science teachers appreciate the importance of safety, but students may regard it as an irrelevance, or as an inconvenience that gets in the way of "real" science. They might be required to wear a lab coat and use safety glasses in the laboratory, but only comply with these rules because they are mandatory. Students tend, especially in their teens, to doubt the need for protection from chemicals, and to be particularly uninterested in protection from themselves and from their co-workers. By contrast, school administrators may take exactly the opposite position, fearing litigation were an accident to occur in a laboratory in which safety precautions were not being followed to the letter.

Both students and administrators may, for quite different reasons, see safety as a separate matter from the underlying science. In fact, science and safety are inextricably linked, as several case studies in this paper will illustrate. These case studies are drawn from a variety of real incidents reported on the media or on the Internet. In most cases those concerned have deliberately not been identified.

1.1. Case Study A

A chemistry laboratory activity on the web describes a potentially valuable exercise for science students in a high school. Groups of students are given a hypothetical budget of $20,000, and are then issued with promotional literature and catalogues from science suppliers. Their task is to furnish from scratch an imaginary science laboratory.

Among the stated aims of the exercise is that the students should "...review the safety equipment needed for a chemistry lab", which suggests that safe working will be a key consideration. However, in the exercise no indication is given about how safe working within the laboratory could be promoted.

In fact, the task of buying equipment for the imaginary laboratory appears to be completely detached from its subsequent operation, though in fact the two should be closely linked; safety should influence the purchasing decisions at every stage.

This exercise is potentially valuable. It would be regarded as an interesting challenge by typical students, but the way that it is presented plays down the importance of safety. The exercise may give students the impression that safety is an extra that can be bolted on once laboratory design is complete. This is an unfortunate - and potentially dangerous - view.

2. Integration of safety into teaching

Safety should be a part of everything that we do in the practical science laboratory. In this paper, we consider first the principle reasons why safety is so crucial in the school laboratory, beginning with the most obvious reason – the need to avoid accidents.

2.1 Safe practice

It is clear that chemistry students, and those who study other subjects but must use chemicals in their practical work, need to learn about chemical hazards so that they can carry out experiments safely. Instruction designed to ensure safe working not only protects students, but also the school in the unfortunate event of an accident. Case Study B illustrates how inadequate or inappropriate preparation for a practical demonstration can have serious consequences.

2.1.1 Case Study B

"I never saw anything like it," said student Diana S, who was in the chemistry lab when the blast occurred.

This second case study concerns an accident in a school chemistry laboratory. The local news media reported that:

A beaker exploded Friday after a chemistry experiment went awry at X High School, sending out a fireball that burned three students and a teacher.

The explosion occurred [as a] teacher was attempting to perform a common experiment that uses methanol and mineral salts to show how different metals produce different colors of flames.

She told the class, "This is why fireworks turn colors," and proceeded to pour material into a glass beaker…..the teacher [then] attempted to ignite methanol in some coffee cup-sized glass beakers. "When they failed to ignite, she began to add more methanol. … there was an explosion as the undetected flame ignited the fresh vapors," fire officials said.

It appears that the teacher in this instance had not fully appreciated the danger to both herself and to her students of what she was doing. Methanol burns with a flame that is hard to see, especially in a well-lit room. Evidently the accident was a result of her failure to recognize this, or to be aware that far safer methods for conducting flame tests exist.

2.2 Understanding chemical properties

It is essential to ensure safe working conditions in order to avoid accidents of the type outlined in Case Study B, but there are further reasons why safety should routinely be integrated into teaching, among them the opportunity that safety instruction provides to reinforce other aspects of science.

When a substance poses a risk to those handling it, this risk is a direct reflection of the substance's chemical or physical properties. Because the hazards that the substance presents are determined by its structure, as students learn about safety they can simultaneously be developing their knowledge of chemistry itself. The safety message and the chemical understanding reinforce each other.

2.2.2 Case Study C

Tuesday was just the second day of class at Y High School when teacher M began his science experiment, which had always been exciting but safe. Instead, a 5-gallon glass water cooler bottle shattered, sending shards of glass flying across the room and 22 students to local emergency rooms.

This was another incident illustrating the dangers of using methanol in other than well-controlled conditions. The reaction of local officials was perhaps surprising.

Officials quickly determined that the explosion was simply an unfortunate accident.

"Unfortunate" the event certainly was, and "accident", in the sense that it was unexpected, was a good description of what had happened. However the combination of these words into the phrase "unfortunate accident" seems to suggest that the incident could not have been foreseen, which would not appear to be the case.

"This was an approved demonstration experiment," High School principal D said. "What went wrong nobody can tell at this point."

A local University Professor provided a more detailed explanation of what had gone wrong:

"Methanol is …. used in a variety of experiments because it burns clean and, under normal circumstances, is quite controllable. The problem with methanol, a volatile liquid, is that it gives off vapors at a low temperature, around 50 degrees. It has a "wide flammability range" which means that there doesn't have to be a thick concentration of vapours for a fire to ignite."

Notice in this explanation the degree to which the accident might have been anticipated through a knowledge of the properties of the chemical involved. Methanol "burns"; it is "volatile", it generates significant quantities of vapour at modest temperatures and has a "wide flammability range". If these properties had been known to the students and kept in mind by both them and their teacher, the "unfortunate accident" might have been avoided.

As one of the students in class subsequently is reported to have commented:

"And people ask me why I don't like chemistry."

while a parent commented more perceptively

"An accident isn't really an accident. It's someone else's mistake."

2.3 Long term appreciation of safety

Every substance that exists is a chemical. However, consumers are often impressed when a product contains "no chemical additives", or that "no chemical fertilizer was used in the production of this grain", since there is an increasing desire to avoid "chemicals" in food.

This illustrates the deep apprehension - and misapprehension - that exists amongst members of the public about chemicals. Quite reasonably they wish to avoid putting themselves or the environment in danger, but lack the basic knowledge required to make reasoned judgments about whether their actions may do this.

Many difficult environmental and ethical scientific issues exist on which there are wide differences of opinion among the public: genetic manipulation, the greenhouse effect and global warming, the enlargement of the ozone hole, the discovery of residues of contraceptives and agricultural fertilizers in drinking water, the widespread use of colourants in food and more.

Ideally, decisions about such matters would be taken by the population at large, not by scientists alone or (much worse!) just by politicians. However, without an adequate understanding of safety or, more broadly, science, people make decisions on the basis of gut feelings, or incomplete knowledge.

Within a few years of studying science at High School, students will find themselves with the power to influence decisions, as voters, or even the chance to put forward possible courses of action, as lawmakers. In order to assess realistically the hazards associated with a chemical, an understanding of safety and the ability to make a realistic judgment about the potential hazards of an operation or chemical are vital.

The failure to make justifiable assessments of risk is illustrated by the several chemicals that are discussed in Case Study D.

2.3.1 Case Study D

The Food Standards Agency (FSA) in the UK is a government-funded body responsible for ensuring the safety of all consumer foods.

In February 2005, the FSA became aware that a batch of chili powder used in the preparation of a range of foods had been contaminated with Sudan I. Sudan I, a bright red dye licensed for use in a variety of products but not, in most countries, in food, had apparently been illegally added by suppliers in the Indian subcontinent to a batch of raw chili powder to make it appear more appealing. More than 450 food products in the UK suspected of contamination were removed from shops within days but the problem quickly emerged in other countries as products that might have been contaminated before export were identified.

The rapid action taken by the FSA in the UK, and by similar bodies in other countries was understandable. The IARC had previously reported that Sudan I had been found to be carcinogenic in mice following its subcutaneous administration, producing tumors of the liver. It was thus judged by the FSA to be dangerous to health.

But was the action taken by the FSA a realistic and proportionate response to the dangers posed by Sudan I, or just one that the public would expect and approve of?

Although the IARC stated that Sudan I was carcinogenic by subcutaneous administration, it also reported that tests by oral administration in mice and rats were negative.

Food Standards Australia similarly indicated that the dye did not present an immediate or serious risk:

"There is ..... no evidence that [Sudan I dye] can cause harm in humans, particular at the low levels found in these foods."

In view of the very low level of any Sudan I residue and the fact that any contaminated food would have been swallowed rather than administered subcutaneously, it is reasonable to conclude that the real risk posed by the contamination was almost certainly negligible.

Despite this, there was a high level of concern among consumers in Europe. The public response to the withdrawal of food products was revealing. On 10th March an anonymous poster on Irishhealth.com wrote

"What worries me is what other dangerous additives are in food. If you look at the list of ingredients on some of the packaged foods, some of the items listed are barely pronounceable."

The implication that a chemical whose name one cannot articulate is somehow more dangerous than one whose name one can, is surely not a view that a scientist would have sympathy with.

Irishhealth.com reported that

".... many people contacting the authority .... wanted to know whether they could check the ingredients on packets of food for [Sudan I]. But as it should not be in food in the first place, it is obviously not listed. "

This sort of query from consumers reveals both a deep level of mistrust about "chemicals" in foods and a serious of understanding about how one might assess any dangers.

A further illustration of how difficult it is for the general public to know what chemicals are or are not safe is provided by the NTP (National Toxicology Program).

In its 11th RoC report, released on Jan 31, 2005, the NTP identified 2-amino-3,4-dimethylimidazo[4,5-f]quinoline and phenylimidazopyridine as potential carcinogens; both may be formed when meat or fish is grilled at a high temperature or barbecued. Sudan I is not listed by NTP as a carcinogen, but these chemicals produced by barbecuing are.

It is illogical, though perhaps understandable, that many people would be happy to continue to barbecue meat and fish, but at the same time would feel nervous about eating a commercial product contaminated with a dye which represents perhaps only a modest danger and is present in foods at levels so low as to be close to or below detectable limits.

This reluctance or inability to accurately assess the harm that a chemical might pose is deeply embedded, as a further example illustrates.

Acetaldehyde is classified by NTP as one that is reasonably anticipated to be a human carcinogen.

Should we therefore be trying to avoid all exposure to acetaldehyde? In fact, it would be extremely hard to do so: acetaldehyde is used as a flavoring agent and adjuvant. It is added to milk products, baked goods, fruit juices, candy, desserts, and soft drinks to impart orange, apple, and butter flavors. It is used in the manufacture of vinegar and yeast and as a fruit and fish preservative. It is found in trace amounts in all ripe fruits and may form in wine and other alcoholic beverages after exposure to air. It is found in leaf tobacco, tobacco smoke and automobile and diesel exhaust.

It is a product of alcohol fermentation and is a metabolic intermediate in higher plants. It is a volatile component of cotton leaves and blossoms. Acetaldehyde occurs in oak and tobacco leaves and is a natural component of apples, broccoli, coffee, grapefruit, grapes, lemons, mushrooms, onions, oranges, peaches, pears, pineapples, raspberries, and strawberries.

There are numerous other sources, including cheese, cooked chicken, rum, room deodorizers, marijuana, cigarette smoke, burning wood, forest fires, volcanoes, rosemary oil, mustard, and ambient air. It is clear that this is a ubiquitous chemical. Despite that, it is listed as a hazardous air pollutant by NESHAP and a potential occupational carcinogen.

This lengthy case study illustrates how difficult it is to assess potentially harmful chemicals and determine how one should react to their presence in the environment. Only in the easiest of cases, for example exposure to cigarette smoke, are the hazards well documented and means of avoidance simple to understand.

However, exposure to moderately harmful chemicals is very widespread, indeed it is virtually unavoidable, and the scientific training needed to make informed decisions regarding such exposure resides with only a small proportion of the population. If safety becomes more deeply embedded in science teaching we may be able to create a population more able to make the critical judgments about chemical exposure.

3. What are we doing wrong?

Science has a mixed public image. Scientists have been responsible for great advances in society, but for great threats too.

At school, science may have a "nerdy" image, and enthusiastic science teachers can try to raise its popularity by engaging in spectacular and flashy experiments, to create excitement about the subject. Such experiments are often memorable, perhaps in proportion to how dangerous they are, and may succeed in increasing interest in science.

Nevertheless, they are not without their disadvantages. From them, students may get a distorted picture of both science and safety. They may come to believe that the dangers in chemistry are readily observable and controlled: "See, the chemistry teacher gets this spectacular explosion right every time, she never blows her hand off". Conversely, they may come to believe that chemistry is the science of danger, full of hazardous and unpredictable materials.

Neither view is the whole truth, but much of the rather poor reputation that chemistry has can be traced back to this kind of unbalanced view of the threat that chemicals pose. Safety depends upon context: chlorofluorocarbons (CFCs) are inert at ground level, yet present a hazard in the stratosphere where they destroy ozone. By contrast, ozone itself is harmful to both animals and materials at ground level, yet life would be virtually impossible without its presence in the upper atmosphere. Some understanding of science is necessary to understand how such chemicals can be both safe and harmful.

4. How can we improve safety?

As the earlier case studies illustrate, one of the most important responsibilities of the teacher is to develop in students an understanding of safe practice.

With suitable instruction and encouragement students will work more safely in the laboratory; they will more readily comprehend the properties of substances if they understand that safety and chemical structure are linked; they will be able to make more reliable judgments about important scientific issues in the “outside world” if they have been well versed in safety matters; and they will be more likely to see the chemistry teacher's flash-bang experiments for what they are - demonstrations of the properties of exceptional chemicals, not a demonstration of how everyday chemicals can be expected to behave.

Improving students' understanding of safety so that they both learn effectively and work safely requires an attack on several fronts. While many of the suggestions below are straightforward, there will perhaps be some ideas for improving safety in the classroom you have not tried.

1. Safety is not optional, so cannot be open to negotiation between students and teacher.

More than in any other area, it is essential that safety rules be clear, unambiguous and rigorously enforced. The requirement to work safely should be as central to the course as the use of textbooks.

2. Students should be provided in advance with safety data where appropriate, but also encouraged to search for data on-line or in books so as to become familiar with sources of data, their structure, and the abstraction of relevant information from them.

Time required for initial instruction on how to search will be time well spent. However searching must be done with care - simply typing "Ethanol MSDS" into a search engine will generate hundreds of thousands of hits, but the data must be in a form that students can understand without additional help. Detailed MSDS data are difficult to interpret, so a short list of web sites that provide data in a suitably simplified form is helpful.

The HSci Safety web site [1] provides data on a number of common chemicals in a format that is readily interpretable, and suggestions for additional chemicals for inclusion on the site are welcome.

It is valuable to assess web sites before they, or particular pages from them, are recommended for use, otherwise the information that they provide can be counterproductive. For example, the otherwise very helpful site LabSafety.org reports that

"While many lab accidents involve methanol—an extremely flammable liquid also known as methyl chloride—........"

3. Safety should not be treated as an after-thought, tacked on at the end of the instructions for an experiment.

Whenever the risks presented by a chemical are being discussed, an attempt should be made to spell out the physical and chemical reasons *why* a chemical is dangerous, not just the fact that it is.

Diethyl ether presents a considerable fire and explosion risk. This should be explained by making it clear that the ether is very volatile (due to its low molecular weight and the comparatively low intermolecular forces in the liquid), that it forms a heavy vapour that can travel across benches and settle in sinks (molecular weight significantly higher than that of air) and that it burns very vigorously (formation of carbon dioxide and water from organic compounds is usually very exothermic). The linking of safety matters to properties should enhance student understanding of both, as well as encouraging them to think!

4. The health and safety hazards of all substances involved in a procedure should be researched and noted down by students before the experiment is begun.

If students have discovered for themselves that they will suffer burns if the chemical is spilled on the skin, the message seems to have more of an impact than if they are merely told about it. An occasional check on students' safety research before they start work will encourage them to do a good job.

5. When environmental issues can be introduced into a discussion, they should be treated in an unbiased fashion, neither emphasizing nor downplaying the risks.

Encourage students to interpret environmental problems in terms of the way the chemicals behave, not just the fact that chemicals can, under certain circumstances, be harmful.

For example, CFCs are stable and harmless at ground level, but harmful in the stratosphere and so have largely been phased out of use in refrigerators, deodorants, etc. It would be simple to explain that CFCs have been found to damage the upper atmosphere by destroying ozone, but it is surely better to explain why there is a problem.

What particular properties of a CFC are responsible for its classification as a pollutant? If CFCs are banned, can we estimate how many years will pass before they no longer present a hazard? The lifetime of CFCs in the atmosphere is very long; what feature of these compounds and their behaviour is responsible for this? When chemicals such as CFCs are banned, how can we judge whether alternative chemicals will be any better? Might the environmental impact of alternatives be different but perhaps just as harmful?

By tackling a topic in this way, the safety issues are integrated into a study of chemistry and the environment, making the whole exercise both more effective and more interesting.

6. Students must be encouraged to appreciate that environmental issues are almost always complex.

For example, DDT concentrates in body fat and has had a serious effect on the reproductive capabilities of wildlife near the top of the food chain in many parts of the world. Consequently it is now rarely used.

However, common replacements for DDT are inferior in terms of mosquito control, and it is legitimate to ask what level of suffering amongst humans and their livestock is permissible to obtain a given improvement in the welfare of surrounding wildlife. There is no easy answer to such a question, but students will gain much by being given the opportunity to consider it.

7. Students should be asked to take sides when debating issues of safety.

By doing so they will learn to appreciate the complex nature of environmental decision-making and be better able to make a reasoned judgment in the future.

8. Links between safety and ethical issues should be addressed.

Who is responsible if a hazardous chemical is dumped illegally in a water course, or if an industrial company allows toxic waste to contaminate its land? The answer is obvious, but not all pollution problems can be so easily laid at someone else's door. Who is responsible if a municipal water supply becomes contaminated with residues of contraceptive pills, as is now happening in many western countries? In some senses the risks presented by chemical contamination are only a small part of a story since most chemicals produced industrially are harmful only if used in inappropriate ways.

9. Everything is chemical – this should be made clear from the start of a course, as soon as students learn what a chemical is.

The belief that "chemical" fertilizers are harmful while "natural" fertilizers are safe reveals a gross misunderstanding of what the term “chemical” means. A blanket view of the safety of chemicals is neither necessary nor wise. The chemicals that are given "E numbers" when added to foods include many that are therapeutic, yet it is common to hear people arguing that the fewer E-numbers a food contains the better it must be. It is helpful if positive images of chemicals are presented, for example their use in recycling, to counteract the inevitable negative examples.

10. Where possible, the hazards that a chemical may pose should be related to its position on the Periodic Table and to the behaviour of those chemicals close to it on the Table.

Students learn almost as soon as they encounter the Periodic Table that all elements in group I produce corrosive hydroxides and that those in Group 8 are inert and therefore generally safe. The hazardous properties of chemicals can be considered alongside other properties, such as mass or degree of metallic properties. It is also often helpful for students to be asked to compare two substances, both chemically and in terms of the hazards they might present.

11. A standalone safety course should not be used to replace more traditional approaches unless there are strong arguments in its favour.

A course devoted entirely to safety is almost inevitably theoretical rather than practical, but the best way to learn about safety is by learning from a competent teacher in the laboratory. When a purpose-built safety course is offered, those teaching “standard” science courses may feel that safety has been adequately covered elsewhere and that they need give little further instruction, or just rely on showing a CD once a term.

12. Within a group of students the burden of finding out about safety should not fall on a just one.

It is tempting for a group of students to assign the task of researching safety issues to one of their number, while the others get on with the experimental side of the task. However, the experimentalists may then fail to appreciate the safety implications of what they are doing, or overtake the safety expert in the group and encounter a problem before the relevant safety information has been located.

13. Students should spell out, in written form, the health and safety implications of the experiment before they start work.

The analysis should explain *in their own words* how the students will minimize or eliminate relevant risks - a few printed pages of MSDS data should not be regarded as sufficient to demonstrate an understanding of the problems that might arise.

It is helpful to ask students to speculate about "what could go wrong?" Suppose the beaker of flammable liquid they are using is knocked onto the bench and breaks, spreading liquid across the bench; is there a source of ignition nearby? If a fire ensured, are there other chemicals on the bench or shelves above it that might also catch fire and perhaps lead to a major incident?

14. Approaches should be tailored to the needs of different groups of students.

Clearly a group of ten-year olds will need a different approach from a group of seventeen-year-olds, but so too will a group of chemists need an approach that is different from that required for a group whose interest is in geography or biology.

15. Both processes and properties should be discussed.

Runaway reactions are responsible for accidents in industrial laboratories and in university teaching laboratories each year. Discussing these reactions provides an excellent core topic around which the interplay between kinetics and thermodynamics can be discussed.

5. References

This section contains references to a small number of online sources of information on safety. The Internet is a somewhat less reliable source of data than the printed page, but is undoubtedly cheaper and generally more convenient. With care, therefore, in the choice of web sites, the web can provide an effective means of securing safety data for all the common chemicals used in the laboratory.

[1] The HSci database of chemical information for students provides data on a small but growing number of chemicals that are widely used in school and College laboratories. Suggestions for additions to the database are welcomed by the database owner and are normally dealt with rapidly.

http://ptcl.chem.ox.ac.uk/~hmc/hsci/hsci_chemicals_list.html [June 1, 2005]

The Safety Database of the Physical and Theoretical Chemistry Laboratory at Oxford University contains a wide range of safety data, covering not just chemicals but reactivity and other risks, a chemical glossary, data regarding choice of protective gloves and similar information. http://ptcl.chem.ox.ac.uk/MSDS [June 1, 2005]

The Siri web site contains links to a large database, much of it provided by suppliers of chemicals. There are numerous further useful links. http://www2.siri.org/msds/index.php [June 1, 2005]

The Occupational Safety and Health Administration and its sister agency NIOSH provide extensive background data, and is a useful resource for those investigating policy rather than just the safety of specific chemicals. http://www.osha.gov/ [June 1, 2005]

The U.S. Environmental Protection Agency web site is a second source of general information about a wide range of environmental and safety issues. http://www.epa.gov/ [June 1, 2005]

The EPA and OSHA web sites are sufficiently complex that, if you intend to use them in class, it is wise to do some preliminary research so that you can readily direct students to useful information if they get lost!

Science with a Difference – Organising Planet Walk in Malta

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Abstract. *Even to this very day, many look at science as something that is done in a classroom. Perhaps, an experiment conducted in a laboratory may relate well to what one understands by 'Science'.*

A group of twenty young people in Malta decided it is time to show that science can be done with a difference. These young people formed a club, which they called Astro-Club. They got to know about 'Planet Walk' from the author of this paper who is the advisor to the group. With their enthusiasm for science, directed especially towards Astronomy, they started on a venture aimed at setting up 'Planet Walk' in Malta, thus aiming at promoting science to the general public. The project generated a lot of energy amongst the group members. They knew that nothing like this had ever been done in Malta. This presented more of a challenge.

This paper looks at the process, the difficulties encountered and the satisfaction involved in creating 'Planet Walk', offering an incentive and encouragement for others to follow and create more "Planet Walks" in their own countries.

It is argued that the wonder and mystery that are related to astronomy may be used further towards promoting a better attitude towards science, laying the foundations for a long-term relationship between the world of science and the child. An explanation is offered as to how science can become more exciting and how it can be taken out of the classroom and used fruitfully, showing that science has all to do with the way we live.

Keywords. Astronomy, Clubs, Intellectual Curiosity, Planet Walk.

1. Introduction

Malta is a small island in the middle of the Mediterranean Sea. The island is renowned for its heritage – museums, churches, archeological sites, megalithic temples and plenty more for the islanders and many a visitor from abroad to see and to appreciate in terms of a cultural and historical experience. However, the issue that is being discussed in this paper focuses on the scientific aspect of what Malta can offer.

Some important points that one can ponder upon are:

(a) What does 'Science' stand for in as far as the Maltese population is concerned?
(b) How big an issue is 'Science' in Malta?
(c) What importance do the Maltese give to science education?
(d) Which are the sites on the island that one can visit in order to increase one's motivation towards the appreciation of the fact that science can be fun and is alive?

2. Science in the Maltese context

In order to try and answer the above questions briefly, one may begin with a general example. The issue of the environment in Malta may be considered. Many Maltese have become aware of the importance of keeping our environment clean. Government regulations regarding waste management and pollution overall, have helped a lot in this regard. Reading the regular Environment Section articles of the Maltese weekly newspaper "The Sunday Times" (2004-2005) gives full evidence of this. But, on the other hand, does the general public necessarily relate waste management to 'Science'? Even to this very day, when the word 'Science' is mentioned, more often than not, a science class comes to people's minds. Perhaps even an experiment conducted in a laboratory may relate well to what one understands by 'Science'. Some may associate 'Science' with the reading of long, maybe abstract or difficult to understand text, with calculations involving sometimes easy or at other times difficult mathematics.

3. Science in Maltese schools

In Maltese schools, students are taught General Science in their primary classes, going on to do the separate sciences throughout their secondary education. The National Minimum Curriculum emphasizes the importance of instilling in our students, a greater awareness of the role of science and technology in everyday life through

- arousing curiosity concerning natural phenomena and stimulating the asking of questions about them,
- presenting science as a systematic means of asking and attempting to answer questions arising from observations,
- recognizing that different students can experience science differently.

(Ministry of Education, 1999, p.49)

In fact, a Science Centre exists within the Department of Curriculum Development of the Education Division in Malta. In a recent interview conducted during the month of June 2005, with the teacher in charge of this centre, it was confirmed that the work of the centre is aimed at developing the curriculum related to primary and secondary science and helping to better implement it in schools. The centre provides ongoing in-service training for science teachers in primary and secondary schools – training aimed at improving teaching methodologies so as to try to teach and reach all students. When asked about whether specific school outings were set by the department, for schools to be prompted to indulge in educational visits, the response was that with more decentralization, state schools have been given autonomy to act on their own. It is up to the teacher to decide where to take the students and to choose the type of visits which are expected to be most beneficial for that particular class and level of education.

Indeed, educational outings have always been organized for school children of different ages. Educators know that "good practice has always looked outward from the classroom and has drawn on the known experience of children to illustrate and instruct" (Hopkins, 1968, p.1-9). Specific reference to such outings was made in a B.A (Educ) dissertation written in 1981. Some of the outings with a scientific aspect were described and analysed for effectiveness. Amongst these outings, the authors mentioned a ship repair facility, a brewery, a printing press, the Meteorological Office, the Government milk production facility, the power station, an edible oil production plant and the Natural History Museum.

Today, other establishments have been set up like, for example, a Nature Theme Park, which includes a mini zoo (Guzeppina Deguara Primary School website). During an interview with the Headmistress of a Junior Lyceum Secondary School, some other outings with a scientific theme were identified. Students had actually visited these places during the scholastic year 2004/2005. These included the Plant Propagation Unit, where plants are propagated by tissue culture, a National Nature Reserve, and also a Centre for the Study of Marine life. Progress definitely brings about changes and additions. This Headmistress said that students are taken out on scientific outings three times per scholastic year. She said that school outings are a possibility but they are not obligatory. In fact, some teachers prefer to do experiments in the laboratory, to taking their students on outings.

If one looks closely at the places that students are taken to visit, one realizes that except for the Natural History Museum, the rest are either private enterprises or Government establishments where one needs to ask for permission before entering.

However, one must also mention 'Science Week' in Malta, which is another scientific activity that has gathered momentum these last years. It is a hands-on exhibition organized "to get people interested in science in a fun way" (The Malta Independent, April 2005).

When one considers all of the above, one can say that while it can be that not all the Maltese can relate all scientific issues to Science yet policy makers do realize the importance of Science and science education. It is the expression of this importance into even more practice, which is what is highly desired and yearned for. With the importance of science that exists in every aspect of one's life and the great need to increase public awareness of science as well as interest in everything around us, one can never say that one is doing enough.

4. Why Astro-Club?

At the beginning of the scholastic year 2004-2005, the author of this paper made a call to students at the institution where she lectures in Physics, suggesting the start of an Astronomy Club with the aim of increasing awareness that science can be done with a difference. The choice ended up on Astronomy because it has a sense of wonder and mystery linked to it – something that all of us are intrigued with. A number of young people aged sixteen to twenty two, were enthusiastic about the idea and formed the group, some also bringing their friends with them. The group consists of twenty members, boys and girls, and meets every week.

Ever since the first meeting, the group of youths has shown a lot of energy directed towards what can be done for Malta, in relation to science. Their motto is the same as described by Mayo (2002): “Making a difference in the science education community”

The group decided to call themselves Astro-Club and the Logo they designed for their club can be seen in Fig. 1.

Figure 1. Astro-Club Logo

During an HSci conference held in Cologne in 2004, the author of this paper, as advisor to the group, had learnt about ‘Planet Walk’. The idea of setting up ‘Planet Walk’ in Malta was mentioned to Astro-Club members. The group showed a lot of enthusiasm at the possibility of working at something scientific, on a large scale. They saw a great challenge in working to make project ‘Planet Walk’ a reality and bring it to completion.

5. What is Planet Walk?

One of the most incomprehensive aspects of Astronomy is, in fact, the large distances involved. Even our own solar system’s distances are quite hard to imagine. In ‘Planet Walk’ a number of monuments, starting with the Sun, is set up in such a way that visitors can get the feel of how the solar system is organized, by walking from one monument to the next. The distances between the monuments are in the same ratio as the actual distances between the Sun and the planets in the solar system, but, of course, scaled down. The planets are also scaled down in size and this truly adds perspective to the ‘Planet Walk’ (Walking through the Solar System, 2005). What makes ‘Planet Walk’ so fascinating is the fact that it helps to physically experience the solar system “in a way that no other medium (book, computer) can. Anyone can directly grasp the dimensions of the solar system” (Planetenweg, 2004).

A number of planet walks are already in existence in the world. There are definitely planet walks in Germany, Sweden, the United States and also in the United Kingdom. It is of interest to know that the first planet walk in the world was set up in 1971 in the German city of Hagen and the largest model in the world is in Illinois, USA (scale 1 : 125,000,000), which extends for a distance of 64 kilometers (Planetenweg, 2004)

6. The Project: The work of Astro-Club members

As one can imagine, it is no joke to take up an initiative such as ‘Planet Walk’ and bring it to completion. Astro-Club, being a non-Governmental, non-profit making organization, working on a voluntary basis, realized that the biggest problem was going to be one of financing the project. The members, therefore, applied for the Youth Programme: Action 3 of the European Union and were fortunate enough to get recognition for what they aim to do and thus received some funding. However, these funds are not enough to finance a project that involves the setting up of ten monuments, including the sun, together with a plaque near each monument showing some basic information about each planet. The group is thus working at trying to get more funds – mainly from those who will be the future beneficiaries of ‘Planet Walk’, namely the general public, including school children, all of whom will gain from the ‘Planet Walk’ experience once this is finished. They are also contacting important institutions, with the aim of finding more sponsors.

The group has done a lot of research. This will be used as base knowledge to set up the monuments that will be a unique set, specifically designed for Malta. The group also intends to contact members from other local astronomy groups, in order to discuss their work with the members of these groups and thus get feedback for their project. Thus, if any changes need to be done, they will be done before the monuments are set up.

After a study of the various places where best to set up ‘Planet Walk” on the island, a nice promenade by the sea, extending over 2 kilometers, has been located. Astro-Club members talked to the Local Council under whose jurisdiction this site falls and, after a committee meeting, the Council approved the Planet Walk Project. An adequate scale was chosen for the distances between the monuments and also the relevant sizes required. Table 1 shows the actual diameter of the sun and each planet, as well as their distances from the sun, and the relative scale values to be used for Planet Walk.

Table 1. The Sun's satellites

	diameter (km)	model scale size (cm)	distance from Sun ($x10^3$km)	scale distance in walk (m)
Sun	1,390,000	200		
Mercury	4,878	0.70	57,910	19.59
Venus	12,104	1.74	108,200	36.59
Earth	12,756	1.84	149,600	50.60
Mars	6,794	0.98	227,940	77.09
Jupiter	142,984	20.57	778,330	263.24
Saturn	120,536	17.34	1,426,940	482.60
Uranus	51,118	7.36	2,870,990	970.99
Neptune	49,528	7.13	4,497,070	1,520.95
Pluto	2,320	0.33	5,913,520	2,000.00
scale	1 : 695,000,000		1 : 295,676,000	

The group set to work hard in coming up with various designs of the monuments, visiting local artisans and getting feedback about the feasibility of their designs, as well as the costs involved. However, a major difficulty has still to be overcome. A permit is required from the Malta Environment and Planning Authority (MEPA), which is the regulatory body in Malta, to set the monuments on site once they are completed. At the moment Astro-Club is working with the Council's architect in order to decide on the final design of the monuments and their layout and in drawing final plans to be submitted to MEPA for approval. The group is trying to avoid disrupting the promenade as much as possible, so that the costs will be reduced and so that approval will be easier to obtain.

A lot of work still needs to be done. The group is also trying to promote awareness amongst the Maltese. A publicity campaign has been launched and members of the group have already appeared on two popular television programs explaining the project and its aims. The group intends to continue to work hard through the summer months, bringing the project to completion by the end of this year.

7. The wonder of astronomy

This project has made more evident once again, that science can be approached with enthusiasm. Astro-Club members joined the group because they were looking for something more than what was being offered to them elsewhere. This need not have been just Astronomy. It could have been that they were looking for new friends through the club, for example, but those who looked only for something outside astronomy left the group, once they got what they wanted. Those really interested in Astronomy stayed on and have a great desire to see the fruits of what they started. This has been expressed by the members of Astro-Club themselves, in answers that they gave to a questionnaire, which was used to get feedback from the group.

8. Foundations of scientific knowledge

The following are some responses to questionnaire that undoubtedly need further reflection.

M1: ' I joined the group because I like astronomy a lot…., since I was a child. I think that we should be able to finish our project but problems may arise due to lack of money and time.'

M2: 'Astronomy is one of the subjects I really get interested in.'

M3: 'I joined the group to broaden my knowledge about Astronomy and also to meet new people and make new friends. I have been interested in Astronomy since I got to know that there are other planets besides our Earth and got to know about the Universe and what it is made up of. I believe that if everyone makes an effort we will be ready by the end of the year.'

M4: 'Originally I joined Astro-Club because I was interested in Astronomy. I've been interested since I was 12 years old. It is possible to get the project done. Our pace is slow at the moment, due to exams. This makes it less likely for us to get it done; not unless we work really fast through the summer'.

These quotes show that these members have built their foundations of astronomy quite some time earlier on. But we have to be careful of what we really mean by 'foundations of scientific knowledge'. Indeed, the word 'foundations' may be misleading. One can interpret the word as a base, consisting of concepts and skills, which, once acquired at an early age, can secure the construction of the whole edifice of scientific knowledge. However, it can also be argued that while a strong conceptual base is a prerequisite for this construction, yet the latter cannot take place without the establishment of a long-term relationship between the world of science and the child. The implication is that early childhood education should work at creating the right attitudes towards science. It is attitudes that are even "more important than a strong conceptual base since they are the motivators for children's engagements in science activities. Intellectual curiosity, for example, is such an attitude" (Hadzigeorgiou, 2001).

On the other hand, it is interesting to look at some answers to the question, 'What is Science to you?':

M1: For me science is part of my life. I like to study it a lot, especially Chemistry and Biology. I like to learn about our mysterious world and universe.

M2: Understanding the facts of life, the answer to why certain things happen.

M3: Science is what I see. It provides answers to certain things and gives solutions for a better life.

M4: Science is knowing what is around you, why things happen the way they do…it is logical and requires reasoning. It provides answers to many of our questions - though not to all… Science could ultimately lead to discovering more about yourself.

These are answers coming from people with an enthusiastic attitude towards science. Astro-Club members are simply emphasizing the importance of Science for ALL. "The greatest insight into the way scientific knowledge is acquired will be gained by students if they themselves are engaged in real science activities. This will include not only their personal investigative work, but sharing their ideas and results at meetings and contributing to and reading journals" (Driver et al , 1997, p.147).

9. Conclusion

What Astro-Club members are actually doing is making 'Science' part of their every day life experience. "Science is an adventure that people everywhere can take part in, as they have done for many centuries" (Science for All Americans: Benchmarks On-line, 2005, p.12)

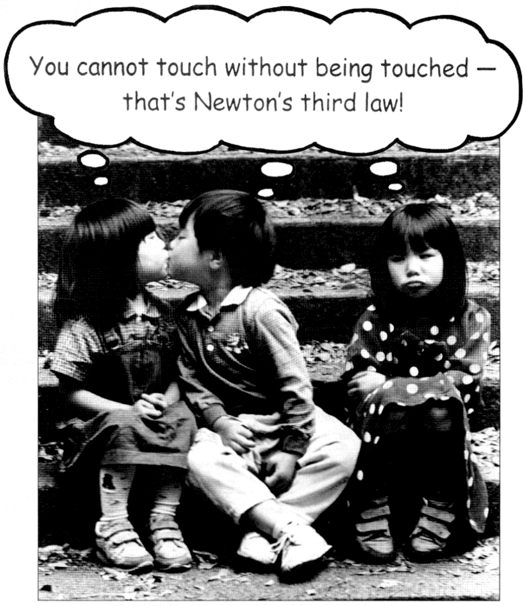
Moreover, the formation of the club is giving the club members a better chance to grow socially through meeting new people with similar interests. Together they can learn to co-operate with each other, forming part of a team. They learn how to gain the courage to discuss and ask questions, exposing their ideas to criticism. Through the meetings they gain confidence at clearly communicating their views, also evaluating and improving their critical thinking skills and independent thought.

The high enthusiasm generated in the expectations for the project to work, is helping to improve the attitude of the members of the group towards science. Some members have explicitly said, in their questionnaire answers and during informal meetings, that they look forward to the weekly meetings. They have learnt that science is not necessarily a set of facts or a pack of notes to be memorized. Whitehead (1929) rightly believed "that any subject should first come alive and become stimulating before the student can establish a long-term relationship with it". It is, indeed, such a relationship that educators wish for every child or student under their care.

In as far as the advisor's role is concerned, this is a position that must be handled with care. A good balance must exist between the advisor as a member of the group and the professional who is there to give advice when required. All members need to feel comfortable as they talk to the advisor and air their views. It is the job of the advisor, as the mature individual in the group, to initiate and maintain interest in what is going on and in what needs to be done. Through brainstorming, one realizes how many ideas the members come up with. Young people are indeed a wellspring of ideas. The advisor has to guide the club members so that right choices are made, emphasizing the practical perspective of the plans and the jobs that need to be done in relation to the project.

In conclusion, it is hoped that not only will Planet Walk in Malta be a pleasant experience for all visitors to the site, but that, more especially, it will be one of those sparks that will generate wonder and enthusiasm for science, thus laying a solid foundation for a life-long interest and understanding in Science. The author also wishes that there would be more Astro-Clubs and Planet Walks, budding in other countries. One must find the courage to take the plunge, similar to what Astro-Club is doing now in Malta. One must remember that unless one acts, one cannot expect anything back.

Newton's Third Law of Motion that "for every action there is an equal and opposite reaction", gives us more reason to be sure of this.



(Hewitt, 2002, p.19)

Figure 2. Newton's Third Law

10. Acknowledgements

The author thanks Ms. M. Theuma (Teacher in charge of Curriculum Development within the Education Division) and Ms. M. Bonnici (Head of Sir Adrian Dingli - Girls' Junior Lyceum) for allowing the author to interview them at short notice.

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Mathematics and Technology: Infinity through a WebQuest

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Abstract. *As technology becomes more available in classrooms, it is essential that teachers be secure with the use of that knowledge. As a Mathematics teacher this challenger increases. Knowing that some subjects are very complex, such as the notion of infinity, we've created a WebQuest to work out with the students, on this matter, at the classroom. A WebQuest is an organized learning activity available in the World Wide Web that applies to a variety of teaching situations and leads the students to a rich and powerful experience. It's supported by the new potentials of collective and interpersonal communication that Internet provides and allows cooperative work. Students must work in groups following a procedure of extracting information from various sources. This approach involves students in asking questions and making observations in order to find answers and learn scientific concepts with a hands-on experiment. The intention of this article is to propose a set of desirable attributes for such activities.*

Keywords. Hands-on experiments, Mathematics, WebQuest.

1. Introduction

Since ancient times, Art and Mathematics crossed each others ways and there always has been a concern to establish a perfect ideal. With the developing of technology, Mathematics becomes more challenging to the students. As a result of this, we've decided to make a WebQuest about the infinity to be applied, during a month, to students between 13 and 16 years old.

According to Martinho (1996, p. 42), *Art and Science walked together during many centuries, reckoning there is a common factor between both: creativity as an increasing motor of forms and ideas*[3] [11]. She adds that (p. 51) *the approach to an abstract universe through concreted constructions and entertainment activities seams to be, not only extra motivator, but also a efficiently media of formulating students conceptions and contributing to their reformulation*[4] [11].

We will try to suggest that thinking in terms of nondeterministic processes may be helpful in creating Mathematics and that the resulting Mathematics is the Mathematics of creativity.

Costa (2004) adds that *Science teaching at school should be generalised aiming not only the sound establishment of a "Science" culture in our societies but also to guarantee a steady basis for the improvement of Sciences and its technological applications. (…) Scientific and Technological literacy is also of great importance for citizenship and democratic participation in a world where Science and Technology issues and demands have a dominant role* [7].

Everyone needs to study to obtain a degree. Students spend most of their time in the school. So teachers have a crucial role in our society. They are models for our children. Most of the pupils will decide what to be in the future by interacting with those. They must seek an enlarged involvement of the community in order to get feedback from the pupils.

In this paper, we are going to explain what a WebQuest is, how is going to be applied and in what way students can learn more efficiently Mathematics using this kind of material, what is the advantage of analyzing Mathematics in this way, offering the possibility to add an experimental element to the study of logic.

2. Characterization of the school

1 Original version: a Arte e a Ciência caminharam juntas durante muitos séculos, não sendo difícil reconhecer que comportam um factor comum essencial: a criatividade como motor gerador de formas e ideias.

2 Original version: a aproximação a um universo abstracto a partir de construções concretas e actividades lúdicas parece ser, não apenas mais motivadora, mas também um meio eficaz de problematizar as concepções dos alunos e contribuir para a sua reformulação.

The Escola Básica 2.3 de Freixo is placed in the north of Portugal, next to Ponte de Lima. Most part of the community lives from the agriculture. Mainly the pupils don't have many aspirations to continue studying. So the teachers need to be continuously motivating them to their matters. In the case of Mathematics, the lessons require for sure an extensive search for support material that may allow the students to execute their task without difficulty and more efficiently.

The school has 438 pupils, 201 girls and 237 boys, almost 50% of each gender. It's a public institution. It presents the educational community with a computers classroom where every group of pupils have at least one class for week. This way the WebQuest can be applied.

Figure 1. School symbol.

3. WebQuest: description

The originator of the WebQuest concept was Bernie Dodge (1995) at the activities of EDTEC 596, "Interdisciplinary Teaching with Technology", and according to him (1995), a WebQuest is an inquiry-oriented activity in which some or all of the information that learners interact with comes from resources on the internet, optionally supplemented with videoconferencing [8]. This way, WebQuest give students a task that allows them to use their imagination and problem-solving skills. They can explore issues and find their own answers.

There are at least to levels of WebQuests according to the goals complexity. In this case we adopted a longer term because of the theme: infinity. We expect that this complexes matter through an amount of educational images among the technology extends and refines that knowledge.

A WebQuest should contain six building blocks: introduction, task, process, resources, evaluation and conclusion. It might be improved by wrapping motivational elements around the essential configuration by giving the learners a task to participate. A WebQuest is a group activity based in the Internet. According to Carvalho (2002, p. 148), a WebQuest is a step ahead in the utilization of the Web inside the classroom. It combines the teacher's work with the student's tasks, becoming an important intermediary between both [4].

To increase the motivation of the pupils we used some of Escher's images. The infinity was one of his predilections. According to him (2000), not one of us needs to doubt the existence of an unreal subjective space. But personally I am not sure of the existence of a real, objective space. All our senses reveal only a subjective world to us; all we can do is think and possibly mean therefore we can conclude the existence of an objective world [9].

Figure 2. Self-portrait. M. C. Escher (1943).

4. Infinity

From the time people began to think about the world they lived in, questions about infinity arose. Would the world go on for ever or was there a finite end? Above the earth one could see stars, planets, the sun and moon, but was this space finite or do it go on for ever? What happened if one cut a piece of wood into two pieces, then again cut one of the pieces into two and continued to do this. Could one do this for ever?

We know Mathematics that requires quantification over infinite sets is useful because it can make it easier to decide practical questions.

But is there really such a thing as infinity?

According to Spencer (1997), it's a tough question, because the word "infinity" can mean different things in different contexts. (…) in the context of a number system (…) "infinity" would mean something one can treat like a number, (…) in the context of a topological space (…) "infinity" would mean something that *certain sequences of numbers converge to*.

Figure 3. Moebius band II. M. C. Escher (1963).

In the context of measuring sizes of sets (…) "infinity" means a measurement of the size of an infinite set. In this context, such "infinity" concepts do exist but there are more than one of them, since not all infinite sets have the same size. So there does not exist any one single "infinity" concept; instead, there exists a whole collection of things called "infinite cardinal numbers" [13].

Martinho (1996, p. 24) adds that the infinity can be classified as potential and as real (cardinal, ordinal and not-standard) [11].

Around 1956, Escher dedicates most of his work to infinity. We can organise it in three categories: cycles, tessellations and limits.

Martinho et al. (1998. p. 23) said that in the cycle concept it is implicit the knowledge of potential infinity. What better way that a cycle to represent finite a non-stop process![5] [12]

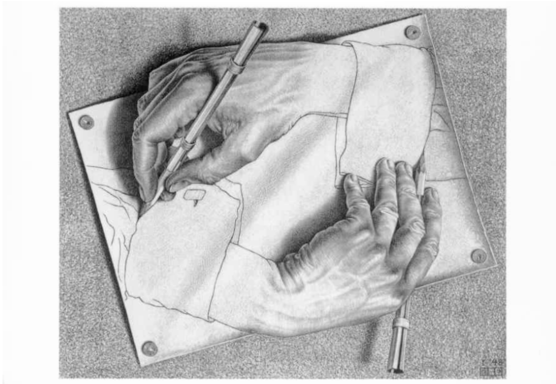

Figure 4. Drawing hands. M. C. Escher (1948).

According to Martinho et al. (1998), *the regularity of the tessellation process suggests an unlimited procedure (…) so that Escher made some three-dimensional representations in wood spheres*[6] [12].

Figure 5. Sphere with fishes. M. C. Escher (1940).

According to Escher (2000), *to get a sense of what this space is like, imagine that you are actually in the picture itself. As you walk from the centre of the picture towards its edge, you will shrink just as the bats in the picture do, so that to actually reach the edge you have to walk a distance that, to you, seems infinite* [9].

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[3] Original version: implícito no conceito de ciclo está a noção de infinito como um potencial. Que coisa melhor que um ciclo recorrente para representar finitamente um processo que não termina*!*

[4] Original version: *a regularidade do processo de pavimentação e o seu carácter sistemático, sugerem a possibilidade de prosseguimento ilimitado (…) Escher concretiza então representações tridimensionais em esferas de madeira ou marfim.*

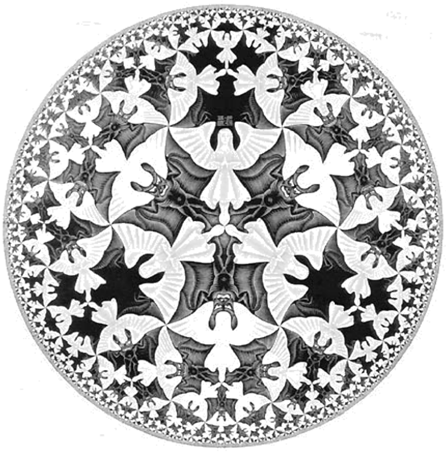

Figure 6. Circle limit IV. M. C. Escher (1960).

5. Goals

- According to Costa (2004), *we will collect and sum up continuously knowledge, information, materials, ideas, curricula and experiences from past and ongoing Socrates (Comenius and others projects in related fields)* [7]*;*
- According to Costa (2004), *describe good practices and transform these into better practices in Teaching and Learning Science* [7]*;*
- We expect that this WebQuest leads the students to a better comprehension of the Mathematics;
- Pupils should improve their Mathematics results;
- Teachers might be able to locate many difficulties that children have in their attempt to understand the infinity;
- Use the Internet as a powerful source of information.

6. Conclusion

A self-made knowledge will be achieved by the pupils that participate in the project. The product of their work will be exposed to the whole community at the Mathematics week. The students that will be absorbed with the acquisition of particular competencies about the infinity can build up a critical attitude and develop the taste for studying. They may also increase the predisposition to analyze problems with different approaches.

Notice that the effective use of hands-on experimental activities in the classroom can induce the students to learn how to learn. At this point they must observe and interact with the problems of our society, connecting with the school, in particular with Mathematics.

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Van de Graaff Generator

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Abstract. *In this work it was developed a Van de Graaff generator that we design and built and that is intended to be used in secondary schools for teaching basic principles of electrostatics, electromagnetic as well as a number of other applications.*

Today many schools laboratories and museums use this kind of generator for electrostatic demonstrations.

Electrostatics was first noticed by the Greek philosopher Thales, who discovered that amber attracted light objects when rubbed. For centuries this phenomenon was only considered a natural curiosity. It is a fact that extremely high voltages can be generated by friction of dissimilar substances. This fact is the base of electrostatic generators. The first known electrostatic generator was built in 1660 by the German experimenter, Otto von Guericke. The Van de Graaff generator was invented by Robert Jamison Van de Graaff, in the USA, by 1929, with the objective of generating high voltages for experiments in nuclear physics. Ancient electrostatic machines can be traced to the 1800's or before. The classical machine consists in a motorized insulating belt that transports charge to a hollow terminal. Inside the terminal the charge is collected by a comb close to the belt and transferred to the exterior surface of the terminal by the Faraday Effect. Charges are sprayed over the belt surface by another comb that is below, connected to an electronic DC high-voltage supply (motor). Guides and hints about the safe use of it in the classroom will be presented.

Keywords: Electrostatic machine, High Voltages, Van de Graaff generator.

1. Introduction

Electrostatics was first noticed sometime in 600 B.C. when the Greek philosopher Thales discovered that amber attracted light objects when rubbed. The phenomenon demonstrated a fundamental concept of electrostatics. It is an elementary physical fact that extremely high voltages can be generated by friction. [1]

This fact is the base concept of functioning of Van de Graff generators.

The Van de Graff generator is named after Dr. Robert J. Van de Graaff who patented his electrostatic generator in 1935. He developed this generator for studying the acceleration of charged particles to explore the atom.[2]

The Van de Graaff generator is an impressive electrostatic generator that is capable of producing enormously large static electric potentials. Giant Van de Graaff generators can produce millions of volts. More modest "class room" sized Van de Graaff generators typically produce 100,000 V to 500,000 V. [2]

This instrument marked several decades of contemporaneous science and was applied in several fields of physic, astrophysics, medical and industry. In the same way is very useful in school as a teaching device in electromagnetic and electrostatics.

The Van de Graaff generator, which was developed from the end of the 1920^{s} derives from a series 18th century electrostatic machines.[3]

In this work it will be present a generator build with the purpose of demonstrating basic principles of electrostatic in basic schools.

Some hints are presented to help in the construction of a Van de Graaf high voltage generator, and some demos that explore some physical facts and amazing exhibitions that can be performed with this device safely.

2. The Van de Graaff Machine Ancestors

Otto von Guericke, using a sulphur globe frictioned by hand, builds the first electrostatic generator in 1660. The globe could be removed and used as source on electricity experiments [4].

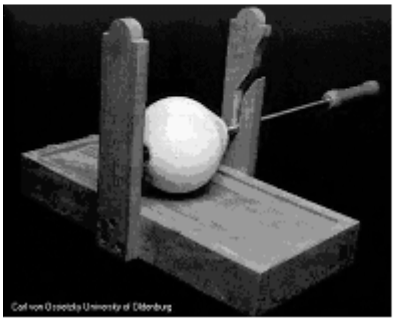

Figure 1. First electrical generator by Otto von Guericke.

Other electrostatic generators followed this one, between them generators by induction that also used friction.

In 1784, Walckiers constructed a machine with an horizontal looped silk strip passing over two wooden rollers.

The young physicist Augusto Righi in 1872 in his PhD thesis described an “induction electrometer” this apparatus was a perfect Van de Graaff generator. However, this machine had not been conceived as a generator but as a “charge magnifier” for investigating weak electrostatic phenomena.

Abraham Bennet in 1786 and William Nicholson in 1788 proposed their “multipliers”. [3]

With these apparatus very small charges, too weak to be detected by a common electrometer, were “multiplied” by electrostatic induction until they could be measured. Righi was working in the same direction when he proposed his machine.

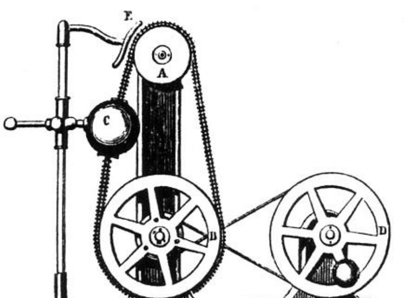

Figure 2. Righi`s apparatus.

A rubber belt carrying a large number of brass rings rotates on two metallic pulleys. The lower one, which is insulated, is connected with a crank and the upper one is grounded with a copper strip. Close to the belt, in the neighbourhood of the upper pulley, there is a small metallic conductor (the inductor) which is connected to the weakly charged object to be studied. The inductor charges one after another the brass rings of the belt which pass on the upper grounded pulley. Continuing their journey the rings enter a hollow insulated copper sphere, where they touch a third small metallic pulley fixed on its inside. Thus the charges of the rings accumulate on the external surface of the sphere. As the process continues the charges are continually added to the sphere. [3] This machine works in the same way as the Van de Graaff generator.

The endless-belt machines were never really popular and they could never compete with the disk induction generators of Holtz, Toepler, Voss, Carré, Wimshurst, Wommelsdorff and others.[3]

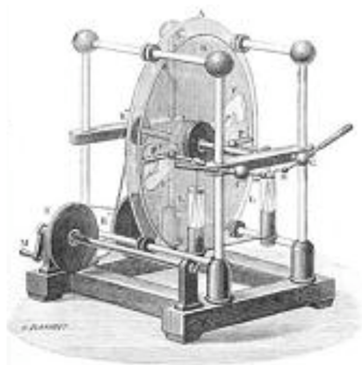

Figure 3. Holtz generator.

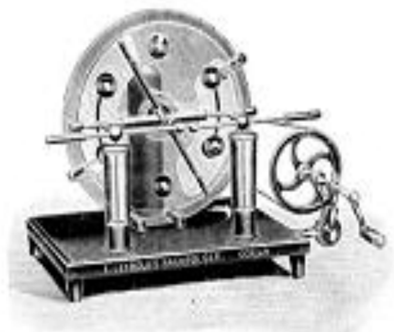

Figure 4. Voss generator.

Figure 5. Wimshurst generator.

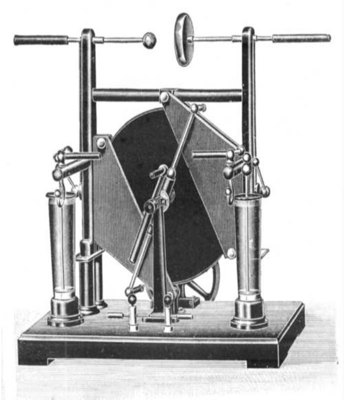

Figure 6. Wommelsdorff generator.

3. Motivation

In 1917 the British physicist Ernest Rutherford introduced to Robert J. Van de Graaff the urgent need to develop a better method of accelerating atomic particles to very high speeds.

During his investigation he comes across to the fact that atom smashing required very high energies. Natural radioactive elements such as the very expensive radium were sources of particles (alpha, electrons, as well as gamma rays) but their energy and their number were too low for penetrating the potential barrier of the nuclei of heavier elements. It was desirable not only such particles were available in adequate amounts and with sufficient energy to penetrate the atomic nucleus, but also that they be homogeneous and steady in energy and that they emerged from the apparatus in a parallel beam with little accompanying stray radiation.

By the 1920^s the developments in nuclear physics emphasize the need of a new technique adapted to deliver enormous energies in concentrated form in order to penetrate or disrupt atomic nuclei. [5]

4. Invention and Evolution

The first working Van de Graaff generator produced 80 kV DC. A dual positive-negative Van de Graaff generator developing over 1 MEV was presented to the 1931 meeting of the American Physical Society [6].

Van de Graaff high voltage electrostatics generators were very simple using only 1 moving belt and 2 pulleys to produce high voltage direct current.

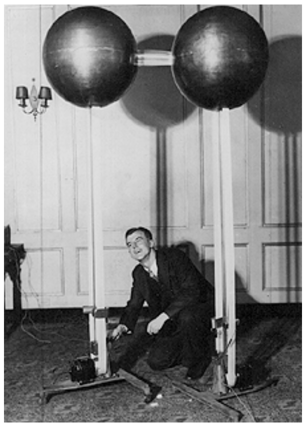

Figure 7. An early Van de Graaff generator being demonstrated by Robert J. Van de Graaff. [7]

In 1931 Van de Graaff began to construct a large double generator in an unused dirigible shed at Round Hill (South Dartmouth, Mass.) [3]

Figure 8. The Van de Graaff generator in the Hangar.

It consisted of two 7 m high insulating columns each containing two belts and supporting an aluminium sphere, 2 m in diameter. [3]

A laboratory was set up in each of the two domes. Here, scientists could study the effect in the accelerating tube that ran between the domes.

The columns were mounted on railway trucks so that the distance between them could be easily modified and also be wheeled out of and within the hangar. [7]

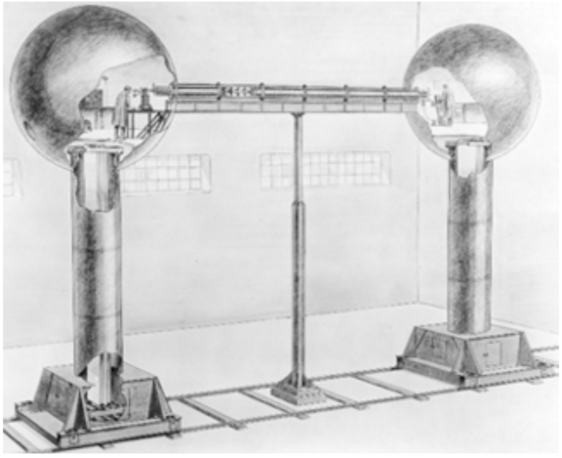

Figure 9. An image of the columns connected by the accelerating tube. [8]

It was functional in November 1933 and it was claimed to produce 7 million volts but in fact it developed about 5 Mev. [3]

Due to the difficulties of mounting the discharge tube between the spherical terminals this generator was never satisfactory as an accelerator. It was subsequently moved to MIT, where it was completely modified and used for atom smashing and high-energy X-rays research.

At MIT the Van de Graaff high voltage generator was enclosed in a pressurized tank filled with a blend of insulating gases which enabled the Van de Graaff generator to achieve even higher accelerating potentials. [6]

Finally in the 1950s was donated to the Boston Museum of Science and in 1980, was installed in the Thomson Theatre of Electricity of the museum. [3]

The two Van de Graaff high voltage generator terminals, were grafted together to form a singular huge terminal. The right column contained the working belts, motors, and brushes. The left column (which is now empty serves only as a support for the sphere) contained equipment to generate high energy x-rays. [8]

The electrostatic generator was likewise employed with advantage in non-nuclear applications.

5. How it works

5.1. Theory

To understand the bases of a Van de Graaff generator it is important to understand static electricity.

Static electricity is an imbalance in the amounts of positive and negative charges in the surface of an object.

Some atoms hold on to their electrons more tightly than others do. How strongly matter holds on to its electrons determines its place in the tribo-electric series. A material is more positive in this series if is more apt to give up electrons and more negative if is more apt to capture electrons when in contact with other materials.

The following table shows the tribo-electric series for many materials:

- Human hands -Very positive
- Glass
- Human ha
- Silk
- Paper
- Steel - Neutral
- Wood
- Hard rubber
- Nickel, Copper
- Gold, Platinum
- Silicon
- Teflon - Very negative

The relative position of two substances in the triboelectric series tells how they will act when brought into contact. For example, glass rubbed by silk causes a charge separation because they are several positions apart in the table. The farther the separation, in the table, the greater the effect. [5]

The term "static" in this case is deceptive, because it implies "no motion," when in reality it is very common and necessary for charge imbalances to flow.

Another important factor in electrostatics is humidity. If it is very humid, the charge imbalance will not remain for a useful amount of time. Humidity is the measure of moisture in the air. If the humidity is high, the moisture coats the surface of the material, providing a low-resistance path for electron flow. This path allows the charges to "recombine" and thus neutralize the charge imbalance. Likewise, if it is very dry, a charge can build up to extraordinary levels, up to tens of thousands of volts! [9]

5.2. Scheme of a Van de Graaff Generator

The generator consists of a well-rounded high-voltage terminal supported from ground on an insulating column, and of a charge-conveying system consisting of one belt of insulating material running in two rollers between this terminal and ground. [5]

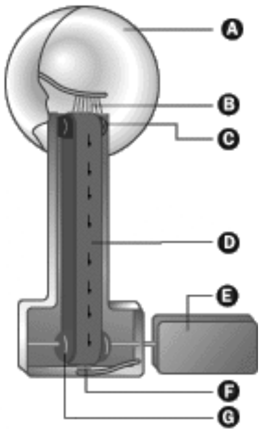

Figure 10. Scheme of a Van de Graaff Generator.

Legend:
A – Output terminal (collector)
B – Upper brush
C – Upper roller
D – Belt
E – Motor
F – Lower Brush
G – Lower roller

When the motor is turned on, the lower roller begins turning the belt. Since the belt is made of rubber, the lower roller begins to build a negative charge and by induction the belt builds a positive charge on the outside surface. This charge imbalance occurs due to the triboelectric effect: the lower roller is capturing electrons from the belt as it passes over the roller.

A conducting brush at the top of a belt is connected to the "collector". By this comb the positive charge of the belt goes to the collector while the rubber is moving. At the base of the roller is a comb which drains the negative charges on the outside of the belt to ground.

At any instant the terminal potential is $V = Q/C$, where Q is the stored charge and C the capacitance of the terminal to ground. [5]

Due to the geometry of the outer sphere the free charge will be uniformly distributed about its surface. As the generator continues to charge, a potential difference between the sphere and the grounded base of the Van de Graaff can reach nearly one-half of a million volts. In fact, the sphere will continue to build up charge until a voltage break down occurs in the air. Prior to the breakdown, the air around the sphere becomes ionized. The air turns from an insulator to a conductor. With the air ionized the electrons leap off the collector creating a brilliant spark.[1]

5.3. This Van de Graaff generator

This generator was constructed with materials that can easily be achieved.

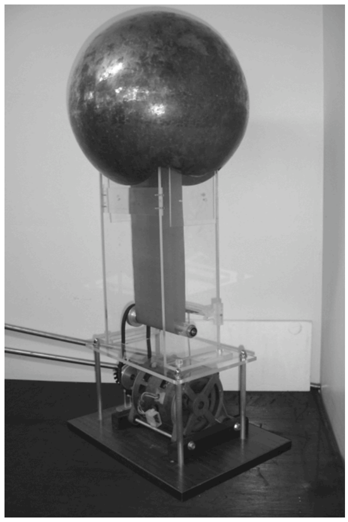

Figure 11. Picture of the Van de Graaff generator.

This is a basic Van de Graaff generator; build with two rollers, a belt, a motor, two combs and a collector (a sphere).

The spherical dome was build in copper by a copper artisan while the rest of the structure was home made. The generator has a column build with acrylic which supports a sphere of copper. The rollers of acrylic make a natural rubber belt turn vertically by action of an electrical motor. Near each roller is a comb made of copper wires. The upper comb collects the positive charges from the belt to the sphere will the lower comb drains the negative charges from the belt to the ground.

5.4. Safety

When using this device there are several safety measures that have to be taken in account.

If using a Van de Graaff generator in a classroom, do not allow students to use it unsupervised.

People with cardiac pacemakers should never operate the generator or come in contact with it.

Stay about 90 cm away from the collector while it is charged. Full intensity, white-hot sparks can jump as far as 38 cm, less intense, red-purple sparks can jump 50-76 cm. The current is too low to injure, a surprise spark is no fun. Keep the generator at a safe distance from the outlet where it will be plug in. If you're too close, you won't be able to turn it off safely.

Always discharge the collector dome between experiments using the discharge wand. Hold the discharge wand by the handle. Do not touch the grounding strap when discharging the generator. The voltage is so high that the current can pass through the insulation into the hand.

Do not run the generator continuously for long periods of time. Turn it off when not in use.

Keep the entire device clean and dry. Dust and moisture degrade the generator's performance. [10]

6. Hints

When trying to build an electrostatic machine there are some hints that can be very useful when the generator is not working as it should be.

Avoid using wood, cloth, paper or other fibrous materials as insulating structures. Their insulating properties will vary unexpectedly because of humidity changes, so on some days they are insulate and in others become conductive. Work with plastics and rubber.

Do not use sharp edged conductors or there will appear corona discharges in those edges. The charge will not build up on the sphere, instead it will leak into the air.

Keep the metal parts far away from each other and away from the "ground". If oppositely charged parts are close together, or if charged parts are closed to grounded parts, they form a capacitor with significant value. This can slow the charged-up time of the device and make the electric field between them become extremely intense. This can cause sparks or silent and invisible corona discharges to appear on the metal surfaces. For any particular current, the lower the capacitance, the faster the device charges to maximum. The bigger the metal parts, the farther away they should be from each other.

Keep all insulating parts clean, because with dirt or dust they can become slightly conductive, especially when humidity is high.

To "see" the voltage, cut some short strips of tissue, and then stick them to the metal parts of the device with a bit of tape, so that the strips hang down along the metal. When the metal becomes charged, the tissue strips will be repelled outwards. The further they raise, the higher the voltage on the metal object. Motion of the tissue makes the voltage "visible".

To keep the belt from wandering on the rollers, it is necessary to adjust the rollers so they are nearly parallel and the belt only drifts sideway very slowly. The slow drift can be stopped putting a lump in the center of the flat roller, for example, winding it with many turns of electrical tape. [11]

7. Demonstrations

Here are some of the most interesting demonstrations that can be done with a Van de Graaff generator. These demos allow people to understand electric fields and electric forces.

Sparks - When the grounded discharge wand is brought near the collector dome, lightning discharges will occur, accompanied by a crackling sound. Try varying the distance between the wand and the collector to see the different types of sparks the generator can produce. I believe the rule is 8 cm for every 100,000 volts.

Understand lightning and Tornadoes - In the darkness, place the fluoro-tube length ways above the VG and watch micro vortices (tornadoes) of plasma dance up and down the VG sphere and the tube. Watch as the top vortex on the fluoro-tube corresponds to the bottom vortex on the sphere. Watch as these vortices meet in mid air, a spark will jump to exchange a charge the way lighting does.

Paperclip Ray – Tape a short piece of wire or an unbent paperclip to the side of the generator sphere. Bend the wire so it points outwards. When the generator is running, a stream of charged wind spews forth. This stream is a genuine *Ion Beam*. It will electrify distant surfaces, charge whole people if they are standing upon an insulator, and will run e-motors and fluorescent tubes at a distance. Warning: never direct the ion beam towards a computer, it can induce electrostatic discharges inside the computer.

Hair Raising - Pick a volunteer preferably with long blonde hair. Darker hair is too heavy and short hair isn't very dramatic. The volunteer should also have clean, unprocessed, un-moussed hair. Thoroughly discharge the generator before beginning. Have the volunteer stand on an insulating spot and place one hand on the generator. The volunteer should not be touching the table or anything else and also not be wearing a jacket, hat, or layers of loose clothing. These can serve a discharge points. Turn the generator on and wait. The volunteer's hair will begin to levitate by electrostatic repulsion. When you are done turn off the generator. Tell the volunteer to remove her hand. Discharge the generator with the discharge wand. Tell your volunteer to "shake off" the excess charges before leaving the insulating spot. This will reduce or eliminate the shock.

Demos on electrical repulsion:

Lay a stack of pie plates on the generator and turn it on. The plates will rise off one at a time by electrostatic repulsion as if they were UFOs.

Blow soap bubbles at the generator sphere. They will be initially attracted, but then will become charged by ion wind and will be violently repelled. They will also be attracted to any other object.

Tear long narrow strips of newspaper and tape them on to the collector with scotch tape. Turn on the generator. The strips will try to align themselves with the electrostatic field.

Bring a lit candle near the collector after the generator is turned on. The flame will deflect away from the collector. This shows the flow of ions away from the collector and mimics the solar wind to a certain extent. If you bring the flame very close, a portion of the flame will be attracted toward the collector. The ions in the flame are separating by charge. [10/11]

8. Conclusions

The Van de Graaff generator in its simplest form is seen as a didactical instrument, because of its solidity and simple construction. This generator became an ideal demonstration apparatus of electrostatic influence machine.

Van de Graaff high voltage electrostatic generators are used in public schools and universities for teaching basic principles of high voltage electrostatics charge and laws of electrostatics. The Van de Graaff generator is extremely useful because it produces electric fields which are strong enough to be measured, manipulated, felt directly and played with.

Men have always been fascinated by lightning and big sparks, therefore this machine was always the ideal and much appreciated display in important exhibitions, science museums and science centers. Table top Van de Graaff generators develop over 200,000 Volts and floor models offer up to 1,000,000 Volts of high voltage lightning electrical discharges.

9. Acknowledgements

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Motivation and Hands-on Experiments

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Abstract. *The main objective of the paper is to show the relationship between simple experiments and motivation of students in science education. The first part presents a psychological base of cognitive motivation. Outcomes are cognitive motivational teaching techniques. One of these techniques is the use of simple experiments. Next, the author presents simple experiments as incentives of cognitive motivation, prevention against misconceptions and a source of creativity. Presentation is supplemented by original simple experiments. The last part deals with science teacher skill to motivate students by experimenting. It describes the role of simple experiments in teacher training.*

Keywords. Cognitive motivational teaching techniques, simple experiments, preconceptions and misconceptions, creativity.

1. Cognitive motivation in science education

Motives are the psychological characteristics of a personality [1] which we consider to be the internal cause of behavior. Motives are factors which awake, keep going, and focus the behavior. Motives consist of elementary structures of consciousness which are called needs. Needs are the elementary motives, which we can imagine as a condition of a lack or abundance in an organism, causing tension in an organism which is directed and starts activity. Motivation is a psychological process, in which motives (needs) are implemented into the behavior and experiences of an individual (by outside factors):

MOTIVES ↦ MOTIVATION ↦ BEHAVIOR

At the beginning of the motivational process there is the "inner state of tension" and at the end is the "final action". Motivation is localized intro-psychologically in a human's consciousness, but it is also closely connected to a human's relations with subjects and phenomenon in their environment. Motivation results in certain, aimed activity.

The structure of needs is hierarchically arranged according to development of individual, evolution of humanity, and interaction between an individual and their environment. Important classification [2] of needs according to A.H. Maslow (1954):

- Physiological needs.
- Need of security.
- Need of solidarity and love.
- Need of appreciation.
- Need of self-fulfillment (included cognition need).

Needs develop progressively during the ageing process. If the basic (physiological) needs are not satisfied, it is impossible to satisfy higher needs. It is also important to note that everyone has their own hierarchy of needs which forms the spectrum of motivation. Factors affecting motivation can change during one's lifetime.

There are two ways to increase the need, impulse or incentive of a person. Impulse is an inner initiative marking some change in the body or mind. The example could be the feeling of thirst, the need to drink, when the body's organs signal a lack of liquids. Homeostasis is the condition of an organism when organs do not signal any lack and no impulse is apparent. In the condition of homeostasis (without impulse) the need can be increased by the use of an external initiative - incentive. An example of this situation is when the appearance of something to drink increases our thirst, this occurs without signals from the internal organs indicating the need for liquid. Incentives are very important, especially in the field of education.

Incentives can be positive or negative. Positive incentives increase and satisfy needs at the same time. When we are thirsty, the positive incentive is a soda machine. If we have the coins and we know how to use them, we can get something to drink. The same machine becomes a negative incentive if it doesn't work or we do not have the money. Negative incentives increase the need, but do not satisfy it.

Incentives are simple, or complex depending on the number of needs they affect. Simple incentives affect only one need. Complex incentives affect more then one need at the same time. Every kind of need has a whole group of incentives which increase the need. However, it is important to notice that certain incentives work individually and have different impacts.

There is usually more then one incentive present at one time. They are influencing each other and this interaction increases and decreases their impact. There is also a possibility of a development of individual by alteration of the efficiency of incentives and their combinations during the development of a student [4]. Teaching provides a typical complex incentive, in this situation for learning, with a variety of interacting needs and other motives.

Interest is an important complex motive, especially from an educational point of view. It is based on a variety of needs. These needs can be innate or acquired. Interest can develop from different groups of needs, while the same groups of needs can become the source for different kinds of interests. A further, important characteristic of interest as a complex motive is the close connection between the motivating and emotional elements. Interest causes inner positive motivation when the activities (objects, phenomenon), which are the subjects of interest, increase and in the same time satisfy that group of needs which is the basis of interest. The entirety of this motivational process is followed by strong positive emotions, experiences of pleasure and self-satisfaction. There is also a connection between the interest and the willing capability of an individual. Interest and will are directly proportional. From an educational point of view, the process of the development of interest is important, especially in general learning, but also in certain subject studies, e.g. science.

Teaching and learning are complicated activities, implemented in schools typically in a social context, when a student reacts to the achievement requests of the teacher and school. In education, we can put forward three special groups of dominant needs in students which are being continuously developed:

(a) Social needs.
(b) Achievement needs.
(c) Cognitive needs.

The group of social and achievement needs usually includes the needs of identification and positive relationships (especially the teacher-student and the student-student relationship), status, influence, competence, realized goal of successful performance, and the avoidance of failure. Social and achievement needs lead to external motivation of the student which has a high motivational impact and which quite often contains a dominant motive. This boosted motivation can be both positive and negative and this is its biggest disadvantage. Luckily this negative motivation isn't included in the group of cognitive needs on which we will concentrate.

Each part of teaching (e.g. undertaking experiments) usually boosts social, achievement, and cognitive needs all together. The teaching is complex incentive which induces these groups of needs depending on the individual structure of the personal sphere of needs.

2. Cognitive motivational teaching techniques

Cognitive needs are the basis for cognitive motivation which is the inner motivation of students and it is always positive. It often leads to development of interest in studying a certain subject. Because this form of cognitive motivation increases student interest so much and appears more frequently, it is important we should use such a technique in our teaching.

Cognitive needs of students exist also in science education at school and also out of school. Science teachers have the possibility to instigate the cognitive needs of students. The students' cognitive needs are induced in the students by the educational process and hence the teacher plays an important role in affecting the students' cognitive motivation [5].

These cognitive needs we compared with students' school activities in science teaching. This led to the set of science cognitive motivational teaching techniques (CMTT) given below through which students can be motivated:

1. Stimulation through unconscious perception and experimentation.
2. Use of models of natural objects and phenomena.
3. Solving problem exercises and projects.
4. Demonstrating simple experiments and toys.
5. Seeing paradoxes and tricks.
6. Watching films, video programs and computer programs.
7. Experiencing humour in science.

The characteristics of each of the mentioned science CMTT have a certain special incentive effect on one or more desired cognitive needs.

We want to get students' interested in science education even though they may be more interested in different school subjects, or in non-school activities (art, sports etc.). Motivational teaching techniques which do this are interdisciplinary CMTT. They are similar to science CMTT (because interdisciplinary CMTT also stimulates internal cognitive motivation), but not using pure science incentives. These techniques use facts or situations which stimulate a student's interest based on the stimulus from different fields of studies.

Classification of interdisciplinary CMTT is based on a spectrum of subjects and activities which can be used for motivation. By comparing these subjects and activities with science components, we discovered interdisciplinary CMTT which can stimulate interdisciplinary cognitive motivation:

8. Use "Science for life" (health, food, energy, environment etc.).
9. Application of science knowledge in technology.
10. Exploitation history related to science discoveries and scientists' lives.
11. Reading sci-fi literature and watching sci-fi films.
12. Application of science and art.

For each interdisciplinary CMTT, there is a certain characteristic interdisciplinary connection.

3. Simple experiments with everyday objects

The distinctive quality of a simple experiment is transparency of presentation of physical phenomenon base. This transparency is given especially by the three following factors:

1. Reduction extra phenomena which may occur within an experiment.
2. Qualitative ness of an experiment when students' attention is not taken away from phenomenon base to unnecessary measure.
3. Easy realization by students who perceive an experiment by every sense.

The significant group of simple experiments is group of experiments with everyday objects. So the transparency of phenomenon base observation is supported thanks to the fact that students know these objects from their daily life, so their attention is not taken away from the demonstrated experiment and they can concentrated on it. These simple experiments with everyday objects can be marked as hands-on experiments.

Also undemanding technical realization of simple experiments with everyday objects is an important quality. This brings students a great opportunity to conduct simple experiment by themselves at school as well as out of school. It also results in development of manual skills of students.

We must not omit economical undemanding ness of a simple experiment with everyday objects. Many schools still contend with insufficient equipment with expensive commercial aids which can be partly substituted by usual low-cost items.

3.1. Motivational incentive

The fundamentals of scientific research are observation and experimentation. In science education, teachers' demonstrations and students' experiments are also very important. It should be obvious that every correctly chosen and appropriately used experiment is valuable for motivation of students. Nevertheless we can still find one group of experiments with even higher motivating potential: simple experiments.

Simple experiments can be a complex incentive in activating cognitive needs such as problem solving, modeling of natural phenomena, the needs of our senses and muscular activity etc. This simultaneous activation of some cognitive needs can result in a strong motivating impact. Qualitative ness of a simple experiment activates students' cognitive need of problem solving and thus its consequent activity leads to the pursuit of problem solving. These cognitive needs are activated particularly by paradoxical experiments, tricks and toys.

A paradox is a phenomenon which creates a conflict between experience and perceptions of reality. It is a multiple incentive which can activate sensory activity (students focus their attention because of the conflict created with their previous experiences) and the need to solve the problem (which is closely connected with the paradox). We can begin to understand it after a deeper study of natural laws.

Paradoxes and other surprising phenomena are often elements of magic and tricks, commercially utilized in entertainment (e.g. equilibrium of bodies, rotation of bodies, and light reflection in mirrors). It is usually a combination of perceptive illusions and/or demonstrating imitations of our senses. The principle of commercial utilization of tricks is to keep the fundament of paradox a secret. If we use a few tricks, it is necessary to explain the fundamental ideas.

Evidence of the motivational efficiency of toys as simple experiments is their successful commercial utilization in the form of toys for both children and adults. Bubble makers, yo-yos, click-clacks, and kaleidoscopes are example of these toys.

3.2. Preconceptions and misconceptions

From the pedagogical-psychological constructivist view there is significant use of simple experiments with everyday objects known by students from their daily life. Thanks to this knowledge students have often already formed correct preconceptions. In this case we can use these correct preconceptions and base teaching on them.

Significant problems of education in natural sciences are students' misconceptions. They strongly keep from effective teaching and bound understanding of physical phenomena. They are also source of students' motivation loss for science education. There exist several teaching techniques leading to get over students' misconceptions. This contains follow-up therapy which is not much effective while misconceptions are quite stable.

Simple experiment can be important preventive instrument against misconceptions forming. Misconceptions have their matrix in difficult situations when many overlapping or often even contrary phenomena come through. Then it is difficult to find out the simple relation leading to the correct preconception. If a simple natural phenomenon is presented to students in a simple experiment with transparent phenomenon, the correct preconception can be formed and thus we can avert creation of misconceptions. This conclusion leads to use of simple experiments in primary science education in the lowest age.

3.3. Creativity and skills

Simple experiment allows for the creation of alternative variants of an experiment and open space for the creation of new experiments. Use of simple experiments in education therefore supports development of students' skills of experimentation and develops their creativity.

One of other possibilities of use of simple experiments in education is simulation of natural phenomena which helps us survey and verify physical relations without precise measurement with difficult measuring instruments. It is about making changes in specific parameters of an experiment for better cognition of phenomenon base or possibly for determination of dependent character among quantities describing the given phenomenon. In this way we can deduce or verify relations for the given phenomenon within teaching. Experimentation leads students not only to effective cognition but also to the development of manual and intellectual skills.

Teaching aids for the simulation of attributes of buoyant hydrostatic force made from polystyrene (a set of blocks) by author can be used as an example of simple simulative aids:

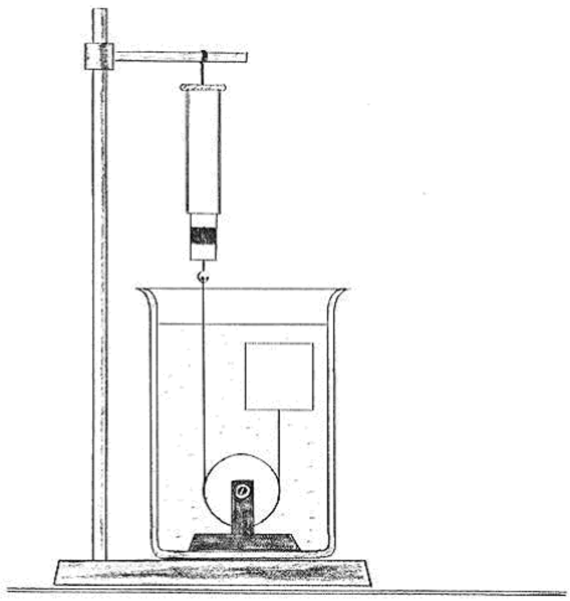

Figure 1. Polystyrene block in liquid

4. Teaching technology using simple experiments

Analysis of a teaching stage and method appropriate for the best implementation of an experiment has to be made for optimization of educational effect of a simple experiment use. A simple experiment can be used in every stage of teaching. For example, paradoxical experiments are best applied in the motivation stage, both in initial and running motivation. In the explanation stage we use simple experiments for initial periods when demonstration of phenomenon base is needed. Simple experiments can be used also in the fixation stage when we can apply them effectively for students' creativity development. Students can create their own alternatives or even new experiments. These experiments will be integrated also into application and diagnostic stages.

Use of simple experiments is optimal in direct students' experiments. Simple experiments are appropriate also in some special teaching techniques with ICT use:

(a) Videos with simple experiments: Simple experiments can be demonstrated by video projection. Projection of these experiments can be used as:

- initial and running students' motivation,
- supplement of real demonstration experiments (time saving, safety),
- instructing for the students' following experimenting,
- projection without sound with students' comment in fixation and diagnostic stage etc.

(b) Simple experiments on the Internet: many of web pages contain the presentation of simple experiments. This can be used within the fixation teaching stage when students search for these experiments by them selves and then present them in class or use them as an inspiration for the creation of their own experiment modification.

(c) Records of students' experiments: individual students' performance during demonstration of simple experiments can be recorded by camcorder for motivation as well as for the experience stages of teaching. These records thus can be analyzed with students from a physical and technical view.

(d) Experimentation instructions: photos or short videos with descriptions and experimentation instructions can serve students and teachers as simple experimentation instructions and simple aids making instructions. PP presentations on PCs and data projectors are appropriate.

(e) Web presentations: photos or videos with simple experiments can be placed on school web pages. Thus the project of students' presentation in the field of simple experiments can be realized.

5. Resources of simple experiments

The above mentioned ideas of simple experiments use in science education have to be compared with real situation at schools. Can teacher get information about simple experiments as much as necessary and does he use them in teaching?

Methodical publications with simple experiments have been published recently. Simple experiments are a base of some videos, e.g. "Physics in Experiments" [8]. In 2005, "Fair of Inventions", the tenth year of national conference of school physical and science experiments in the Czech Republic will be held. An important part of the conference is formed by simple school experiments and their description is published. Methodical journals publish periodically articles about the use of simple experiments. Some commercial companies are specialized in making simple aids for school experiments. Teaching aids for simulation of principles of flying created from polystyrene by author and made by commercial company as example:

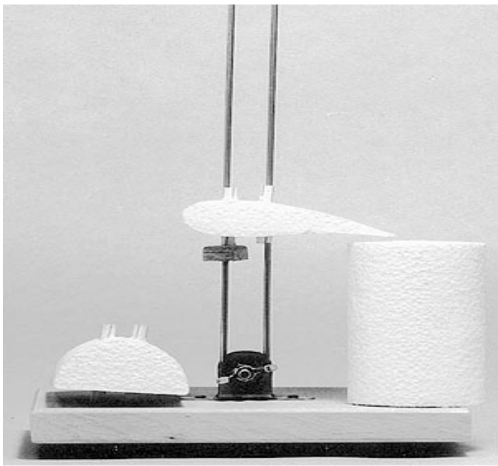

Figure 2. Principles of flying

Attention is paid to simple experiments also on the international level. We can see it on web pages. The international interest is also demonstrated by a three year organized all-European conference "Physics on Stage" where the majority of European countries present their physics and science school experiments. Many of them are just simple experiments with usual things. Documentation from these conferences is available on web pages [7]. Use of the experiments in teaching depends primarily on individual teacher. Our research shows that simple experiments with usual things together with ITC attract more and more attention.

The author of this article created and put together several quite extensive sets of simple experiments and aids exploiting everyday objects and materials from daily life. These are especially experiments with coins, plastic syringes, toilet paper, polystyrene and matches. These sets of experiments show, among others, that everyday objects and materials can effectively serve for school experimentation in most fields of physics and science. These experiments are recorded on videos [8].

6. Teacher skill to experiment

How is it necessary to prepare science teachers in the field of simple experimenting [6]? The character of science experimenting generally brought us to conclusion on the necessity of acquiring experiment skill in three stages:

1. Scientific experiment skill (skill of 1st order) - complex qualification to carry out scientific experiments.
2. School experiment skill (skill of 2nd order) - complex qualification to carry out school experiments.
3. Skill to teach students to experiment scientifically (skill of 3rd order) – technology to teach students by using school experiments.

The skill to simple experimenting is located into second and third stages. Science teacher have to obtain detailed information about simple science experiments and about their role in science education. Not only knowledge but particularly the acquiring the skill to experiment simply is very important [3]. Five acquiring stages exist in the training of science teacher's skill to simple experimenting:

(1) Motivation stage:
Completing of professional interest and attitudes towards simple experimenting.

(2) Stage of subject orientation in acquired skill:
Acquiring knowledge necessary for the experiment skill (thought item of skill).
Creation of experimental habits (sensual and motor items of the skill).

(3) Stage of "crystallization" of new skill:
Solving of simple applied tasks of simple experimenting.

(4) Stage of completing the skill and its including into wider contextual frame:
Solving of complicated applied tasks of simple experiments.

(5) Integral stage during which the new skill is integrated into skill structure:
Solving of teaching problem situation etc. in school practice.

Completion and integration stages are conditioned by several-year field experience of the teacher and that's why acquiring experiment skill is not possible to finish as soon as pre-gradual training of teachers.

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Teaching Ninth-Grade Genetics Through Inquiry

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Abstract. *This study investigated the effectiveness of using an inquiry-based approach in teaching ninth-grade genetics. The inquiry method enables students to assume an active role in the construction of knowledge and has been shown to positively affect some of the important aspects in the process of learning science, such as conceptual understanding, problem-solving, and scientific method. The study involved teaching a unit of basic genetics to a control and an experimental group in the traditional teacher-centered and the inquiry approach, respectively. The results indicate that the inquiry teaching-method achieved a significantly better learning outcome compared to the traditional method.*

Keywords. Fertilization, genetics, inquiry, mechanisms, Mendelian inheritance, meiosis, mitosis.

1. Introduction

Through fascinating applications such as genetic screening, cloning and the development of genetically modified organisms, genetics is assuming an increasingly more central role in our lives. As a result, today's modern citizen is asked to practice his democratic right, which is also a duty to take critical decisions regarding applications of genetics that affect the individual and the society. For the citizens to be able to carry out these duties responsibly they need to have a certain degree of scientific literacy in genetics. This is normally achieved during formal education.

However, research studies indicate that educational systems fail to achieve an adequate degree of learning of genetics in secondary education [6, 7, 8, 9, 10, 19]. This outcome is usually caused by one or more of three types of problems that characterize the teaching of genetics: a) the teaching methodology traditionally used by science teachers does not utilize the appropriate tools to promote the students' conceptual understanding on the important genetics concepts and the way they relate to each other, b) the school biology books do not clarify the connections between the phenomenon of inheritance and the mechanisms of meiosis, fertilization and mitosis that are responsible for its appearance, and c) the curricula for teaching genetics are too descriptive and contain a large volume of didactic material that is expected to be covered in a short period of time.

The purpose of this study was to investigate the effectiveness of using an inquiry-based approach in teaching genetics at high school level in order to achieve a learning outcome that would approach the scientifically accepted model of inheritance and its mechanisms.

2. The inquiry approach

The term 'inquiry' [13, 16], as it is meant in the context of teaching and learning, refers to the abilities students should develop to be able to design and conduct scientific investigations and to the understandings that they should gain about the nature of scientific inquiry. Also, inquiry refers to the teaching and learning strategies that enable scientific concepts to be mastered through investigations. In other words, the inquiry approach enables students, instead of acting as passive receivers of information as it is usually the case with the traditional teacher-centered methods, to assume an active role in the construction of knowledge by getting involved in processes of inquiry.

Inquiry was chosen as the method of teaching because research has shown it to positively affect some of the important aspects in the process of learning science, such as conceptual understanding, problem-solving, critical thought, scientific method and developing a positive attitude towards learning science [5, 14, 17, 18]. In addition, inquiry takes advantage of the natural curiosity of the students and utilizes it to maintain their interest in learning.

3. Theoretical background

Learning genetics is a complex process that involves not only understanding the basic concepts and phenomena, but also the structuring of strong conceptual connections between the three epistemological aspects that define and describe it, namely, the phenomena, the mechanisms that cause the phenomena and the reason for the existence of the phenomena.

The most basic phenomenon in genetics is inheritance, which in its most simple form, is defined as the transfer of traits from the parents to the offspring through the transfer of genetic material. A trait is a characteristic shared by all individuals of the same species (e.g. eye color) and can exist in a number of variations (e.g. blue, green, brown, etc.)

The phenomenon of inheritance is caused by the combined action of three cellular processes/ mechanisms, namely, meiosis, fertilization and mitosis. Meiosis accomplishes the transfer of genetic material from the mature individual to its gametes. Fertilization brings together one gamete each from a male and a female parent to form the zygote, which contains genetic material from both parents. Finally, the zygote multiplies mitotically to form the body of the new organism. All of the new cells contain the same genetic material as the zygote resulting in an individual who exhibits a combination of traits from both parents.

The reason we observe the phenomenon of inheritance on the planet is because it creates individuals with new combinations of traits within a species. This outcome allows the species more opportunity to adjust to a constantly changing environment increasing its chance for survival. Therefore, the mechanism of natural selection has enabled the species that reproduce sexually and therefore exhibit the phenomenon of inheritance to survive and as a result we can observe this phenomenon.

In view of the above, it becomes clear that teaching genetics and Mendelian inheritance in particular is a very complex and demanding endeavor. In order to achieve an adequate level of learning in the students, it is of utmost importance to facilitate their construction of conceptual connections between the phenomenon of inheritance and the mechanisms that cause it. Only then will the students be able to fully understand the process by which a trait is passed on from a parent to its child. If this is not accomplished, the students might still be able to regurgitate information they have learned but they will not be able to apply it in novel situations they might run into either in the classroom or sometime later in their life.

4. Methods

4.1. Participants and teaching curriculum

The participants of the study were 45 ninth-grade students (age range 14-15) from a suburban secondary school in Cyprus. The students, divided into an experimental (22 students) and a control group (23 students), attended a biology course that involved, among others, a unit focusing on basic genetics and Mendelian inheritance topics. The emphasis was on the understanding of the nature, function and correlations between the basic genetic concepts (e.g. DNA, genes, and chromosomes) and the phenomenon of Mendelian inheritance, in the light of the three biological mechanisms that are responsible for its appearance, namely meiosis, fertilization and mitosis. None of the participants had been taught genetics in the past.

4.2. Study design

A pre-post comparison study design was used for the purposes of this research. Conceptual tests (pre- and post-test) were administered to assess students' understanding of basic genetics and Mendelian inheritance topics both before and after the unit on genetics was taught. The same pre-test items were also included in the post-test (Part A), however, the post-test included some additional items that required a deeper understanding of the topics (Part B).

The pre-test and Part A of the post-test contained open-ended items that asked conceptual questions regarding the phenomenon of inheritance and the mechanisms responsible for its appearance. Specifically, the students were presented with the fact that some traits that appear in the parents also appear in their children and were asked to express their views regarding: a) the nature of these traits, b) the general mechanism that explains this phenomenon, and c) the selection and distribution pattern that these traits follow as they are transferred from parents to offspring.

Part B of the post-test contained closed-ended items that tried to document the degree of conceptual understanding developed in the students on the most important topics they had been taught, such as: a) the nature, role and correlations between the important genetics concepts (e.g. DNA, genes, and chromosomes), b) the nature and role of meiosis, mitosis and fertilization, and the way these three mechanisms collectively cause the phenomenon of inheritance, and c) applications of the first and second laws of Mendelian inheritance.

Furthermore, clinical interviews were conducted with 8 of the students from the experimental group at the end of the study. The interviews provided the opportunity to further enhance understanding of the degree of learning achieved by the students, to recognize the specific topics in genetics that cause learning difficulties to the students, and to collect additional evidence regarding the effectiveness of the teaching approach applied to the experimental group.

4.3. Teaching approach

The participants in the control group followed the traditional approach in studying the basic genetics and Mendelian inheritance topics, a method that is usually used in public schools and which relies heavily on teacher lectures and the school biology book. The participants in the experimental group followed an adaptation of the inquiry approach, which was initially developed for teaching physics [13]. The students in the experimental group worked in groups of four. The school biology book was not used at all and the role of the teacher was reduced to that of a coordinator of the students' work. The students' main learning aid was a set of worksheets, which was specifically prepared for the teaching of the genetics unit. The worksheets complete with short articles as a source of new information, tables, diagrams, pictures, exercises and guidelines for small investigations, facilitated the application of the inquiry approach. Although the basic structure of the worksheets was prepared in advance, several small changes had to be made as the teaching progressed to adjust to the specific needs of the students and to support their investigations.

The teaching of the experimental group was structured according to the following general format. At the beginning of each subunit within the unit of genetics the students were presented with a scientific phenomenon or set of data and were asked to make observations and specify relevant research questions. After selecting an appropriate problem for investigation the students would analyze the available information, propose possible explanations and consider various forms of investigation. They would then proceed with a particular path of investigation. In the process, the students would involve themselves in a variety of activities such as collection and analysis of additional data and information, evaluation of results, re-examination of the initial hypotheses, etc. At the end of the activity cycle the student-groups announced their conclusions to the rest of the class and during the subsequent discussion they would try to defend their positions against criticism from their classmates. The study of the unit would conclude with the adoption of a common position.

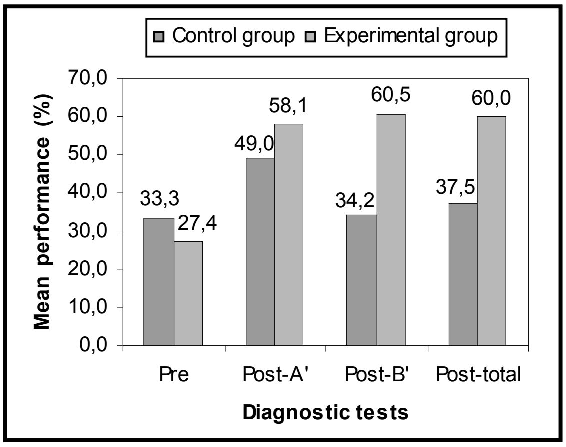
5. Data Analysis and Results

The analysis of the data collected through the use of the pre- and post-tests and the clinical interviews involved both quantitative and qualitative procedures.

5.1. Quantitative analysis

The quantitative data analysis involved the evaluation of students' pre- and post-test scores. To ensure objective assessment, the tests were coded and scored anonymously. Each item in the tests was scored separately; however, a total correct score was derived for each test (Table 1).

Table 1. Diagnostic tests results.



The resulting pre- and post-test scores were used in the analysis to assess the improvement achieved by the students in the experimental and control groups as a possible outcome of having attended the unit in genetics as well as to evaluate the difference in performance between the two groups both before and after the unit in genetics was taught. The statistical procedures used for the two types of evaluation were the paired and the independent samples *t-test*, respectively [15].

The statistical analysis revealed no significant difference in the performance of the two groups in the pre-test, while both groups showed significant improvement ($p<0.01$) from the pre-test to the post-test (only the items that were identical in both tests were compared). The experimental group performed better than the control group in both parts of the post test, but only the difference in Part B was significant ($p<0.01$). In total, the experimental group was found to have significantly higher scores in the post-test than the control group ($p<0.01$). These results indicate that while both the traditional and the inquiry teaching methods succeeded in helping the students acquire basic knowledge in genetics, the inquiry-based method was significantly more efficient.

The difference in the results of the statistical analysis of the students' performance in the two parts of the post-test is due to the nature of the parts themselves. The open-ended items included in Part A did not require extensive knowledge of the topics taught and were relatively easy to answer by students who did not reach this level of knowledge. In contrast, the close-ended items in Part B required a deeper understanding of basic genetics and Mendelian inheritance on behalf of the students and therefore, were more difficult to answer. As a result, the control-group students managed a moderate performance in Part A but failed to reach comparable levels in Part B. On the other hand, the students in the experimental group performed approximately the same in both parts of the post-test (Table 1). Since Part A and Part B weighted 18% and 78% of the total maximum score for the post-test respectively, the much larger contribution of Part B lead to the significantly higher performance observed for the entirety of the post-test for the experimental group compared to the control group.

Internal reliability data were also collected. A second independent coder reviewed the data from the pre-test and Part A of the post-test for both student groups. The items in these tests were of the open-ended type and could therefore take a number of acceptable answers. It was not considered necessary to re-evaluate the data from Part B of the post-test as the items included in it were of the closed-ended type and could therefore only accept one correct answer, or a limited number of different variations of the correct answer. The degree of agreement between the two coders was calculated using the *Pearson Correlation Coefficient* [15]. All the reliability measures were between 0.88 and 0.95. This high correlation suggests that the criteria set for the evaluation of the test items were precise and were applied faithfully in the coding and scoring of the tests.

5.2. Qualitative analysis

The qualitative data analysis focused on identifying and classifying students' concepts/ ideas both before and after the unit on genetics was taught, based on the procedures of phenomenography [11, 12]. Furthermore, it was attempted to decipher the specific difficulties that the students face in their effort to understand basic genetics and Mendelian inheritance topics. The prevalence for each one of the resulting categories of concepts/ideas and difficulties was calculated separately for the students in the control and the experimental group and was used to qualitatively compare the status of the two groups.

The students' responses in the pre-test and Part A of the post-test were analyzed qualitatively and the resulting concepts/ideas were presented in conceptual diagrams of the 'bar' type [1], allowing direct comparison within and between groups, both before and after teaching. The 'bar' type conceptual diagrams present synoptically the concepts and ideas that each student utilizes in his/her effort to answer the test questions. At the same time, they allow parallel observation of the different aspects in the student' s comprehension on specific topics, as these appear as different positions in his/her responses. In this manner, a more complete picture of what each student knows and thinks regarding a particular issue is presented.

In addition, the information from the conceptual diagrams was used to construct summary tables, which present the positions held by the group of students as a whole. Table 2 for example presents the percentage of students that hold specific ideas about the mechanism that is responsible for the appearance of the phenomenon of inheritance. The first three statements represent partial but scientifically acceptable descriptions of this mechanism. The last two responses can not be considered adequate explanations. According to the data, although both groups show marked improvement after having attended the unit on genetics, the percentage of students from the experimental group that express one or more of the first three positions in their answers is much higher compared to that from the control group. What is of most importance is the fact that almost half of the students in the experimental group (45%) consider the processes of meiosis and mitosis as part of the mechanism of inheritance, whereas none of the students in the control group do so even after having been taught genetics.

Table 2. The mechanism of inheritance.

Students believe that heredity is caused by:		Contr. (%)		Exper. (%)	
		Pre	Post	Pre	Post
1	The transfer of DNA, genes, or chromosomes	10	57	14	82
2	The processes of fertilization and / or reproduction	32	57	5	68
3	The processes of meiosis and/ or mitosis	0	0	0	45
4	The transfer of characteristics	9	0	0	5
5	The living habits and/or the social environment	5	0	29	0

Furthermore, the examination of the data from the pre-test revealed students' naive ideas about basic genetics and Mendelian inheritance topics. Students seem to believe that: a) the acquired characteristics are inherited, b) inheritance is controlled by either God or the living habits of the individual, c) the distribution of the characteristics inherited from parents to offspring depends on the sex of the parent or the offspring, and d) the only type of characteristics inherited are the important, the strongly expressed or those selected by God. These ideas appeared at approximately the same frequency in the control and the experimental groups. Similar ideas were also reported in other research studies [2, 3, 4] with the exception of the role played by God in heredity.

The students' answers in the post-test items and the clinical interviews from the experimental group revealed a number of difficult learning areas that students encounter in their effort to understand genetics. These are: a) the construction and interpretation of diagrams representing Mendelian inheritance, b) the structure, function and correlations between DNA, genes and chromosomes, and c) the way meiosis, mitosis and fertilization collectively cause the appearance of the phenomenon of inheritance. Similar results also appear in other research studies [6, 7, 8, 9, 10, 19]. What is important to emphasize is that although these difficult learning areas were common for both student groups, the magnitude of the problem was significantly reduced in the experimental group.

6. Conclusions and implications

The research results indicate that the inquiry method, in the form that was applied in the teaching of the genetics unit in the experimental group, was able to achieve a significantly better learning outcome compared to the traditional teacher-centered method, in the form that was applied in the teaching of the control group.

In all but one of the 11 items included in the post-test the experimental group performed better than the control group. The biggest difference was observed in Part B items. When comparing the items in the two parts of the post-test, the open-ended items in Part A could be answered correctly in a variety of different ways and could be considered less demanding on behalf of the students. On the other hand, the items in Part B were of the close-ended type and could accept only one or a limited number of different but specific answers. Therefore, these items could be considered highly demanding with regard to the level of knowledge and understanding required for a correct response to be provided by the students.

The above hypothesis works well with both the quantitative and qualitative results recorded for the two groups. The performance of the control group was considerably higher in Part A than in Part B. On the other hand, the students in the experimental group performed equally well in both parts. These results suggest that the methodology applied to the teaching of the control group did not succeed in equipping the students with the appropriate learning tools that would allow them to achieve an in-depth understanding of the topics taught. In contrast, the inquiry method used in the teaching of the experimental group managed to achieve a high degree of conceptual understanding in the students. Also, the difference in the level of knowledge and understanding between the students in the two groups becomes evident when comparing the quality of the responses they provided in the post-test. For example, almost half of the experimental-group students gave responses that showed an adequate degree of understanding of the conceptual connections between the phenomenon and the mechanisms of inheritance. None of the control-group students exhibited this level of understanding in their responses.

The above findings can be best explained when considering the basic characteristic features of the inquiry method. The students construct their own knowledge through their active participation in the process of learning. In addition, their interest is constantly stimulated through a variety of activities in which they are involved. The students are the ones to decide what there is to learn and in an effort to acquire that knowledge they ask the questions, propose the answers and carry out the investigations to test their proposals. In other words, the students are responsible for their own learning.

The implications from the findings of this study are more than obvious. If educational systems are to improve the degree of learning genetics in secondary education they need to adopt teaching methodologies that can achieve better learning results. The inquiry teaching-method is one such example.

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"Teaching Science by Experimentation: Hands-on method".

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Abstract. *The implementation of the method here described, was motivated by the lack of interest students showed towards school, as well as the difficulties they demonstrate in the learning process, most of the times associated to the absence of methods and study habits, as well as family background, which could hardly sustain any different attitude regarding school. These students showed the lack of previous knowledge that should be acquired in the previous years, namely in the preceding school year, were the syllabus was only accomplished in half of the planned.*

During the school year of 2003/2004, some of the classes of the basic school (formed by students between 12 and 15 years of age) of Fermentões – Portugal, had Physical Chemistry lessons, in which the approach to the curriculum contents was made in a experimental way, where the objectives for every class were fulfilled, rising as conclusions that students formulated, as the outcome of their work.

This way, during the Physical Chemistry classes, the students were divided into small groups. In a first stage they followed the steps described in a lab protocol, using few materials that they had to choose, among a pre-selected group (the implementation of the activity was followed by the teacher, who also provided some help); in the end, after the students register the observations, they discussed the results and tried to reach a conclusion.

The great success of this method is related with the fact that possible wrong hypothesis could be tested wright after their conception and in this way, by application of the scientific method, the expected conclusions were obtained.

Near the end of the class, in a few minutes, the teacher systematizes student's conclusions in a structured way, so students could establish them in a meaningful approach.

During the school year, the teacher's role got less important, and the students took the leading part in classroom action, performing their activities with a rising level of autonomy.

Concerning the evaluation, the results allow me to conclude that with this method, the students are capable to learn faster, in larger proportions, and in a meaningful way, because they show the capacity to apply the abilities they learned during the classes to the every day situations.

Keywords. Science Education, School, Hands-on experiments, scientific method, meaningful approach, learning autonomy.

1. Introduction.

During the school year of 2004/2005, in the Basic School of Fermentões, I chose a different set of teaching strategies, very different of the ones I used until then. The motives that led to this choice are described in this report, as well as its results.

2. Causes leading to the experimental method implementation

2.1. Social-economic situation of the school community

The Basic School of Fermentões is inserted on the outskirts of Guimarães City that has a population that derives mainly from families with meager economic resources, who also present serious dysfunctions regarding family structure (for instance unemployment, alcohol and/or drug abuse), which contributes to the lack of conditions for the students' learning process.

It is also important to mention that most of the families are composed, generally speaking, by four to five people and the students live with their parents.

The families are mainly derived from poor to median social-economic backgrounds. Most of the mothers are house or textile workers, while the fathers are mostly secondary sector laborers, mainly textile workers. Most of the parents in charge of the students' education possess a very low scholar degree, having only the initial school years. Most of the students have needed financial aid that is awarded by the government.

2.2. The students

While as the object of the teaching/learning process, the students, in an early stage, didn't show suitable conditions for the good developing of this process; the main characteristics of our students are:

- lack of habits, methods and organization regarding work, which are not the desired by the students, in spite of the assisted study area efforts to help them to optimize these aspects;
- difficulties regarding writing and speaking, as well as reading and text interpretation;
- lack of previous knowledge, mainly regarding contents related to Mathematics;
- lack of scientific curiosity, as well as reduced critic/observation capabilities;
- general lack of motivation, resulting in interests other than school;
- lack of social, cultural and/or professional ambitions.

All the previous aspects are combined in a general lack of interest in the learning process, developed in the classroom. It is also important to mention that some students are under the 319/91 Law (students with special education needs).

As a result of a global analysis of the classes, we can conclude that they lack mainly participation, possess several difficulties regarding learning and concentration and have interests and motivations which do not regard school.

2.3. The Curricula: minimal objective accomplishment

For students with such difficulties, the accomplishment of the various curricular plans becomes hard. Frequently is not possible to introduce all the contents that are part of the National School Program for these school levels, making necessary to take certain choices. But, when the levels of unaccomplishment take larger proportions, the demand for new solutions becomes crucial.

When we arrived to this school, we saw that the teaching programs were given up to 50% of its total, which made our task even more challenging. Considering all these motives, a "hands on" teaching model was generated.

2.4. Method description

This way, during the Physical-Chemical Sciences classes, the students were separated into groups of two. In an early stage, they followed a protocol using the materials that were previously selected by the teacher (who followed the implementation of this protocol); at the end of the work, the students would register their observations, as well as formulate theories regarding them.

The great success of this method is due to the fact that the wrong theories are suitable to be tested after their elaboration, being possible, this way, trough the application of the Scientific Method, to reach the correct and expected ones.

At the end of the class the teacher would display the contents in a sequential and organized way, allowing the students to arrange them in a functional and meaningful way (such as a concepts map).

During the school year, the teacher's role fell to a secondary place, where the student assumed the leading position, carrying the tasks with greater autonomy.

The results, regarding continuous evaluation, allow me to conclude that, in fact, the students managed to learn in a more significative way, as well as regarding the quantity of retained concepts (they became more capable of directing their learning and applying it in school and regular day situations.

2.5. Results

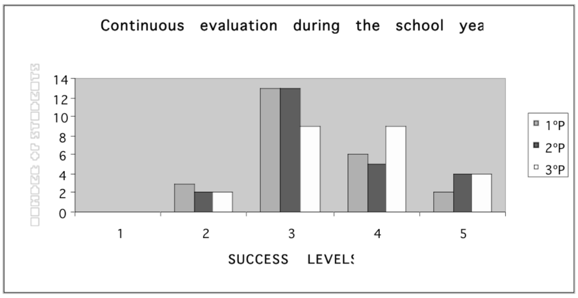
It was hard to mobilize the students, in the early stages of the process, making us wonder if this was the right approach.

Never the less, after about a month of experience, the students started to perform in class as intended: assuming the leading role.

We can conclude that, at the time of the preformed learning evaluations, the experimental practice showed itself useful, as the students demonstrated applying the acquired knowledge being made easily.

During the evaluation exams it was clear that the students became capable of fluently mobilize the acquired knowledge, where the experience allowed them a significative learning, having the contents became more than words, but objects with meaning and sense of fulfillment.

The chart bellow represents the evolution of the evaluation results during the school year.



Regarding the success of the learning process, as we could see in the previous chart, it is possible to conclude that, in addition of the decrease of scholar failure, we also managed to raise the scholar success to very satisfying levels.

2.6. Evaluation

A teaching strategy should only be preformed in a continuous manner if, through it, the number of retained knowledge by the students is effectively reached; any strategy should not be applied regardless of the final results.

An important factor for this strategy evaluation, besides the continued evaluation, was mainly the manner in which the students behave during class.

This behaviour doesn't result only from their discipline, but more important, their way of responding to the development of the classes: participation, curiosity, observations, conclusions, etc.

It is very satisfying having students who find important to participate, thrilled with what they observe and mainly with what they experiment; it is not needed to impose the activities, which are sufficiently appealing for themselves, in order to make the students more concentrated, becoming possible for them to carry out and reach their own conclusions.

It is our conclusion that the possibility of experimentation, confirmation of theories and mobilization of the acquired concepts are fundamental for an effective learning process and knowledge consolidation.

2.7. Conclusion

We consider that teaching by an experimental method is, in fact, a powerful ally in the task of forming, educating and transmitting contents and attitudes, like those that are present in the Science domains.

It seems unlikely to us that it's possible to perform such a noble task, specially near the minds of the youngest, if all the transmitted knowledge cannot find the support for the realization, experimentation and verification.

There is no greater satisfaction for a teacher than seeing the evolution of his students, their development as individuals capable of undertaking what we offer them to learn - for us, while teachers, we found in this way of performing our task, something extremely fulfilling, which drives the teacher to carry out his duty in a truly excited way, just like our students.

We recognize that this method of teaching requires a more exhaustive preparation of the classes, regarding the selection of materials, the learning of a conduct (relatively to laboratory work) by the students, creation of support materials used in class, etc. After a certain adaptation to this new method of teaching, regarding teachers and students, its application becomes natural, occurring a certain generalization of the process.

In order for the results to last and be noticed in the higher school levels, it is necessary that this kind of activity is preformed continuously, that it exceeds its character of exceptional, allowing the students to be capable of, in any given circumstances, to mobilize their experimentation conduct, interacting actively with the observations in the daily environment.

Referring to Piaget, to know an object is to be capable of acting on it.

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Science interpretation in high school

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Abstract. *In cooperation with the "Hands-on science" network of the Socrates-Comenius programme, we have carried out an activity in interpreting science within the context of prehistoric archaeology, using as an example an ancient Palaeolithic site situated within the nearby geographic surroundings and called Chan do Cereixo. This activity was developed in a secondary school from Val Miñor (Pontevedra) and was aimed at pupils between the ages of 12-18 from the whole area. This essay presents the general basis of the activity and the methodology used as well as the more outstanding results.*

Keywords. Archaeology, Hands-on Science, Interpretation, Science education, Science Museum.

1. Introduction.

Interpretation as a methodology for the studying of heritage was defined [1] by professionals in the national parks of the USA [2] in 1957, as an educational activity which attempts to reveal meanings and relationships through the use of original objects, by first hand experiments and illustrative mediums instead of the mere communication of facts.

Within this context, the principles proposed are based on the relationships between the objects and the experience of the participant, involving an integrated transmission of the information by using diverse strategies and endeavouring to create incentives to awaken interest [3]. This informal tool of learning is used more and more in archaeological and nature parks, as well as in zoos, aquariums or museums [4].

One of the objectives of interpretation is to help the participant to develop a deeper understanding, appreciation and awareness of the activity in question and/or the values that are trying to be transmitted; thus converting the activity into an enriching and pleasant experience [5]. In general, the interpretation of heritage [6] is a creative exercise based on the knowledge of the interpreting process and of the matter to be dealt with, by putting into play resources with clear, short and attractive messages that create an impact on the participant.

On the other hand, the carrying out of didactic activities developed outside of the traditional academic framework, such as museums, interpretation centres, exhibitions, etc. prove to be highly beneficial for the comprehensive education of pupils, but specialized equipment and appropriate technical resources to ensure a service of quality is needed [7]. Its evaluation is complex and the methodologies need to be adapted to what is being considered in each case. There are some methodological proposals which tend to form generic models in relation to a specific discipline but they can turn out to be a good starting point [8].

Based on this philosophy, we organised an activity for pupils between the ages of 12–18 which attempted to divulge the scientific method applied to the study of Prehistory from a methodological and practical perspective: prehistoric investigation as an interdisciplinary science - archaeology, geology, biology, physics, chemistry, topography, etc.- and as an example of the application of a scientific method within the human sciences [9].

We selected an interpretive methodology so that in a pleasant and attractive manner, it allowed us the transmission of appropriate messages and the highest impact possible on pupils in relation to the knowledge to be transmitted [1,7,10,11]. Thus, we designed an active exhibition for a learning centre, looking for participant's implication, and encouraged or guided by monitors with the main aim of fostering in pupils interest and facilitating their immersion into the subject of archaeology.

The main novelty of the proposal consisted in creating a tailored exhibition integrating interpretive principals and mediums for a perfectly defined public from a formal education and dealing with a theme not usually dealt with in interpretive activities. In the activity we also attempted to recreated, in the centre's entrance hall, the realistic environment of a Prehistory archaeological excavation, possibly the most known of tools used by archaeology, and to relate the contents of the activity with the curriculum of the pupils and their daily experiences. We also attempted to show the visitor the wonders of these special historic places and convert them into active defenders of Heritage.

Even though our experiences with school groups and the general public in the divulging of other disciplines in the human sciences, such as art, history, architecture, museums, photography, etc. [12] were normally based on principals and objectives of a didactic nature, our experience became an essential tool for assuming the challenge of applying interpretation in this area and with these characteristics.

The main sustaining elements of the interpretative and participation principal were the creation of several panels with thematic meaning, the disposition of hands-on elements, the construction of an archaeological crate which allowed us to take a plot of land from a real site to the school and the projection of an audiovisual in which was shown the site taken as reference and a demonstration of carving stone Palaeolithic tools.

In this manner the participants not only had to read, but they also could touch the earth, charcoal, bones, different stones, smell smells, distinguish dampness, manipulate, measure etc. offering a real possibility of understanding and living an archaeology investigation, an alternative that is not common in daily life.

In this essay, we present the methodology used in the assembly of this interactive set-up with the site in the educational centre. The analysis of the results of a voluntary questionnaire carried out on the majority of those who attended is shown, reflecting the degree of satisfaction and use of the activity.

2. The activity.

The cognitive and attitudinal aims of the activity were orientated on: clarifying concepts, presenting the Palaeolithic site of *Chan do Cereixo* (Gondomar, Pontevedra), a site not investigated of the earlier Palaeolithic era, one of the oldest in Galicia, according to the characteristics of the material recovered twenty-five years ago; increase interest in Prehistory; demonstrate archaeology as an interdisciplinary science and make society interested in the study and conservation of heritage.

The location available was the entrance hall of the Auga da Laxe Secondary School (Gondomar), one of five secondary educational centres in Val Miñor (Pontevedra-Spain), with pupils of between 12–18 years old, which included in its curriculum a prehistoric subject. The activity was organised by the *Instituto de Estudos Miñoranos* and was co-financed by the *Dirección Xeral de Investigación e Desenvolvemento* of the *Xunta de Galicia* within its activities of Science and Technology Week 2004.

The messages that were to be transmitted and the medium for its divulging was organised around the corresponding interpretive signs, audiovisual mediums, as well as hands-on and demonstrating materials. The space available was organised according to its functions: a reception area for groups of students, another for presenting an audiovisual, another explicative area in which was shown the interpretive panels with the material on show, objects which could be manipulated, etc. The pupils' visits were attended by specialised monitors who were part of the activity organisation and supported by voluntary pupils from the host centre. This was done in such a manner that the entrance hall of the centre became a combination of a small interactive museum and a real archaeological site as well as for the carrying out of normal teaching work.

The criteria for the preparation of the necessary material were methodologically ambitious, aiming for a complete vision of investigation and paying special attention to the participants. Therefore, for this group from the public who are learning, we designed sheets-activity guides, for personal use and which they later to take to their classrooms, giving them an opportunity to continue to work within a formal academic environment, as well as serving as a means of reinforcing the activity. There were also samples in the hall, which were plasticized, for free use by those accompanying the group or the general public.

These sheets had the function of serving as a guide during the activity, clarifying questions and stimulating participation by presenting fourteen simple activities-games to be done during the visit, looking for the solutions within the actual interpretive set-up, whilst others were to be solved with the help of a teacher in the classroom. They also contained a selection of bibliography and links for those participants interested in knowing more about the contents of the activity.

Figure 1. Working on the site.

Once a date and time had been arranged, a group of pupils, of no more than 25, were received by a monitor who introducing him/herself and presented the activity; on having given out the sheets, the guide commenced the tour by presenting the Palaeolithic site of *Chan do Cereixo* with diagrams and photographs of two light boxes situated at the entrance, this being the first surprise, realising that a place known to them had, up until now, a value they did not know of- Palaeolithic sites in the open air do not show visible signs in the outside. Together with the monitor, the voluntary pupils of the host centre, acted as helpers, offering the material, explaining the handling of equipment, giving out and collecting surveys, etc.

Afterwards, the pupils became involved in the investigation of the site (Figure 1), beginning with its survey: understanding the meaning of terms and its methodology, using some of the necessary equipment: GPS, compass, aerial photographs, orthophotographs, stereoscopic photography which they could see with the stereoscope, diagrams, etc.

On having familiarised themselves with the site, they began their investigation which was based on the following elements (Figure 2):

a) The interpretive panels: were often used for analysing the scientific methodology used in the archaeological field. They were headed by a sentence – a subject that in a simple and attractive manner, gave the message which was intended to be transmitted by the panel. The comments and illustrations that followed: photos, drawings, sketches, diagrams, etc. were for displaying and closing - not amplifying - the message of the sentence - a subject, which was not longer than three lines.

   The subject matter displayed on the panels were: surveying, excavation, auxiliary sciences in the reconstruction of the natural environment, palaeontology, geology, palaeobotany, carpology, anthropology… and the question of chronology in its two perspectives: methodologies of relative chronology, archaeological method (typologies, stratigraphy, etc.), and methodologies of absolute chronology -C^{14}, dendrochronology, potassium, argon, palaeomagnetism, uranium – thorium….

b) Expositive elements in display cabinets, such as replicas of stone tools, samples of stone raw materials, work elements from the archaeological team, part of a tree trunk with growth rings which could be counted and a sample of a stratigraphic column for observing the horizons which the ground forms and a commentary on its differences.

c) In the central part of the space, an archaeological crate measuring 2 x 2m representing the development of an excavation was situated: the surface was divided into work units of 1 x 1m and identified by numbers and letters of the Cartesian system of coordinates, with the remains of a Palaeolithic field site and archaeological work tools. Plan 0 was established to measure the depth of the objects, making available a complete topographic station and a telescope rod. Once the participants were familiar with the methodology of the fieldwork, they were able to take measurements using the equipment and integrate a set of concepts from diverse scientific disciplines.

Figure 2. Visiting the exhibition.

d) The visit ended with the projection of an audiovisual of the Palaeolithic site of *Chan do Cereixo*, in which was also shown a demonstration of Palaeolithic stone carving. This practical activity was previously carried out by pupils from the secondary school host centre (Figure 3), by designing a specific material which had been adapted and allowed them to follow the process: raw materials, origin, technique, products obtained, functionality…

Figure 3. Carving workshop.

Before the leave taking, they were asked to fill in a small questionnaire, individually and anonymously, which was used as a tool for judging different aspects related with the activity.

3. Analysis of the activity.

The questionnaires used for the evaluation of the activity were designed by the *Dirección Xeral de Investigación e Desenvolvemento* of the *Xunta de Galicia* for their own use and even though they referred to different parameters – divulging of the activity, satisfaction, participation, subject matter and organisation-, the excessive standardisation in the wording of the questions is confirmed.

We analysed the questionnaires of a population of around 500 participants, in which 94% of them defined themselves as a captive public for having to visit within the obligatory times of school hours. We will concentrate our essay on the results obtained from this group of pupils, which are of an average age of 14.75 years old.

The chronological distribution of the population in relation to educational cycles shows a higher frequency of secondary school students (Obligatory Secondary Education, between 12 and 15 year olds, both inclusive) (70.45%) than that of pre-university studies (from 16-18 years old) (29.55%). In the distribution by sex, we have a balance between women who attended (52.45%) and men (47.55%).

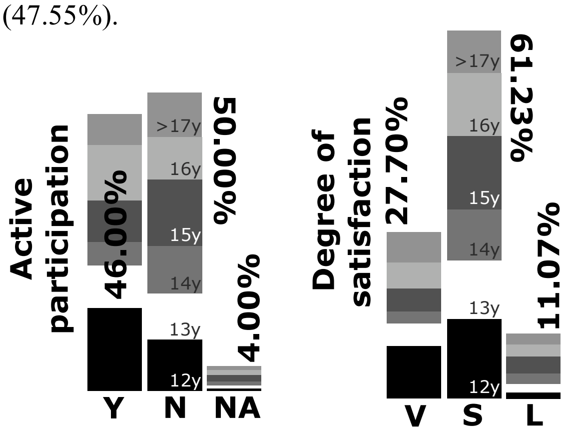

Figure 4. Active participation and general degree of satisfaction by ages.

The evaluation obtained from the degree of active participation (Figure 4), shows in general that 50.00% did not participate, against 46.00% that did participate and 4.00% that did not on considering that the activity did not allow it. The analysis of participation by ages shows that the pupils aged 12 registered a higher percent of participation, the value falls progressively up to the age of 16, at which is registered again another peak of participation that is higher than

50.00%, in the remaining age groups, the participation barely reaches a third.

Undoubtedly, the factors related to this aspect are diverse and complex, but in general we consider the influence of the physical frame in which the activity was developed, very conditioning for the normal functioning of the centre, imposing serious time limitations on the duration of the visit, having to be out of necessity 50 minutes long, the same as the length of the school's classes, so that group changes did not cause problems.

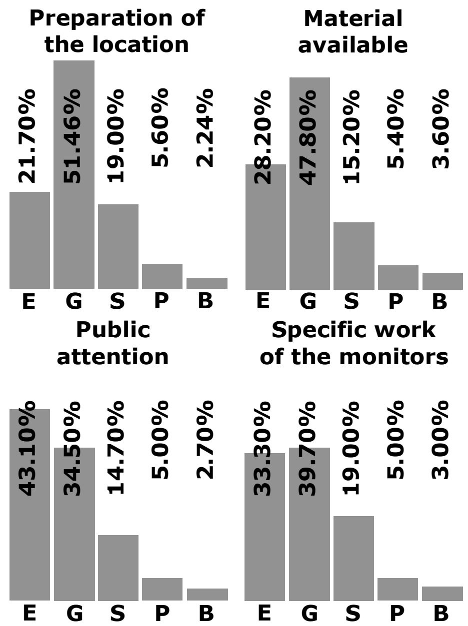

Figure 5. Evaluation of the staging and service given to the participants.

The evaluation of the staging and the service given to the participants were collected in questions in relation to the preparation of the location, the material available and the service given to the public. The results are reflected in Figure 5, and it is highlighted that 73.16% of the participants consider that the preparation of the location was Good or Excellent, 19.00% considered it Standard and 7.84% as Passable or Bad. In relation to the material available for manipulating, 76.00% considered it Good or Excellent, 15.20% considered it Standard and 9.00% as Passable or Bad.

Finally, a high percentage of the participants that considered as Good or Excellent the service given to the general public (77.60%) ratifies the high degree of general satisfaction found in the activity (Figure 4): 88.93% considered it Very satisfactory or Satisfactory, while 11.07% considered it as Little satisfactory. In relation to this, the individual high evaluation of the specific work of the monitors (Figure 5) who guided the activity (73.00% considered it Good of Excellent) is coherent with the degree of general satisfaction found of the visit and confirms important diverse methodological questions in the designing of divulging activities: an interpretive methodology is effective and valid for transmission and communication and implies an intermediation of a specialised interpreter, that is to say, it establishes a direct treatment between the subject, object and the interpreter, offering a high quality service which obtains a high evaluation by the users [7].

The evaluation of the support material, the abovementioned sheets-activity guides, shows that a high percentage of the participants acknowledge a certain utility (54.00%), being more than those who considered it Very useful (28.50%) and those who saw it of Little use (17.50%).

Finally, there was a parameter that tried to obtain information about the coherence of the contents with the general theoretical idea of the proposal, reflected in the title of the activity, and on the public's expectations. The results show that in 69.50% of the cases the expectations of the contents were satisfactory as Very Much and Enough, mean while the rest were only satisfied as Somewhat (22.00%), Hardly (3.00%) and Little (5.00%). This parameter is in relation to the level of previous knowledge that the public has of the subject, considering that the results evidence an important degree of divulgation of archaeology, even though there is a new factor in this activity: an open scientific and interdisciplinary focus that normally constitutes a side less known generally on a school and public level.

4. Conclusions.

The results obtained throughout this interpretive activity of prehistoric investigation are interesting and allude to different aspects of the activity and in general show highly satisfactory results in regards to the objectives proposed initially, after having taken into account the abovementioned limitations. In particular the questionnaires reveal a high degree of satisfaction by the participants in aspects related to the election and proposal of the subject, the set-up of the activity and the services offered (interpreting monitors), which confirms the great effectiveness of a mediating agent which works in the interpretation of contents. This does not mean the explaining of concepts, but the transmission of messages, attitudes, values and sensations in relation to the material and the actual experiences of the public. Other parameters such as participation, were highly conditioned by the physical framework for carrying out the activity, in which was simultaneously produced a formal educational act enforcing environmental and temporal contributing factors in relation to the visit. It is well known, that the availability of a space specially designated for non formal educational activities is an essential condition for the correct development and the attainment of the objectives foreseen [13,14]. In our case, this important factor did not lessen our achievements of the activity. In accordance with the results, the activity seems to have awakened the interest of the participants and they generally thought that the experience was worth it.

5. Acknowledgements.

We would like to thank the members of the *Instituto de Estudos Miñoranos* and the management at the Auga da Laxe Secondary School for the help received, as well as the scientific material provided by the *ETSE de Minas* of the *Universidade de Vigo*. We would also like to thank the Xunta de Galicia for its financing via the *Dirección Xeral de Investigación e Desenvolvemento* (within its activities of Science and Technology Week 2004) and the network "Hands-on Science" (110157-CP-1-2003-1-PT-COMENIUS) of the Socrates/Comenius programme of the European Union.

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An informal interactive science and technology centre

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Abstract. *Interactive centres are an important source of motivation and learning for Science. As a further teaching tool, a small centre for informal learning was set-up in a school, through a process in which both teachers and pupils co-ordinately and cooperatively, carried out the corresponding tasks. Outlined in this essay are the more noteworthy results in relation to the methodology used, a description of the creation process, the design and implementation of the activity and the degree of fulfilment of the objectives which were analysed through questionnaires given out to a notable sample of over 500 people who visited our interactive centre.*

Keywords. Hands-on Science, Informal Learning, Interactive Centre.

1. Introduction.

The learning of Science, as a continual process, needs to reinforce the contents that have been acquired from a formal education with additional tasks, as in many cases it is reduced to a mere collection of facts, directed discussions and occasional activities [1]. On the other hand, it is a well known fact that scientific-technological learning also occurs outside the teaching environment through everyday experiences, and that those experiences influence, in an important way, our knowledge and attitude towards Science [2,3]. In this last case, there is evidence that hands-on activities lead to a greater understanding than that of mere observation [4] and therefore it seems necessary the use of alternative models using constructivist perspectives based on the acquisition of conceptual knowledge through experience and fostering a positive attitude towards Science through the exploration of different learning environments [5]. It is extremely important, within this constructivist context, the previous knowledge, alternative ideas and the nature of the individual as it is a complementary process of the contents.

Within the existing debate concerning what these improved strategies to make Science more accessible should be, interactive centres play an important part within an informal learning context, as they also offer the opportunity to facilitate the general public's updating and to establish a link between Science and Education [6]. Interactive centres provide an opportunity of connecting theoretical and practical concepts and demonstrate Science in relation to daily application through a small semi-guided and personal investigation [7,8]. As dynamic learning environments [9] they provide a rich and structured framework were it is possible to acquire scientific-technological knowledge without the typical restrictions of formal teaching, in which in a non-sequential activity, the participant's choices are multiple and varied in accordance with their own interests and character and the teacher loses his or her regulating or evaluating role. One of the centre's aims is to increase comprehension and to bring Science closer, even though normally the focus is on its products in detriment to the nature of a scientific approach.

Our proposal was to take [10,11] with all its limitations and inconveniences, this informal learning environment to a traditional learning centre, in a process where both teachers and pupils carried out the corresponding tasks, in a coordinated and cooperative manner, with the fundamental idea that it is possible to provide an appropriate vision of the nature of Science to all kinds of public, regardless of their age or origin.

The set-up of a small interactive centre called "Ciencias nas Mans" (Science in your hands) was carried out during the last week of April 2005 in the Escolas Proval Secondary School of Nigrán which was organized by the school's seminars of Physics - Chemistry, Biology – Geology and Technology, with the collaboration of the ETSE de Minas from the Universidade of Vigo, the Instituto de Estudos Miñoranos and the 4th year pupils (who acted as monitors). This was all done as part of the "Hands-on Science" project [13] of the European Socrates/Comenius programme (110157-CP-1-2003-1-PT-COMENIUS.C3). Presented in this essay are the more outstanding results related to the methodology used, a description of the creation process, the design and implementation of the activity and the degree of accomplishment of the objectives through an analysis of a notable sample of the questionnaires filled in by over 500 people who visited the interactive centre.

2. Informal learning at school.

The interactive centre, which was assembled in the school, could be considered as a third generation museum, within the typological classifications of a museum [14], in which a dispersed set of non-contextualised concepts are presented in collections of various subject groups. This is done with the main aim of showing an interdisciplinary and pleasant view of Science, to kindle a thirst for learning, and to connect informal learning with classroom content, thus providing also a valuable experimental supplement, as well as providing the pupils with the possibility of constructing relations and understanding their daily lives through a mixture of exploration, handling and experimentation.

The exhibition [15] consisted of 50 easily reproducible interactive modules, made with easily found and low cost materials; many of them recycled (empty drink cans, yogurt pots, etc.), others that are normally found in school laboratories, and others made by pupils and teachers. The use of familiar and simple objects (Figure 1) allowed visitors to understand in a relatively small amount of time the nature of the corresponding activity, thus avoiding distracting stimulus and arousing the curiosity of the participants. The modules, which were stimulating and fun, were robust and easily handled by any age group or education and they attempt to represent small investigations rather than mere conceptual verifications. Within the experiment was the explicit construction of new meanings and interpretations of how Science works and how it affects our daily lives.

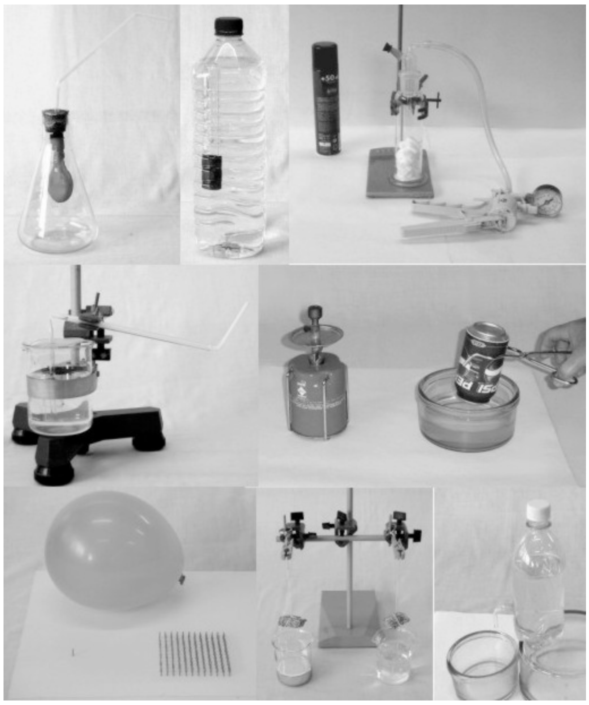

Figure 1. A selection of fluid experiments which showed the materials used.

Each module was accompanied with a self-explanatory panel (Figure 2) which, under a striking heading, contained short written and visual information on how to use them, instructions on possible applications of the contents and some thought provoking issues which attempted to cause the participants to reconsider their mental models, looking for connections with the contents of formal learning which are not evident as a preliminary and necessary step for collecting new information. Complex explanations, difficult instructions or extremely sophisticated set-ups which could inhibit the participant from exploring without help were avoided. The information provided was playful and attractive in order to attract the visitor's attention more and related in some way with the participants' previous experience. This required a certain intellectual implication which avoided the trivialisation of what was trying to be shown. More than learning, the pupils were stimulated to investigate more and to develop a situation in which they could explore for themselves and in their own way, arousing, if possible, the carrying out of further similar activities on their own.

Figure 2. An example of a self-explanatory panel.

The exhibition was initially imagined as catering to about 50 pupils at the same time (one for every experiment). In the following days we found that the space allowed for nearly 70 pupils with no difficulty or overcrowding (Figure 3). The visiting pupils were able to go to any of the experiments with no set order, moving from one to another randomly, this being the most recommendable as they could chose the experiments that most interested them, as would occur in an conventional interactive centre.

Figure 3. The running of the interactive centre.

Although the visit to the exhibition could be done as self guided (Figure 4), many of the experiments (although not all) were permanently attended by nearly 50 of the monitor pupils from the 4th year (with an average age of 16) of the actual secondary school who worked as guides or mediators and provided methodological guidelines in order to communicate with the visitors, as well as providing alternatives to the spontaneous activities of the visitors or carried out necessary adjustments when the occasion arose. In the months leading up to the exhibition, these monitors were trained in all the experiments, so that they knew how to handle and offer scientific explanations about them. It is important to point out that although around 50% of these pupils were not studying either Physics – Chemistry or Biology – Geology; their work was excellent, judging by many of the adult visitors. Throughout the time that the exhibition lasted, the monitors often changed from one experiment to another. To avoid tiring excessively and missing classes of other subjects, the group monitors worked in the exhibition on alternate days.

Figure 4. Exploring.

The visitors showed a great variety of motivations, preferences and interests in regards to learning, being in general the majority a captive public who were pupils from other schools and were visiting as part of an out-of-school activity. The exhibition was open and running during four mornings and one afternoon for the general public which was open for parents and the community, with an approximate participation on the open day of 50 people. Each morning we held two sessions which lasted two hours each with a small break in the middle. All the pupils from the Escolas Proval Secondary School attended; a total of approximately 350. We also invited the primary schools from the Nigrán local authority and the secondary schools from the Val Miñor area (the local authorities from Nigrán, Gondomar and Baiona); giving a total of approximately 230 pupils. Beforehand, the teachers were provided with a 64 page guide book in colour, reproducing the self-explanatory panels of each of the hands-on experiments with the aim of preparing the visit to the interactive centre.

There are many hands-on experiments that exist within the bibliography which can be used in an activity as the one presented above. After an extensive revision, it was decided to make a selection by maintaining the criteria mentioned above, grouping them into seven large subject blocks which were representative of the interdisciplinary aspect of Science and with a strong link to the formal contents which were normally given to students.

The modules were designed with the aim of providing significant learning of a particular scientific-technological topic through its visualization or materialization, even though many times related multiple concepts were demonstrated. On the other hand, the free choice nature of the module caused the visitors to some times do unexpected things. The didactic use of these hands-on experiments became an aspect through which it is possible to evaluate the social dimension of learning by trying to: communicate the significance of Science and increase its understanding, to increase enjoyment in the learning process and achieve a higher active participation and implication. By involving a person actively in these activities through their senses, their memories and their enthusiasm for discovery is stimulated. Thus, they also contribute to more knowledge of Science and this is a good complement for other activities as they do not impose a teaching aspect, but more of a playful or participating aspect. These hands-on experiments not only heighten curiosity, but they also provide an opportunity for self-involvement, by relating the contents with personal meaning.

3. Evaluation of the activity.

It is difficult to evaluate the actual impact of this type of activity with such a heterogenic and diverse public in which so many variables exist [16]. In order to evaluate, it is necessary at least to collect data previously, during or after the activity. On the other hand, a strategy which tries to evaluate the scientific contents acquired during the visit is erroneous, as it seems established that knowledge is not absorbed from just one source. Thus, a survey was designed with thirteen questions, nearly all were of multiple choice, which allowed us to gather information which enabled us to evaluate quantifiable parameters such as age, sex, interest aroused by activity, degree of comprehension of the experiments proposed, the relation to daily life, availability for participation and level of previous experiences of these types of activities, as a captive public or on own initiative. Among the qualitative parameters were included questions of preference and of exclusion for a certain activity, as well as the reason for this last choice, from among four possible reasons: too obvious, did not understand, boring or did not work. Each of these exclusion reasons supposed a determined set of deficiencies about the theoretical proposal of the activity and it became a useful tool in regards to the reinforcement of knowledge, novelty, curiosity and enjoyment. The survey was handed out among students aged between 11 and over 20, from various schools who visited the exhibition as part of their out-of-school activities (Figure 5a). For a very high percentage it was their first experience of this kind, either as part of out-of-school activities from their schools (Figure 5b) or as free time activities chosen by themselves (Figure 5c), which justifies by itself the carrying out of such activities.

The degree of interest in the contents was analysed by a question which accepted as possible answers: a lot, some, and none. The overall evaluation (Figure 6a) shows an extremely high percentage of interest, evidenced firstly by the fact that there was not one negative answer registered and also being 72.00% who acknowledged a lot of interest in the contents of the interactive centre. Consequently, the theoretical subject proposed was of great interest for the public for which it was intended. In regards to the reason for this interest, and taking into account that it was a public who were undergoing learning, it seems that the proximity of the contents is a relevant factor. Other reasons may be the degree of comprehension reached during the visit. This question was also raised directly in the survey with the possible answers of; yes, no, hardly, a great part or the minimum part (Figure 6a). None of the answers manifested not understanding the contents, 7.00% of the answers reflected a low level of comprehension against 93.00% that manifested a high or very high level of comprehension. There are many factors which influence the degree of comprehension during an informal didactic experiment; the relation to the formal contents of the selected activities, the actual set-up of the experiments or the method of transmission, from the agent chosen to be the vehicle of the message to the way it is transmitted. On this aspect, we have already commented on the important role played by the pupil monitors from the centre, who were previously shown how to carry out this important role.

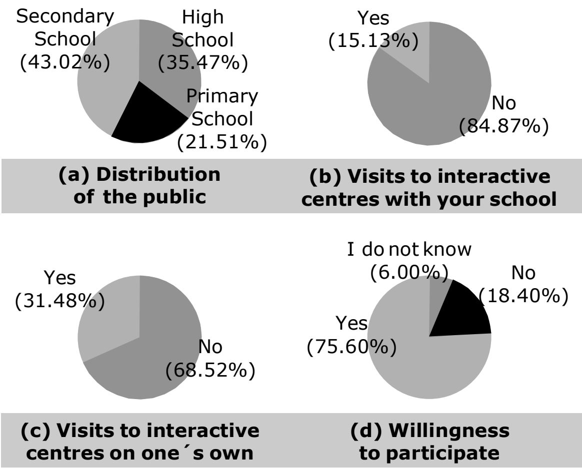

Figure 5. Main topics related with the audience.

The aspects relative to the links that the interactive centre established with the daily experiences of the participants is directly related to the interest and comprehension of the activity, so that the success of these two last parameters depend greatly on the appropriate connection of the subject shown with the daily lives and actual experiences of the public for whom it was directed. Figure 6d shows that 64.00% affirm that the activities reminded them of phenomena that occurred in their daily lives, while 36.00% do not know or cannot find clearly this relation. Undoubtedly, the majority of the visitors who answered in the affirmative correspond to a high and satisfactory level, while just over a third could not establish daily relations.

The general opinion concerning the hands-on experiments that were presented in the interactive centre was shown through the appropriate choice from a set of adjectives (Figure 6c). It is important to point out that the majority thought the experiments interesting (30.00%), funny (15.00%) or surprising (12.00%), Together with 22.00% who acknowledged that they had improved their knowledge. This last answer reinforces the previous question in relation to the individual's experience. In this section it is significant the low evaluation that is generally made of the innovative aspect of the activities against the other options.

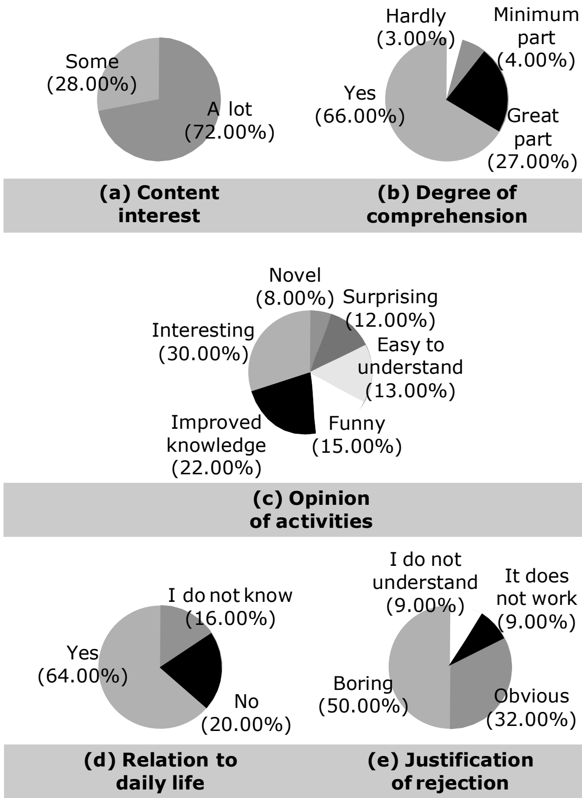

Figure 6. Main topics related with the interactive centre.

The proposal of organising similar activities in their actual learning centres (Figure 5d) appears as a very attractive proposal with a very high percentage of those who answered the survey, showing interest (75.60%) against 6.00% who would not be interested and 18.40% who were undecided.

The qualitative parameters inserted in the questionnaire were used in order to make a general evaluation of the set of hands-on activities shown in the exhibition. For this, they were asked to choose the activity they liked the most and the activity they liked the least, and in this last case, pointing out the reason for exclusion. From a total of 50 activities, there were a group of activities that were liked more and which represent 45.00% and 7.50% who stated that they liked all of the activities. On the other hand, the set of activities which were shown as being liked less is wider and more varied, even though the preferences were also, on this occasion, centred on a group of activities which showed more parallel percentages. In this last case (Figure 5e), the main reason for their dislike was their boringness (50.00%) or for being obvious (29.00%) and to a lesser extent, the activity not working correctly (9.00%) or lack of understanding (9.00%).

4. Conclusions.

The activity carried out tried to show that Science can be something interesting, exciting and easy to understand, thus placing the importance of Science in daily life and as something that can be beneficial, by placing the student into an active and critical learning position: by experimenting, forming hypotheses, interpreting and coming to conclusions. It also tried to transmit, at the same time, the idea that scientific knowledge is basic for everyone in this present-day technical world. Although the duration of the visit was short, the visitors had a positive experience, thus becoming another important step forward in changing their relationship to Science. The public also thought that the exhibition was a useful source of information, which demonstrated daily applications of Science and that it was possible to learn something new from it. The enthusiasm shown by the participants during the activity constitutes also of its own accord an important achievement.

5. Acknowledgements.

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Environmental Education in Greek Schools: The Viewpoint of the Local Coordinators

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Summary. *Although Environmental Education has been introduced into Greek Schools for more than 25 years, it seems that many obstacles still remain including scepticism on the objectives imposed by the state. In this work we present the viewpoints of the local (regional) coordinators for Environmental education in the Greek schools. The data were collected through a Pan-Hellenic survey with a written questionnaire.*

Keywords: environmental education, institutional frame.

1. Introduction

The institution of optional Environmental Education activities in Greek schools covers almost three decades. There are worries however in relation to the existence of the necessary structures, the institutional and legislative frame, and the conditions for its further its development and proliferation.

The realization of Environmental Education projects in schools faces many organizational and institutional problems. The rather low percentage of participation of students indicates that the majority of them, the future citizens, have not profited from the advantages of Environmental Education. Moreover the small percentage of teachers that voluntarily undertake to carry out Environmental Education projects (Michaelides, Kimionis, 2000a) indicate that favourable conditions or motives attracting them to participate in such projects are rather missing.

Many constitutional and legislative regulations refer to the environment, its protection and its conservation. In the National Educational Law anyone may distinguish that the acquisition of knowledge and the development of positive attitudes towards the environment is quoted as an essential objective of Greek education (Michaelides, 1993). To what extent this is really occurring has not been investigated thoroughly.

According to recent surveys important steps towards the promotion of Environmental Education have been made. Mainly during the last decade (institution of local Coordinators for the Environmental Education in each regional Directorate of Education, integration of Environmental Education in the Curriculum, foundation of Environmental Education Centres). Still important problems remain and they generally function as an obstacle to the spread and application of the Environmental Education in schools.

In general the integration of Environmental Education in the educational systems of European countries is realized step by step, and small percentages of students develop an awareness which Environmental Education would provide with (Spyropoulou 2001).

The undefined content and the lack of limitation on the subjects of the Environmental Education projects are quoted among the most important problems as far as the application of Environmental Education is concerned. Furthermore the obscurity concerning the sense of Environmental Education, the lack or the insufficient training of teachers, the lack of motives and the lack of teacher's free time. (Papanaoum, 1997, Giannakaki 2000, Papadimitriou, 1995).

2. Methodology

The current research was conducted through a questionnaire, which was sent to all the 64 Environmental Education Coordinators in Secondary Education Directorates of Greece, by e-mail or fax, from December 2004 until April 2005. Only 41 answered, many after repeated phone calls and inquiries. This is by itself remarkable and needs further investigation.

3. Results

From the 41 returned questionnaires 26 (63.4%) were from men and 15 (36.6%) from women.

The higher percentage (51.2%) of Coordinators who answered, are working as teachers for 20-30 years, while 41.5% have 10-20 years of service. The 2.4% are working 5-10 years and the 4.9% are working 30 years and above.

The duration of service in the position of Environmental Education Coordinators is presented in table 1. As it appears in that table, there is a high percentage of Coordinators with 2 or more periods of service in this position (every period is for a term of 3 years). There is also a percentage continuing to have this position (14 years of service) from the introduction of the institution of the above responsibility. Consequently, it can be considered that the sample of the people participating the research posses enough experience on the subjects concerning the course and application of Environmental Education.

Table 1: Years of responsibility as Environmental Education Coordinators

years	Frequency	Percent
1	2	4.9
2	12	29.3
3	3	7.3
4	2	4.9
6	2	4.9
7	3	7.3
8	2	4.9
9	2	4.9
10	3	7.3
11	4	9.8
14	6	14.6
Total	41	100.0

In any case despite the experience they have acquired in this position and the fact that most of them consider that they have sufficient, even satisfactory training (Table 2), still many of them feel that they need further training (Table 3), acknowledging the need for further knowledge concerning this position.

The questionnaire included specific questions on how the coordinators judged their competency and the degree of their satisfaction from the operation of Environmental education, prominent problems, etc. The results are summarized in Tables 2 to 10.

Table 2: Training concerning the position of Coordinators

Question: Wow do you consider your training concerning your position?		
	Frequency	Percent
Sufficient	16	39.0
Satisfactory	23	56.1
Not satisfactory	2	4.9
Insufficient	0	0.0
Total	41	100.0

Table 3: Need of further training of Coordinators

Question: Do you believe that you need more training?		
	Frequency	Percent
Yes	37	90.2
No	4	9.8
Total	41	100.0

Table 4: Satisfaction with the number of Environmental Education projects

	Frequency	Percent
Very	22	53.7
Mediocre	18	43.9
By no means	1	2.4
Total	41	100.0

Table 5: The level of the application of Environmental Education

	Frequency	Percent
Very good	3	7.3
good	29	70.7
Mediocre	9	22.0
Poor	0	0.0
Total	41	100.0

Table 6: Satisfaction for the existing situation of Environmental Education in our country

	Frequency	Percent
Very much	0	0.0
Very	10	24.4
A Little	28	68.3
Very little	2	4.9
By no means	1	2.4
Total	41	100.0

It appears from the answers of Coordinators that, when they refer to their area of responsibility, where their personal contribution is strong, they seem to be satisfied with the number of projects which are carried out (table 4) and they consider the application of Environmental Education as satisfactory (table 5). However, when they refer to the situation nationally they describe a more unpleasant situation (Table 6) and they declare that they are "a little" satisfied in a percentage of 68.3%. In the question: what is, according to your opinion, the most important problem that the Environmental Education face, a high percentage (53.7%) reports "the institutional". A percentage of 22.0% reports "the economic" while a percentage of 17.1% reports "the organizational" problem. Moreover, some (a percentage of 7.3%), report as the most intense problem, according to their opinion, that of "*evaluation*" or "*teacher's training*", even the "*pedagogic -instructive*". Coordinators consider also that the existing institutional framework is from "a little" as "by no means" sufficient, so that they cannot complete the objectives of their mission based on such a frame (Table 7). Only 7.3% consider that is "very sufficient" and 2.4% that it is "Very much sufficient", while 2 individuals did not answer.

Roughly the same perceptions prevail also in the answers to the question *if the existing institutional framework facilitates the work of the teacher for the completion of the Environmental Education projects* (table 8). A high percentage of 68.3% consider that it facilitates "*A little*" the teachers and a percentage of 22.0% consider that it facilitates "Very little".

We should mention that the current institutional framework was put into practice with the Ministerial Decision 57905/G2/4-6-2002, fifteen years after the official introduction of Environmental Education. Until then, the institutional framework illustrating the application of Environmental Education was derived mainly from the governmental law 1892FEK101/31-7-1990 and the Ministerial Decision F16/102/G1-308/3-4-91 and G2/4867/28-8-92. Someone would expect that the new framework would take under consideration the experience of past years of application of Environmental Education and would fulfil the expectations and needs of the Coordinators of Environmental Education and the teachers who are involved in Environmental Education. It seems though that nothing of the above is occurring, according to the answers of Coordinators, as they were illustrated in the questionnaire of the research.

The Environmental Education Coordinators consider as problematic factors, undermining the participation of teachers, the lack of motives (73.2%), the absence of further training (65.9%) and the lack of free time (70.7%). They also note that teachers are in desperate need specialized training (table 9).

Table 7: Institutional framework with regard to the Environmental Education Coordinators

	Frequency	Percent	Valid Percent
Very much	1	2.4	2.6
Very	3	7.3	7.7
A Little	25	61.0	64.1
Very little	7	17.1	17.9
By no means	3	7.3	7.7
Total	39	95.1	100.0
Missing System	2	4.9	
Total	41	100.0	

Table 8: Institutional framework with regard to the teachers

	Frequency	Percent
Very much	0	0.0
Very	2	4.9
A Little	28	68.3
Very little	9	22.0
By no means	2	4.9
Total	41	100.0

Table 9: Teachers need of further training

Question: Do you consider that the teachers need further training?		
	Frequency	Percent
Very much	19	46.3
Very	22	53.7
A Little	0	0.0
Very little	0	0.0
By no means	0	0.0
Total	41	100.0

Table 10: The intention of the state

Do you consider that the state…	Frequency	Percent
encourages the application of I.E.	16	39.0
is indifferent for as the application of Environmental Education	18	43.9
impends the application of Environmental Education	7	17.1
Total	41	100.0

The desperation and disappointment of Coordinators is reflected intensely in their answers to the question regarding the contribution of the state towards the application of Environmental Education. A percentage of 43.9% considers that the state is “indifferent” and a percentage of 17.1% that the state “impends” the application of Environmental Education. Only 39.0% supports that the state encourage the application of Environmental Education in Greece (table 10).

Conclusions

The answers of the Local (regional) Coordinators responsible for the Environmental Education show a disappointment and a sense of lack of support from the state concerning Environmental Education. The institutional framework does not seem sufficient neither to the teachers, nor to the Coordinators of Environmental Education. The impression they have is that the state in fact is indifferent or even impends the application of Environmental Education in schools since there are not, according their opinion, the essential and favourable conditions that would motivate the teachers, support the Coordinators and encouraged really the application of Environmental Education. Therefore, the reform of the Institutional Framework to take into account the past experiences of the operation of the Environmental Education and the viewpoints of the teachers and of the local Coordinators, as well as that of the staff of the Centres for Environmental Education seems necessary. Further training is of the most important factors to support the Environmental Education. Its importance is pointed out from everybody and many of researches (Flogaeti, 1993, Kimionis 1995, Michaelides-Kimionis 2000b, Michaelides et al, 2002) refer to its necessity. The continuous and sufficient training of teachers in the Environmental Education will give impulse and will contribute positively in the application of Environmental Education. The state should create the necessary conditions that are essential for the support of teachers and those who actively participate the Environmental Education by promoting and encouraging legislatively and institutionally the Environmental Education without promoting activities which remain on the surface.

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The Promotion of Scientific Literacy with Alternative Methods and Activities. The experience of the Laboratorial Centre of Natural Sciences (EKFE) of Rthymnon

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Abstract. *Natural Sciences, even if they firstly attract, they also scare because in the consciousness of students they have been related with a high degree of difficulty and because their models of teaching are not the appropriate ones.*

This has as a result that the students who come out from the secondary education are, in a great percentage, scientifically illiterate. But also new schoolteachers appear to have important difficulties in the comprehension and application of Natural Sciences, as we have realised during in-service training seminars.

In the latest years, a change in educational models has taken place in Greece, which gives priority to experimental teaching and to the connection of sciences with their applications in everyday life.

The creation of EKFE helped considerably in this direction. The EKFE with a lot of alternative ways and activities enable the comprehension and popularization of Natural Sciences by the students and provide precious help to the teachers. Furthermore, with various European programs in which they have participated, they appear to contribute to the osmosis of pedagogic ideas and the transfer of modern and original theories and methods from other countries to their regions in Greece.

Keywords. Laboratorial Centers of Natural Sciences, scientific literacy, in-service teacher training.

1. Introduction

It is a highly admitted that Natural Sciences are exceptionally interesting and fascinating. This is rather attributed to the fact that they have an immediate connection to everyday life and provide – or at least they try to give - answers to thousands questions that a person may ask, both in theoretical and in practical terms. As a result, it is normal to expect that the students would approach them with interest. However, the big majority faces them with fear, indifference, or even antipathy. There are various reasons to explain this behavior. Two of the most important ones, are their high degree of difficulty and the inadequate approaches of teaching.

However, are Natural Sciences really difficult, or do they simply appear like that because of the way they are presented? Undeniably, their comprehension presupposes a minimal base of knowledge of mathematics. This dependence on a subject usually considered as students' nightmare appears to be enough to create, from the very beginning, a negative attitude towards sciences. Furthermore, the type of language used to explain them in a written way is eminently symbolic; in consequence sciences are taken by students as a "knowledgeable" subject. It is really difficult for a teacher to convince them that the writing of «$C_6H_{12}O_6 \rightarrow 2\ CH_3CH_2OH + 2CO_2$» is necessary, in order to describe the creation of a divine gift that is called wine, while the «$CH_3CH_2OH + O_2 \rightarrow CH_3COOH + H_2O$» describes its transformation in the "awful" vinegar.

In addition to these, the way of teaching, at least in the Greek school, puts particular emphasis in "theoretical elements", and makes the possibility of practising the natural Sciences really dislikeable. As a result, students turn their back to these courses and as they are taught in a misinterpreted, unfruitful way, they come out to be: "scientifically illiterate ".

In order to find out solutions to this problem, questions as the following have to be answered: What is essential to teach to our students? How it will be taught? In conclusion, which type of student do we want to "form'' at school? Students theoretically experienced and taught who will know how to solve scientific problems and how to form chemical equations, whereas they won't be able to distinguish whether in the electricity bill we pay for the "power" or "energy" we finally consume? A scientifically illiterate student is a tomorrow's insufficient and depended citizen. A citizen who won't have the ability to interpret, to seek, to correct, to manufacture and to live in harmony with the environment. Furthermore, despite the fact that we are at the beginning of the century of a technological and a scientific boom, unfortunately compulsory education "produces" a paradoxically high percentage of "scientifically illiterate" young persons. Although young people are familiar enough with new technologies (PCs, mobile telephones, Internet, electronic games, etc.), they cannot interpret simple phenomena, manufacture or repair simple appliances, they are deprived of perceptiveness and after all they do not learn how to use scientific methodology in the resolution of various problems related to everyday life.

2. Characteristics of scientific literacy

I will present five characteristics of what we describe as *"scientific illiteracy"*, as these have been realised through specific activities and training experience that I have had in the EKFE of Rethymnon:

A ***-Insufficient ability of application of scientific knowledge:*** In the training seminars of new school teachers, we give them a lamp, only one cable and a battery and then we ask them to turn on the lamp. Above half of them do not accomplish it in the first 5 minutes

B ***-Insufficient perceptiveness:*** In another training activity, we give to young teachers of Natural Sciences, a box that contains a pencil, a rubber, two stones, a paper clip, a small photograph, a coin and a piece of copper, and then we ask them to observe with attention the contents of the box for one minute. Then we take the box away and we ask to describe its contents on a piece paper. A percentage bigger than 80% simply reports with one word, for example: "a pencil, a coin, a photograph etc.''. That is to prove that a very small percentage observes that the pencil was yellow, with black ruler and rubber, type HB.

C ***-Lack of accurate expression:*** I used to ask new schoolteachers the temperature of water at the boiling point. Most of them give a firm answer like: "in 100 degrees". Less than 5% are able to give a complete answer: "clean water" boils in 100 °C, when the pressure above it is one atmosphere".

D ***-Difficulty of interpretation of phenomena of everyday activity:*** Some of the questions that I ask new primary and secondary are the following:

1. Why when cold water stays for long in a glass bubbles are formed on its walls?
2. Why when we open refreshments with carbon dioxide intense foam is observed?
3. Why food is cooked faster in a pressure-cooker?
4. Why when we pull a piece of thread abruptly it breaks easily, whereas if we pull it softly it doesn't?

New schoolteachers find difficulty in giving evident and completed answers to these questions. And it is difficult to teach properly Natural Sciences, when you cannot even realise by yourself their utilisation as a tool for interpretation of simple phenomena of everyday life.

E -Insufficient application of scientific methodology to discover a solution in various problems: We have realised incapacity in the analysis of a problem, its comprehension and in the articulation of simple steps which may lead to a solution. Here is a characteristic example: We give a thread, a metal weight, a meter and a chronometer and we ask them to measure the intensity of gravity "g" in the room, with 5 successive measurements. In this problem the most common weakness, which is observed, is the identification of the relevant natural law, or the "lesson" they will have to use, ignorance of the scientific equation that gives the period of the simple pendulum and the necessity of multiple measurements.

I referred to these examples because they are characteristic of the scientific insufficiency and lack of methodology that characterizes not only the students but also many of the teachers. This situation is a "creation" of an anachronistic educational model, inadequate to promote the charm of Natural Sciences and to provide students with essential knowledge and sufficiency of scientific resources. Even if we recognize an effort that has begun in the last 7-8 years in our country to change the educational methods, something that is also expressed in the contents of new school science textbooks, however the road leading to the acquisition of a qualitative scientific literacy of young people still remains long. The contribution of Laboratorial Centres of Natural Sciences (EKFE) to this effort has been essential.

3. The contribution of EKFE to the development of scientific literacy of students and teachers

The *Laboratorial Centres of Natural Sciences* is a relatively recent institution in the Greek educational system. They were founded only 7 years ago and their main aim is to support the Laboratorial teaching of Natural Sciences in secondary education, but also in primary schools to some extent. Nowadays, 78 Laboratorial Centres of Natural Sciences are in operation all over the country and with a wide field of activities, they support substantially the scientific literacy of students in the field of Natural Sciences. Some of the activities of EKFE are the following:

- **the laboratorial equipment of schools**,
- the **training of** teachers of secondary education in the experimental teaching of Natural Sciences
- the **organisation of visits of Schools** in the laboratory Centres and the implementation of experimental activities by the students
- the **production of educational material**
- the **research** in the domain of teaching through experimental support
- the **application of innovative methods and new technologies** in the education etc.

In a framework of promotion of alternative methods of teaching in Natural Sciences, the EKFE of Rethymnon has advanced a variety of activities since 1997, which we present for reflection. More precisely:

1. We have printed out a manual of many pages of experiments of Natural Chemistry and Biology that is accompanied by a CD and videocassettes, which has been distributed to teachers. The selected experiments are simple and charming.
2. We have recorded and videotaped a lot of experiments that can be conducted with simple materials, in two units (Heat, Fluids). They have been sent to all schools of the prefecture of Rethymnon.
3. We have organised 2 weekly Mobility Programs of teachers training, which dealt with the topic *"the Natural Sciences in the everyday activity of a person"*.
4. We have organised a European Program of Training of Greek science teachers in France, where apart from the briefing in the French Educational system they also had the opportunity to visit two worldwide recognised centres relative to the teaching of Natural Sciences: The *Vilette* (City of Sciences and Technology) and the Museum "*Palais des Decouvertes*".
5. We have organised a school competition of projects and constructions, which had as a topic*: "Making use of alternative forms of energy"*.
6. We have recorded a big number of questions and answers that are related with the application of Natural Sciences in everyday life, which is offered as training material to the new teachers.
7. We have organised a lot of visits of students from Schools to the Laboratorial Centre dealing with *"experimental activities with simple materials*".
8. We have presented educational software of the Natural sciences and simulations of experiments in the various schools of the prefecture of Rethymnon and we have educated science teachers in this software.
9. This year we have replaced a big number of Chemistry experiments with respective experiments in "micro-scale". These were impressive experiments to students and also friendly to the environment.

We consider that through these activities, we brought teachers the students closer to the real meaning of Science. We helped them discover its charming side. Sciences became friendlier to their eyes, easier to approach. We presented the necessity of the knowledge of scientific laws and their application in our life. Finally, we tried to teach the students how to think practically: they ask, search, discover, interpret and manufacture. In other words, acting rather than accepting. They have learned not to be only receptors but also transmitters of messages simultaneously. We vision an intergraded education which will have "the active students" as a centre together with their scientific literacy. However, let us make the beginning. After all, in this place, thousands of years ago, it was believed that "**the beginning is half way through all".**

Computer-Aided Simulations for Hands-on Physics Experiments

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Abstract. *The curriculum for science education both secondary and university level includes laboratory (practice work) experimentations aimed to enhance students' theoretical knowledge gained during lectures and seminars. For this goal school laboratories normally require relatively expensive equipment. Due to economical hardships, the present-day Armenian schools are very poor with technical means of teaching. The shortage of laboratory facilities is an influential factor restricting the advancement of students' hands-on comprehension in science learning. The preset paper is an attempt to examine the opportunities that computers provide in physics teaching practice and to share our experience in this field.*

Keywords. Computer aided instruction, physics simulations

1. Introduction

Armenia was one of the first in the Soviet Union by the percentage of people with higher education. On one hand it was conditioned by the fact, that Armenian industry of the Soviet period was highly technological and science consuming. On the other hand the values of education, knowledge, and professional development were strong and sustainable in society during all periods of Armenian history.

Armenian educational system as all other aspects of economic and social life has largely changed due to the need to adapt to the realities of a market economy in the presence of suppressing economic restraints and uncertain democratic changes. In the meantime these realities impose new requirements and need for educational system and the role of education in the society. Despite the last years' dramatic change in whole economy, the statistics shows that the number of applicants to higher education institutions has not decreased, and the values of education is still very high in Armenian society.

The benefit from the information revolution will depend very much on readiness and capability of country to put in place relevant policies and plans to enable to deploy the power of the Information and Communication Technologies (ICT) to transform its educational system. ICT allow education to be delivered in different ways. They are making high quality technology-based education and training easier to design, develop and deliver and providing the opportunity to educate a greater number of people than was possible before. They promised more than just an improvement in educational productivity; in fact they have potential to deliver a qualitative change in the nature of learning itself. For the first time in history, the world can become a student's classroom through the use of interactive telecommunications such as the Internet. The ICT allows organizing a new progressive and favorable educational environment that can provide our citizens with the opportunities of better access to information, exposure to the Western-type of educational system. The emerging educational technologies, particularly those in the area of ICT are providing new ways of education, training and learning – a window of opportunity to supplement and complement the education and training resources and to support the process of developing an economy based on an advanced and reliable national information and communications infrastructure.

The most current, effective educational solutions based on the possibilities of ICT in education allow establishing a dynamic open-source educational environment that open wide possibilities for continuing distance and online education.

2. Hands-on physics experiments: virtual vs. real

The continuous growth of ICT allows wide integration of computers in virtually every stage of teaching process. The effectiveness of ICT application in teaching depends upon various factors – hardware, software and teaching techniques used by teacher. A great deal of opportunities appears while applying ICT in physics teaching. Since physics is experimental science in essence, its teaching should be accompanied by hands-on experiments. The curriculum for science education both secondary and university level includes laboratory (practice work) experimentations aimed to enhance students' theoretical knowledge gained during lectures and seminars. For this goal school laboratories normally require relatively expensive equipment. Due to economical hardships, the present-day Armenian schools are very poor with laboratory facilities and with technical means of teaching in general. The shortage of laboratory facilities in most of Armenian educational organizations is an influential factor restricting the advancement of students' hands-on comprehension in science learning.

The emerging ICT are providing an opportunity to improve the situation. Using computer simulations of specific experiments imitating the real physical processes it is possible to somehow overcome the lack of laboratory facilities. The main idea is to use computer simulations at science classes as an alternative of laboratory facilities. Virtually all physics laboratory experimentations can be performed by means of computer simulations.

Computer simulations are integral part of Computer-Assisted Instruction (CAI) that feature live video, sound, animation and interaction. CAI with physics (and generally - science) simulations should comprise introductory theoretical materials, exact description of sequential steps that should be implemented and lead to obtaining experimental data and analyzing them. Surely these simulations should supplement and not substitute the existing facilities.

The effectiveness of these simulations in learning process is obvious – they are cost-effective, they have more demonstrative functions then real practice works and they are absolutely safe. Moreover the simulations allow stepping beyond the limits of ordinary physics laboratories and exploring phenomena that cannot be visualized in any other way.

In computer simulations the CPU imitates the real experimental device; the keyboard becomes a control unit while the monitor combined the digital indicator and a window demonstrating the experiment, displaying graphs, charts, tables, etc. that clarify and enlighten whole process. The computer imitators allow:

- Modeling of physical phenomena under investigation,
- Real-time visualization of experimental device,
- Wide-range modification of technical characteristics of devices and the parameters of experiments.

Surely in order to take advantage of the physics simulation opportunities a well-equipped computer classroom is necessary and as a result expenses on its furnishing could be comparable to the cost of real school physical laboratory. But our experience show that in fact hands-on computer simulations could be effectively integrated into teaching process by means of only single computer with 17-19'' monitor. In this case all students perform the same practical experiment (simulation). Thus the school laboratory facilities based on computer simulations are cost-effective in comparison with the real experimental facilities produced by small series.

Authors keep using computer simulations of some laboratory assignments in teaching practice at different universities and high schools. But most computer-aided ready-made teaching tools are in English or in Russian and therefore certain language problems arise while exploiting them at schools. Besides these teaching materials in general doesn't agree with the curriculum requirements and teaching standards of Armenian schools. To overcome these difficulties we are on a way putting into practice self-designed CAI tools in physics. One of simulations in quantum physics that authors include in their curriculum is available online (see e.g. [1]). The simulation demonstrates a phenomenon (photoelectrical effect) that cannot be viewed visually in any other way but by means of computer imitation. This CAI tool comprise following virtual experiments

- Visual examination of photoelectric effect
- The main laws of photoelectrical effect
- Checking Einstein's theory
- Measuring the Planck's constant

You can take a look on screen snapshot of the photoelectrical effect simulation.

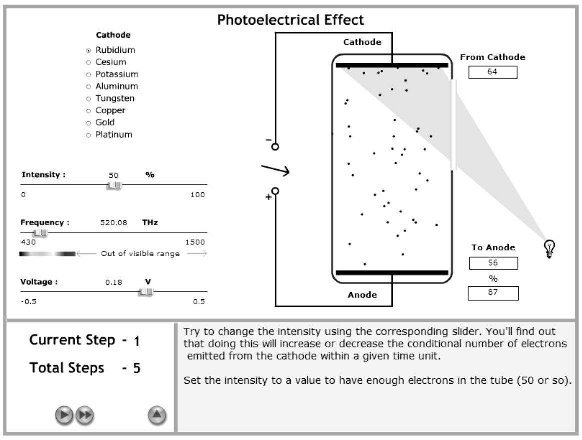

Figure 1. A screenshot of photoelectrical effect's computer simulation.

Instructional language of simulation is English but it could be localized in any language as we used XML format for text information that allow easy modification and/or addition.

3. Discussion

The computer simulations give the instructor wide opportunities to improve the organization of the lesson. He/she can use solely the computer simulations or combine them with real experiments. This is preferable as one hand a good deal of students is willing to do so and on other hand this will offer the students more factual and realistic knowledge about physics experiments.

We carried out an informal survey through our students in order to examine the level of science comprehension after performing computer experiments. Both secondary school (51 respondents from 8-10 grades) and university students (66 respondents from physics and engineering departments) were inquired. The results of survey are introduced in Table 1 and Table 2.

As it is could be seen from the tables most of students prefer the computer experiments vs. the real ones. This ratio is greater for secondary school students. This can be explained by the fact that some of younger students consider the simulations as kind of games and enjoy the process, fan of learning, rather than the understanding of physical phenomena that it offers.

Table 1. Satisfaction level (in percents)

	Secondary school students	**University students**
Completely satisfied	**59**	**44**
Somewhat satisfied	**24**	**38**
Completely unsatisfied	**17**	**18**

Table 2. Evaluation of knowledge enhancement (in percents)

	Secondary school students	**University students**
Computer simulation offers more knowledge then the real experiment	**61**	**58**
Real experiment is preferable than the computer analogy	**15**	**22**
It is better to combine both experiments	**24**	**20**

Our experience shows that in fact, computer simulations solely will not give the students the experience and skills of physics experimentalist. More pedagogical outcome can be gained if every student will have opportunity to perform the part of assignment on natural, realistic experimental device and the other part – by means of computer simulation. The first part of the assignment gives the students an opportunity to reveal the casual phenomena and accidental factors that can lead to methodical and unexpected errors or inaccuracy. Thus real physical experiments provide students with understanding that no single physical phenomenon could be viewed in "clear" attitude and thus the result of experiment depends on how successfully the casual, secondary factors are excluded.

We are planning to construct a physics laboratory of CAI and make them available online. Any physics instructor can use this laboratory to boost students' theoretical knowledge since in our time learning is more than just textbooks. It's about exciting new technologies that actually involve students in learning and that engage students' all senses and brain.

4. Acknowledgements

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A Web Site about Historic Experiments (HE) The Galileo Free Fall Experiment The Topics – The Structure

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Abstract. *Any modern curriculum has science literacy as one of its aims. In such a curriculum the study of the natural science should have a prominent place. We believe that history of science provides another way to the understudying of how science works. The presentation of Historic Experiments is a way to present the evolution of the ideas in Science. The Historic experiments like Galileo's Free Fall Experiment contributed to the establishment of the scientific theory for motions, led to the introduction the new concept of inertia and has influenced the evolution of the ideas in science and the society (Millar R., Osborne J., (eds). Beyond 2000)..*

In this paper, we present our view of how such an experiment should be present on Internet so it serves as educational material in class, for the Secondary Educational level. Text from Galileo's book "The Two Sciences", references to the social conditions the period he was experimenting, animations, simulations of the relevant theories and work sheets are included. We think that this material will help the student:

a) to realize that scientific knowledge is always subject to modification

b) to understand that the gradual accumulation of knowledge over many centuries has led to the growth of science and technology of today and

c) to acquire a deeper understanding to the phenomenon itself, as well as, the way the scientist (Galileo) worked in trying to explain it. In this way we believe that the student is engaged in the scientific process.

Keywords: Historic Experiments, Free fall, Free Fall Laws, Galileo

Inrtoduction

The idea of teaching in class elements from the History of Science and reproducing a number of simple Historic experiments is a way to help students learn about the nature of scientific inquiry and to encourage school teams in working as "researchers" and discover the way of discovering (AAAS, Historical perspectives: 1993),.. More specifically:

- Pupils get familiar with real problems and with the way the pioneer researchers solved them. Possible solutions can be subject of discussion in class. Since in the early years the experiments were done using simple devices, it is quite possible that some students will come up with realistic suggestions. For example, the problem Galileo was facing was how to measure time. Our students are surprised to hear this and are curious to learn how the problem was solved.
- The pupils get an idea of all the difficulties and contradictions around a revolutionary theory, like Galileo's Free fall theory. It is important to realise that it is not easy to understand the physical phenomena (not only to them, but to everybody); you must make a real effort and spend a lot of time in taking continuous measurements and improving the apparatus used. At a later stage the students will find out that the scientists often don't follow in their research the standard step of the scientific method as we teach them at the secondary level; their work includes the collection of phenomena of relevant evidence which in combination to logical assumptions and the intuition of the researcher lead to the scientific hypothesis.
- Dealing with real problems, the students learn the concept of controlled variables; if two or more parameters vary in an experiment then you cannot have clear results from the experimental data. It is difficult, in this case, to correlate specific changes to the relevant magnitudes. One should be careful in designing an experiment and selecting the devices, to avoid such complications (AAAS, The nature of science: 1993).

- The students get aware that the results of a research might be different than the expected ones. New ideas are often the product of such situations and they lead to new research (*T. Kuhn,1962)*.. In the options “The Determination” and “The Hypothesis” of the site, the students will find the first and the second hypothesis of Galileo about the falling objects.
- The determination of the researchers inspires young people; the example of brilliant men and women, who had to prove themselves, motivates them. Hard work in Science pays, maybe not with money or fame, but it gives a real pleasure to the person who becomes able to understand the mysteries of the Nature (Gil-Perer D. 1994).

Presenting Historical Experiments on the Internet has certain advantages:

- In a web site, detailed instructions can be given to school teams that want to reproduce a historic experiment, accompanied by simulations.
- It is possible to exchange ideas and present the work of teams who perform their version of the Historic Experiment (Π. Δημητριάδης: 2000, Stefan Aufenanger: 2000) .
- It serves the Science teacher by providing him/her with material tailored to the needs of the Science lesson. Each presentation can be given in both a short form and a detailed one, which cannot be done in a book. Most science teachers will limit themselves to examining the short option. For someone who is more deeply interested in a certain part (e.g. the historical events, or the detailed description of the experimental data) there is the possibility to find out more about it by reading the detailed description on the site.

The topics - The structure

Figure 1. The main menu

Having all the above in mind, we tried to create as an example a web site about Galileo Free Fall experiment, a historic experiment which has influenced the evolution of the ideas in science.

We tried to give to the web site the appropriate structure, so it covers both the technical features as well as the evolution of the ideas, the personality and the sociological impact of the HE. The content of the site is tailored to the standard steps of the Scientific Method. That is:
The Previous Theories and their incapability to explain the new data
The Hypothesis and its validation through the experiment
Step by Step: A description of the experiment; the declaration of the variables, the collection of the experimental data, the variable dependence in the mathematical model (Π. Δημητριάδης 2002).
The menu options represent the steps above trying to familiarize the user with the Scientific Method’s steps.
Moreover, it allows the teacher and the student to find easily what he/she is interested in.
The text is divided in small parts; we tried to make it simple and clear. In each page there are static pictures, animation or simulation, with some degree of interactivity.
Worksheets varying in content and difficulty are included, in order to keep the attention the students and test them.
The topics in the web site are:

- The Importance (of the Experiment)
- The Personality (Galileo’s personality)
- The Determination (of Galileo)
- Aristotle’s Theory (the previous theory)
- Doubts… (about Aristotle’s theory)
- Galileo’s Doubts (about Aristotle’s theory)

- The Hypothesis
- The Experiment

In the options “Doubts” and the “Hypothesis” a few sentences of the original texts of Galileo is included. That is because, even short parts or specific expressions, usually give away the spirit behind an innovating action. Each Option includes links to other sites and worksheets.

Doubts… (about Aristotle’s theory)

We present the logical arguments and the mental tests against Aristotle’s theory from the ancient years until the Renaissance in the form of text or simulations. Our objective is for the student to realize that the scientific theories are under constant testing and reassessment; sometimes they are proven wrong and they are overthrown. In the work sheets the school teams will be able to find simple instructions how to repeat the ”doubting” experiments themselves and so to understand those arguments; simulations may help in this direction. Some of the activities in the work sheets try to deal with the misconceptions of the students like that “the heavier bodies fall faster” (NATO: 1989, Thorton R.Q 1999).

The Experiment

The Options “The Experiment” includes the following submenus:

- The Breakthrough
- The Steps
- The Formulae
- Simulation Models
- Modern Experiments

The Breakthrough

The page starts with the problems and difficulties Galileo faced in carrying out the experiment. The user is encouraged to try out to find solutions and then, using hyperlinks he/she can see the solutions given by Galileo.

There is, also, a description of the mental experiment of Galileo which led to the introduction of the concept of Inertia. In the simulation of the experiment a ball rolls (actually slides) down a slope, and then rolls up another slope and reaches the same height where it started; the user can change the angle of the second slope and finds out that, each time the ball reaches the same height. It is pointed out to the user that, in this case, there is no friction. In the simulation of the experiment where the friction is not zero they can find out that the height that the ball reaches at the end, depends on the friction value and decreases as the friction increases. In the work sheets the school teams are given instructions to repeat a variation of the experiment using simple material. They make one slope and by using different materials on the horizontal plane, they can find out that the horizontal distance traveled by the sliding bodies depend on the friction. Our objective is that the students get to understand the concept of the controlled variables (height, inclination); it is an attempt of dealing with multi – variable problems.

The Steps

The students can reproduce the experiment of Galileo following the instructions and pictures. They must have already discussed about the problems and the solutions. At this stage they are encouraged to try to redesign the experiment under their teacher’s supervision using probably modern measuring devices. They should define the controlled variables.

The Formulae

The students are given the mathematical equations of the free fall and the ones applied at the experiment with the inclined plane. At a later stage we are going to add the process through which Galileo reached the Free Fall Laws. They should find out whether they can reach the same conclusions through the experiment. We avoid the geometrical approach of Galileo and focus on the concepts of the physical magnitudes like the velocity and the acceleration. The students should be encouraged to work with the relevant graphs and extract information from them (Mokros: 1987, Dimitriadis P.: 1999).

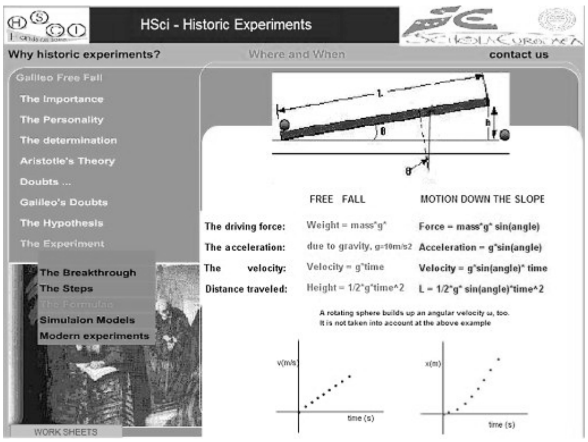

Figure 2. The Submenus

Simulation Models

In this part the students are encouraged to familiarize with the manipulation of the dependent and in depended variables, by using the options of the simulation programs.

The option “Modern Experiments” includes the submenu:

- Measurements (Static Pictures)
- Fall in the Air (Video)
- Free Fall (Video)
- Free Fall on the Moon (Video)
- Your Experiment (Instructions)

In the text, we tried to avoid long and tedious stories, as these will bore the students too quickly. The few students who would like to learn details can use the links to other sites.

An important part is the worksheets. Our experience is that the students are pleased to go through educational material on the Internet, but soon they become bored and lose attention. They must be encouraged through properly prepared questions to discover the satisfaction of observing “physical phenomena” (e.g. a video or simulation of a machine) and of controlling the simulated events by interacting with the programs. Some teachers make the mistake of thinking they can leave their students alone in front of the computer; we should have in mind, that students always need guidance and inspiration, also when they work with material on the Internet.

We tried to take care that the educational material is presented in a flexible form. It should for instance be possible to be presented in class by the teacher or to be worked out by teams of two or three students for one or two didactic periods.

We tried also to encourage the users throughout the site, to try the experiment themselves in real life, because this is the best way to learn.

The plan, further

The web - site has to be improved, in some ways:

- The simulations should become more detailed and interactive
- The work sheets collection should increase
- The texts should become more attractive
- A hands on experiment will be included, a reproduction of the original with the use of modern measuring devices

Still, in this phase, we believe that the web site can be tested out in class. With the use of proper questionnaires, we hope to have a feedback next school year that will indicate if the use of such educational material can contribute to the objectives of the “Hands on Science” project.
Based on the remarks by teachers and students, we hope to be able to improve the content and the style of the site.

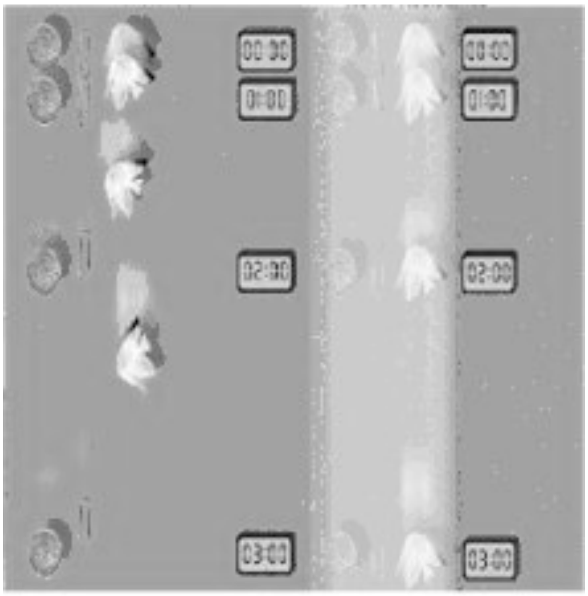

Figure 3. Free and non Free Fall Motion

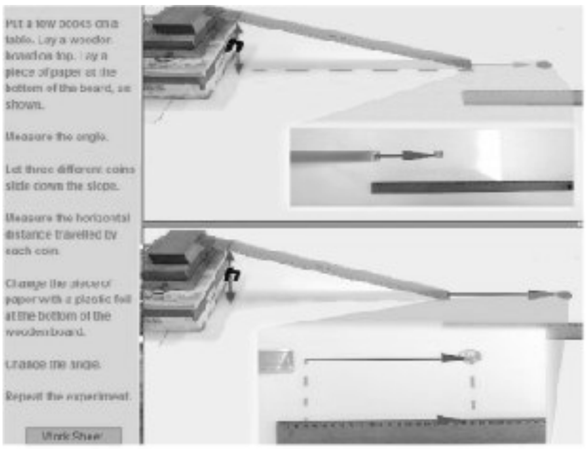

Figure 4. The worksheet

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Teacher's Role in a Changing Education. A Case Study of Asynchronous Education at Technological Education Institute (TEI) of Crete

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Abstract. *In the framework of this research we are trying to discuss and analyze the use of asynchronous education at TEI of Crete. Our main aim is to provide elements about the lecture's role by using asynchronous e-teaching systems. We investigate the potential of Computer-Mediated Communication in education and our analysis highlights the lecturers' opinion for the re-definition of the educational process through modern ICT infrastructures. Among the first conclusions are the overturning of the relation teacher-student and the distinguished role of the pedagogical framework for the effective exploitation of asynchronous education in an institution of tertiary education.*

Keywords. Asynchronous education, ICT, CMC, Knowledge Society, ODL, Role, Teacher, LMS

1. Introduction

According to Turkle [16] computer is more than a tool because we are able to step through the looking glass and we are learning to live in virtual worlds. Applications of Information and Communication Technologies (ICT) in the educational process usually require a different teaching environment than the traditional classroom. One of the most important features of the learning process with ICT is to have the ability to transform the information obtained from learning process into specific knowledge [3]. ICT is not only bringing changes to the world we live in, but also transmorms the way we can learn, opening new gateways to information [6]. Society is evolving rapidly and education becomes inevitably a life long learning activity. Time and space flexibility influence the school organization as an institution and as a system. On-line resources offer new possibilities and challenges to teachers of all kind of disciplines. Consequently, the access to knowledge and to learning process depends on the conventional definitions of time and space less and less. Remarkable colloquies are developed about Open and Distance Learning (ODL) in the new information society era, which concern among others and the tutor. In ODL the instruction could be either "synchronous", meaning that the communication between tutor and learner is simultaneous (real time), or "asynchronous" which means that the student is able to interact at any time, without tutor's presence. The ODL instruction could also be based on a mixture of the above two modes.

The process of changes in the traditional and some times conservative educational practices is not clearly pre-described and modern educator's participation is much more important now [2], [6]. Significant changes take place in the level of provided knowledge and the emerging of innovative methodologies about the new educational process, seems compulsory [14]. All these create a different educational environment indicating ODL as an essential tool for the future [3], [6], [14]. Major part of this research constitutes the different perspectives that emerge for the optimization and the readjustment of the traditional educational process.

2. Theoretical framework

ODL appears to be as a value-added network service. Internet is considered to be a viable distance-independent educational vehicle, used by various institutions, providing capabilities to integrate existing and emerging technologies [10]. Morris and Ogan [12] argue that a new communication technology such as the Internet allows scholars to rethink, rather than abandon, definitions and categories. There is no doubt that distant learning environments are spreading rapidly in all sectors of education opening up an extraordinary variety of potentially useful educational possibilities.

In recent years, Computer-Mediated Communication (CMC) systems like the platform of asynchronous education studied in our research, have begun to capture the attention of scholars from a wide variety of disciplines and are used for educational purposes. With the continuing growth of student population, institutions and tutors are looking for techniques to improve efficiency of materials and assessment.

CMC systems are believed to have powerful effects on social relationships [8]. In CMC in education the situation is neither the classical written nor traditionally spoken communication [14]. Online learning environments for synchronous or asynchronous education provide potential for new forms of collaborative work and reduce barriers of time and distance.

Many authors have noted that CMC technologies enable user interaction on a larger-scale than was previously possible via face-to-face group meeting [2], [4], [7], [14], [17]. In this kind of communication, all the users must have equal access to the communication space; and interaction should be one of the most important activities in a well-designed distance education experience.

Wellman and Gulia [17] note that CMC accelerates the way in which people operate and increase the range of social networks creating a new social form, the network society [3]. When a computer network connects people, it is a social network, which is a set of people (or organizations) connected by a set of socially-meaningful relationships [18]. Communities created by this kind of mass medium can often be viewed as an enigma in traditional, rational and economic terms [3].

Steinfield [15], in one of the first papers about the influence of ICT in education argues that computer conferencing can facilitate information transfer among academics and researchers, helping to foster and maintain "invisible colleges". Today's platforms, concentrating on the need for collaborative learning can be called 3rd generation learning platforms [9]. These approaches try to focus on social and individual aspects of learning as well as providing electronic content in a learning community.

The notion of a learning activity in virtual learning environments refers to something richer than in individual courseware, closer to the notion of project [4], [5]. For Dillenbourg and Jermann [4], virtual learning environments do not only integrate a variety of software tools but also integrate all the physical tools that can be found in a classroom. Very often the classroom management involves a complex set of interactions which can be further complicated for the teacher by the addition of unfamiliar technology [13]. Adapting student-oriented approaches to the online environment has required the development of new skills and changes to teaching practices. However, the transition to online teaching and learning presents new challenges as the roles of both teachers and students emerge in these modern learning environments.

3. Methods and samples

In the framework of this study we are trying to analyze the use of asynchronous education platform at TEI of Crete. This platform provides tools for setup, operation and administration of remote courses. It is based on the open software "Classroom On-line" (claroline) originally developed at the Université Catholique de Louvain (UCL) and it is supported by the non-profit organization Greek Universities Network (GUnet).

This particular platform gives to the lecturer the ability to organize his educational material and present it in various media through the network. Students can remotely access the digital content and submit their assignments. Additionally, the platform supports synchronous ways of communication and interactivity, which is the condition of communication for the users [14]. It is a typical [9] asynchronous tele-teaching platform and authorized users can access it at http://eclass.cs.teiher.gr web address.

This environment of asynchronous education at TEI of Crete studied in our research also named as "e-class" (Figure 1).

Figure 1. E-class user interface

One of the main aims of the present empirical research is the study and the characterization of the potential modulated lecture's role by using asynchronous education systems. It is a case study with a direct contact with the participants (lectures). Major part of this research constitutes the different perspectives that emerge for the optimization and the readjustment of the traditional educational process. Our methodological tools are constituted by 16 questionnaires and 6 semi-structured interviews with the teachers-users of the system. Obviously, this sample was not representative of all teachers at TEI of Crete, but it is quite enough for the tutor-users of the system (totally 25). All the data collection was accomplished during an academic semester.

The main questions of our research deals with: (a) teacher's attitudes in an ODL environment, considering their previous conventional educational experience, (b) the tutor's profile through ODL environments and the teacher's role that emerge, (c) the importance of the ODL material, (d) the advantages - disadvantages of an e-learning system, in terms of creating flexible virtual learning environments, according to the institution's tutors opinions, (e) the evaluation and critical approach of services provided to students by an ODL platform and finally, (f) the inquiry of tutor's perspectives and proposals about the specific Learning Management System (LMS).

The structure our questionnaires and our interviews, is based in the schema in Figure 2 and constitutes of 3 selected thematic axes. Those are: (a) platform use, (b) evaluation aspects and (c) perspectives.

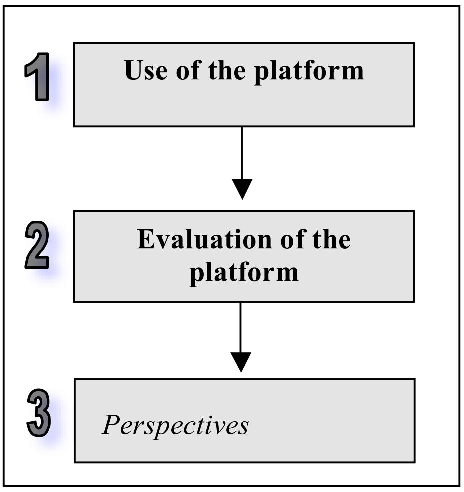

Figure 2. Axes of analysis

Our results were based on both qualitative and quantitative approaches [1], [11] analyzing the roles and attitudes of the lecturer, as they are modulated by a distant learning environment.

4. Global analysis of results - discussion

Starting with the 1st thematic axis concerning the frequency of use of the system and its facilities is rather satisfactory and it is depicted in Figure 3.

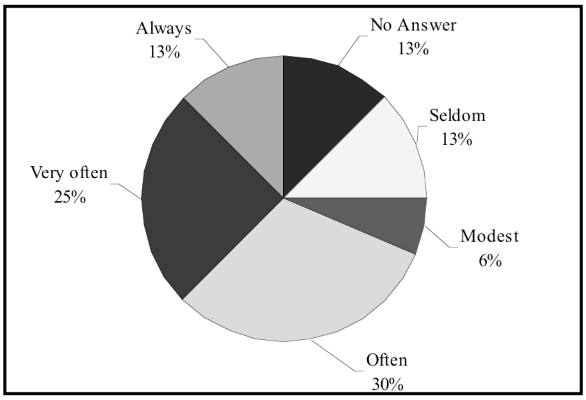

Figure 1. Frequency of platform use

One of the first conclusions of our research is the overturning of the relation teacher-student (platform's users). The educational process is transferred at the student's space, without the presence of the tutor which is a major advantage of the remote educational systems. In such environments, according to the sample of our research, the lecturer acts rather as consultant, in addition to his traditional duties. Teacher also has to further encourage and support the student during such educational process.

The role of the lecturers at the e-class platform of TEI of Crete seems complicate and demanding simultaneously. They often need to spend most of their time and creativity to satisfy the new requirements. The active participation and co-operation of lecturer and student are also major issues in the asynchronous environment of distant learning for the teachers of our research. Our analysis of the questionnaires points out the lecturers' opinion for the re-definition of the educational process as a main need for the student progress. Platform's lecturers consider that they are more active, instructional and productive in the asynchronous education environment, although they do not fully exploit it.

In the 2nd axe of analysis, teachers argue that today tutor's role must meet the challenges assigned by the knowledge society. One of the greatest challenges is to incorporate effectively ICT applications in class. It is remarkable that the teachers of our research do not feel that they are loosing control over the learning process in the ODL environment. They cooperate with their students in the asynchronous education platform but they do not perceive it as a replacement of the instructor. Instead, they view it as an additional resource for students. Distant learning environments for the teachers of our study offer the ability to show their work to a wide audience. For them, in a way, publishing online is an extra motivating factor. Additionally, it is an easy way to have huge impact and large audience in a distant learning environment.

Most tutors offer more than one course through the LMS and they use the platform very often. However, they do not consider the system as the fundamental teaching tool. They rather think that such tools are useful as subsidiary means of teaching (Figure 4 & Figure 5).

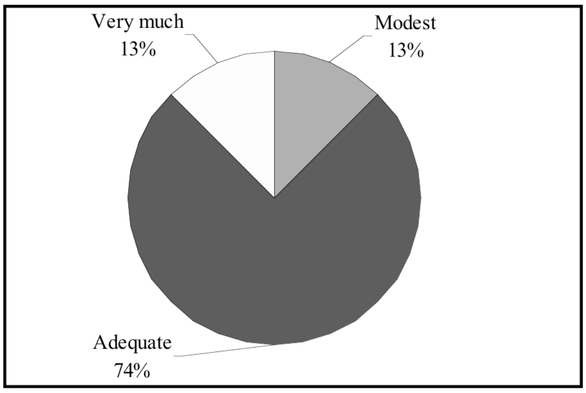

Figure 4. Platform as a subsidiary teaching tool

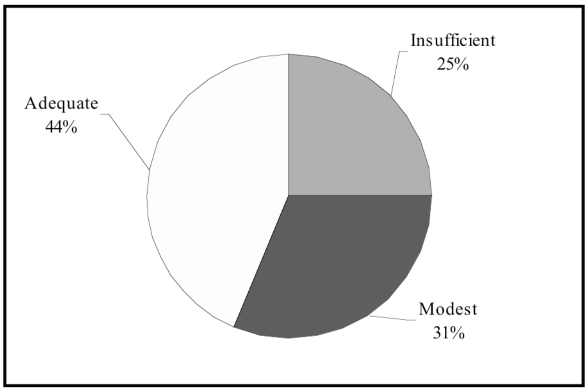

Figure 5. Platform use as fundamental teaching tool

Important questions have been raised about the new roles assumed by teachers when they use distant learning environments [6], [7]. They seem to develop a new image for their job with more responsibility on the students' part. The teacher's role in distant education is changing. Figure 6, summarizes the teacher's roles through the distant learning environment studied in our research.

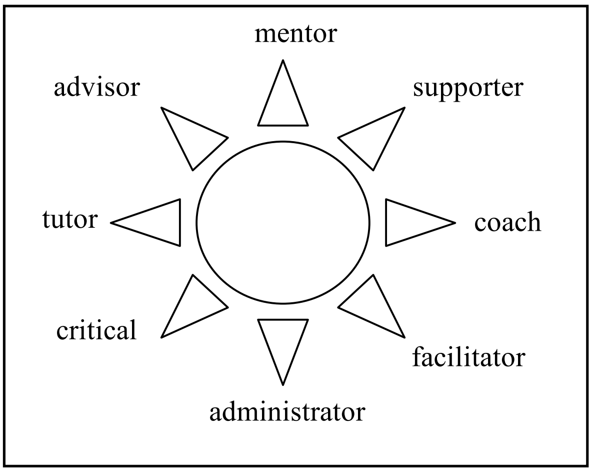

Figure 6. Teacher's role

ICT are often associated with changes for students and this has an inevitable impact on the potential teacher's role. ODL seems to be the vehicle for teachers to carry out major changes in the teaching process. Additionally, it opens new possibilities for interaction and relationships between students and teachers. The quality of the teaching-learning relation highly depends on pedagogical characteristics and on pedagogical context of the platform. In particular, for the teachers of our research the use of e-class can help those students whose style of learning is conducive to the independent, providing an option to "go to school".

Regarding teacher's profile in an ODL environment and considering the new roles that emerge, teachers argue that they are more active and creative. They also argue that educational material and pedagogical framework in an ODL environment are crucial.

On the other hand, teachers do not agree on the student stimulus and participation as depicted in Figure 7.

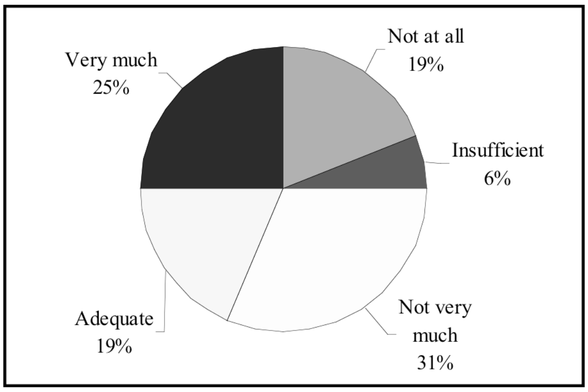

Figure 7. Students active participation

Among the advantages teachers mentioned, are the flexible publication, the effective management and the convenient update of the educational material. Two important positive components of ODL are: (a) the evolution to more active teachers and (b) the continuous structure of the educational material. Many teachers of our sample complained for the additional time required for the management and the updating of their e-courses. They also mentioned that they received students' complains about the lack of network facilities generally. Finally, they consider satisfactory the specific LMS tools.

To improve the LMS teachers of our sample propose: (a) its enrichment with synchronous tele-education services, (b) diversity in educational scenarios, (c) variety methods in student assessment. They also point out the necessity of uninterruptible and reliable operation of the system and the operation of a helpdesk service.

5. Perspectives - Conclusions

It is our position that pedagogy can be crucial in any type of teaching activities and as such is always in the heart of any application of educational innovation [7]. According to the answers on the 3rd axe of analysis, an online teacher must create a coherent learning experience for students and develop new support strategies that maintain motivation and encourage interaction.

However, the use of ICT is not a panacea for education. As note Mazzarol et al. [10], who conducted a survey of 315 education institutions in five countries, concluded that the use of virtual classroom to fully support and deliver high-quality education is yet to be fully proven. They also argue that the need for regular face-to-face interaction is likely to remain.

According to the teachers of our research while interacting with information (either through human or non-human resources), students construct their knowledge. Interactions such as reading, highlighting, manipulating, evaluating, or discussing new information during formal instructional sessions or informal activities, engage learners in constructing these representations [6], [7]. Teachers argue that online courses that integrate learning engagement with resources and social interactions are therefore much more likely to enhance learning.

The teachers of our survey consider that pointing the students via web-resources or online lecture notes is not enough. Understanding the course content, the online educational environment requires learning activities (tasks) to engage students with the material. They believe that when developing an online course, instructors need to think about the instructional challenges and learning objectives specific to their courses and then introduce tasks to help students meet the learning objectives and overcome the instructional challenges.

We argue that further research is required to understand the roles and the demands of students and to find out the conditions in which students are less dependent on teachers. In parallel, with uses of ODL environments, we ought to study more deeply the complex pedagogical issues involved in the uses of ICT.

Prospective teachers and faculty alike are to make the shift from learning to use technology to using the technology for learning [5], [7]. As well as the process of acquiring the skills to use the medium effectively, students must also learn to learn [3]. Thus, a new learning process can be created in a new context taking into consideration socials aspects of learning and support a feeling of commitment to the group in an asynchronous education system. The development of distant learning should be followed closely because it could be the basis of the development for the education in the information era.

6. Acknowledgements

The present work was supported by the project "Infrastructure exploitation to operate advance tele-education services in TEI of Crete" (operational program: "Information Society", EU). We also want to thank our colleagues at TEI of Crete for their patience during the interviews and for answering the questionnaires.

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The New Technologies in the Teaching of Geometric Optics

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Abstract. *The multimedia applications store and represent data - that may include text, sound, graphics, moving and constant pictures, video - in any combination. Therefore, their utilization in the instruction of Physics constitute a strong tool, for the improvement of teaching and learning process. However, it is absolutely essential to combine these potentialities of new technologies with some suitable pedagogical planning.*

The main aim of this work is to present a teaching tool, which can considerably contribute in the comprehension of basic significances of Geometric Optics - a subset of Optics dealing with the attributes of light.

Keywords. Geometric Optics, Multimedia.

1. Introduction

The smooth incorporation and the simultaneous complete exploitation of new technologies, in all rungs of education, constitute the main components for the improvement of educational process. The pedagogical exploitation of this innovation, shapes a new, not only original but also continuously evolving environment of teaching and learning, which has as main characteristic the different instructive approach regarding the traditional teaching.

The teaching in Natural Sciences and more specifically in Physics is one of the most remarkable and wide fields to investigate the potentiality of new technologies. This is due to their experimental dimension, to the difficulty in solving various problems and even more to the requirement of teaching using multiple representations. Therefore, there is a very strong necessity for the creation of certain instructive tools, which will help the students, among other things, to approach the conceptions and laws of Physics, to exercise not only in the observation but also in the interpretation of several natural situations and phenomena, to develop intellectual and practical skills, to cultivate critical thought while they will appreciate and the important role of Natural Sciences in the growth of technology.

The multimedia applications store and represent several data, which may include text, sound, graphics, moving and constant pictures, video - in any combination. Therefore, their utilization in the instruction of every cognitive field - and more specifically of Physics - constitute a very strong tool for the improvement of teaching and learning process. The nonlinear representation of information, in combination with the students' potentiality for a free choice in approaching data, directs us to their multiple applications in the classroom. Besides, the utilization of a series of simulations provides the students with the potentiality to import and/or stabilize different parameters each time, in order that the picture of phenomenon under review will be presented with the most completed way. This activity influences positively the perception of the students for the natural phenomena and allows a qualitative approach for the representation of a real situation.

However, it is acceptable that just only the technology will not guarantee the effective learning – on the contrary, an erroneous use is possible to create serious problems. Consequently, it is absolutely essential that each advanced training environment must combine these potentialities of new technologies with some suitable pedagogical planning in such a way that it will offer the best possible result. The technology should be an important supporting tool and not the central focusing point of the training process.

2. The authoring software

The application of the article is materialized in a special software system – Macromedia Authorware 6.5 – which is enlisted in the category of software systems for the concretization of applications – authoring software – and its operation is based on a set of icons and tools - icon based, event driven tools. This program of creating applications, on one hand, is easy to learn and very friendly to use, while, on the other hand, is providing a strong potentiality to concretize very complicated interactive tasks, either in cd or in the internet. As a result, the Macromedia Authorware software system is classified first in the category of authoring programs. Also it should be reported here, that all the simulations of this application have been created in the environment of Visual Basic programming language, which is an object oriented programming language with a relative easiness in learning while at the same time gives a lot of possibilities to the programmer.

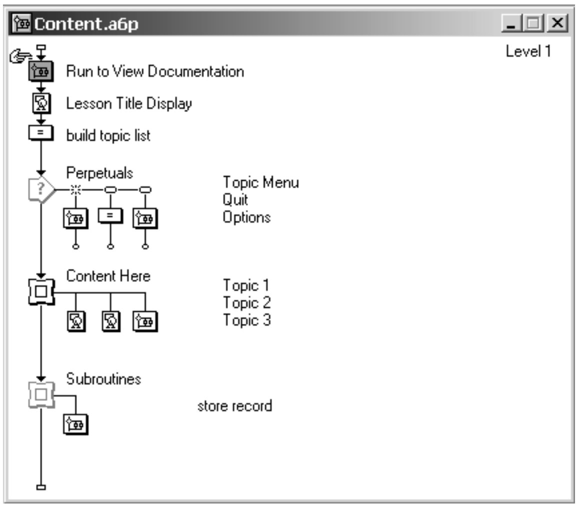

Figure 1. An autonomous section of a flow chart

Initially, the flow chart is created – flow line – according to some script, which must be determined by the writer of software. Depending on the script, the flow chart is continuously extended with icons that correspond in facts, tasks, graphics, sound, text, video, choices and decisions of the final user. This annexation of various icons creates an important series of facts, actions but mainly interactive decisions. As a result, the planning of whole application and especially the potentiality of the predetermination of alternative choices is given to the author so that the system will either react or interact depending on the choices.

The software authoring system utilizes libraries in order to optimize the management of certain resources of the system. Concretely, some often-used files are not integrated into the main executable program but they are called, whenever it is judged essential, with subsequent result in saving space. Also, because the multimedia files – and more specifically those containing sound and video – are very exigent in memory space they can be linked – instead of incorporated - with the main program or the libraries.

Finally, in regard to the creation of interactive pages, the navigation icon provides the potentiality both of the successive presentation of pages and the automatic transfer in a non-serial content via hyperlinks.

3. Concretization of application

The main and important aim of this work is to present a teaching tool, which can considerably contribute in the comprehension of basic significances of Physics – and more specifically of Geometric Optics, which is a subset of Optics and deals with the attributes of light. Even though, there is no clearly defined framework in respect to the requirements, which must be satisfied by any educational software, a few basic governing rules should be followed in order that the software will be considered worth mentioning.

➢*Instructive and Pedagogical Design*

✓ It follows the directions in the analytical program.
✓ It corresponds to the levels of students to which it is addressed.
✓ It supports the experiential approach of knowledge.
✓ It actively involves the students and facilitates their experimentation.
✓ It contributes in the growth of the creativity of students.
✓ It improves the intellectual and practical dexterities.
✓ It cultivates the critical thought.

➢*Design of Screens and Choice of Sound*

✓ Uniformity in the creation of screens.
✓ Stabilization between the interconnection and the individual units.
✓ Elimination of monotony during the design.
✓ Explicit determination for the utilization of every object on the screen and avoidance of any information that may disorientate the students.
✓ Careful selection of the sound in order to influence positively - as much as possible - the disposal of students.

Figure 2. The introductory screen of the application

➢*Interaction and Feedback*
✓ Design, in detail, of communication between the students - or the teacher - and the educational software.
✓ Layout of information in a non-linear form.
✓ Articulation of content in units with a hierarchical structure.
✓ Design of direct feedback that should be on the screen with the question or the answer of student and customized to his needs.

➢*Content*
The content of all educational software should correspond to the training level of student, to which it is addressed and must be formulated with clarity and precision while it should not contain irrelevant, to the unit, information. The organization of the content, in structured units, is as follows:
✓ *Historical Elements* – information about the researchers, which dealt with the particular subject and collectively, formulated the relative theory.
✓ *Nature of Light* – report to most basic theories for the nature of light and examination of all relative phenomena, such as the reflection, diffraction and speed of light.
✓ *Geometric Optics* - report to both the converging and deviating lenses as well as to their systems. Also, certain worth mentioning applications of lenses are presented, such as the photographic camera, the eye, the microscope and the telescope.
✓ *Bibliography* – report to the original resources from which was derived the relative information.
✓ *Activities* - creation of activities that aim at the complete comprehension of all the relative significances and phenomena, such as classification, exercises on completion of phrases, e.t.c.
✓ *Search* – finding of any word or phrase wherever in the existing text via an automatic electronic index.
✓ *Dictionary of terms* – explanation with some helpful information on any of the relative significances.
✓ *Simulations* – presentation of a fictitious laboratory in order that the user will formulate and check each relative, to the theory, hypothesis.
✓ *Animation* – presentation of various moving pictures in order that the user will consolidate, schematically, all the relative significances.
✓ *Information* - report to the members of the research team as well as some other relative informative elements.
✓ *Exit* – completion of the application.

Finally, at any point of this application, if it is judged essential, it is given help, which is relative to the choices of the student at the particular point. At the same time, the possibility to keep notes is provided for future use, at any point of the application.

4. Conclusions

The planning and the concretization of educational multimedia software, which supports the teaching on the unit 'Geometric Optics', was created with both exceptional attention and particular care so that it fulfills all the required objectives. Also, the entire application has been used to support teaching of some particular units of Physics, in certain schools at Rethymnon, Crete, with very satisfactory results. The main objective of the research team in D.P.E, University of Crete, is on one hand, the improvement and on the other hand, the progressive extension of application in order to be incorporated a bigger percentage of units of Physics. Because this particular type of applications has a lot of advantages, which it is impossible to be offered by any book, the full concretization of this idea will constitute, on one side, an innovative tool of learning for the improvement of educational process and on the other side, a driver for the revision of teaching of Natural Sciences.

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Entertaining Experiments in Electrostatics

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Abstract. *While articulating the idea of utilizing materials from our everyday life to demonstrate various science concepts, the author also outlined several different hands-on activities to dramatically and playfully demonstrate the effect of static electricity.*

Keywords. demonstration, electrostatics, hands-on, physics

1. Introduction

There is often a misconception that experiments in teaching physics need to involve sophisticated and expensive equipments. The efforts to access to these equipments lead people to identify physics as something that is far away from our everyday life. The fact is that physics is truly omnipresent. Physics and our everyday life are so tightly intertwined that they are one and the same. Therefore, many materials for scientific explorations can be readily found in our surrounding environment effortlessly. We could use these ordinary materials to demonstrate many fascinating ideas behind physics and to humanize science at the same time. There are many advantages behind this initiative of bringing science into our everyday life. First, the experience of these activities can be leveraged to intensify the students' motivation and interest in the realm of science. Second, the materials required for hands-on experiments can be obtained cheaply and easily. Finally, the restrictions on both the locations and time for performing these types of experiments are greatly decreased and thus we could perform them almost everywhere at anytime.

This combination of science exploration and our everyday life has become the new direction of science education in the recent years. Much efforts and research in the science education community has been directed toward designing experiments that are interesting, individualistic and encourage students in the direction of hands-on sense of discovery and accomplishment.

On the topic of static electricity, traditional textbook often calls for advanced equipments such as the Van de Graff electrostatic generator, gold leaf electrometer, amber rod, etc. Instead, we are going to construct various contraptions to show off the concept of static electricity in an interesting and animated fashion through series of different demonstration in this presentation.

2. Purpose

A series of hands-on activities are presented. These experiments utilize some readily available objects and can be used to encourage the involvement of all the students in classroom to create a very memorable learning experience and that is exactly what we are striving for.

3. Hands-on experiments

The static electric charges are most easily obtained by rubbing two different objects. After having tried several objects such as plastic ruler, plastic comb, glass rod, hard rubber rod, amber rod, etc., we end up with a truncated PVC pipe used in the plumbing since it is easily accessible and at the same time chargeable by rubbing with a piece of wool cloth. An incredible amount of electric charges can be produced and temporarily stayed on the pipe. The charged pipe can readily pick up a whole sheet of tissue paper. With this charged pipe we may conduct the following series of fascinating experiments in electrostatics.

A. The effect of the charged pipe on a conductor

Lay an aluminum can on the table and bring the charged pipe close to it. It can be seen that the can is attracted to the pipe and rolls immediately. In addition, if you wave the pipe above the can, the can imitates the movement of the pipe from side to side.

B. The effect of the charged pipe on a stream of tap water

As you bring the charged pipe close to a small stream of tap water, the stream magically bends towards the pipe. The effect could be more dramatic as the flow of water is decreased.

C. The effect of the charged pipe on a plastic "jellyfish"

We first construct a "jellyfish" by using a piece of plastic wrapping rope. We then rub the wool cloth against the tentacles of the plastic "jellyfish". The tentacles will be charged up and repel one another. Now, with all tentacles stretched out, the piece of the plastic rope looks like a jellyfish. Then we toss up the charged plastic jellyfish in the air and then move the charged pipe under it to prevent it from descending. With careful and sometimes acrobatic maneuvering, a student could use the idea of repulsion force to keep the plastic jellyfish in the air for quite a while.

D. Charging a Leyden cup

Here we describe a simplified version of the Leyden jar. It is a plastic cup lined both the interior and exterior with aluminum foil. We can transfer the static charges from the charged pipe onto the cup. Now have a student hold onto the charged cup with one of his/her hands, and start forming a chain of hands in a circle with every student in the class. The last student then would touch the protruded aluminum strip with his/her free hand. At the instant when the student gleefully makes the touch, a closed circuit is formed and the Leyden cup discharges through every student in the circular chain. All students should experience a slight electric shock at the same time. The shock delivered is harmless and similar in magnitude as an electrostatic jolt received when one takes a piece of synthetic fabric out of the dryer. However, it can be a lot of fun when all students are jolted simultaneously. From this impressive experience, the students will learn how electric charges can be stored, how static charges stored in the Leyden cup could produce shock through a circuit, and that human is a conductor of electricity, etc.

E. Constructing and operating an electrostatic motor

A very primitive electrostatic motor can be constructed by using very easy materials. Operating this motor is similar in principle to the machine invented by Benjamin Franklin in 1748.

4. Conclusion

These hands-on activities has been used in class to encourage the involvement of all the students in classroom to create a very memorable learning experience and that is exactly what we are striving for.

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The Effect Of Using Simple Equipment On The Acquisition Of Plan Map Concepts In The Vocational Schools

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Abstract. *The purpose of this study was to investigate the effectiveness of using simple equipment on teaching plan map concepts as a main topic in a surveying course of vocational education. Six groups of students, enrolled in the surveying course, were randomly selected and pre-tested to examine their experience on plan map concepts. Three groups received traditional methods of teaching and used theodolite in plan map-making, while the other three used simple equipment as an extra fieldwork activity. At the end of the semester, all participants were post-tested. A significant difference was found between experimental and control groups on post-test scores. Also, there was a significant difference between the two groups with respect to students' high-level understanding of plan map concepts. The use of the simple equipment was strongly recommended in science and vocational schools to overcome some main problems.*

Introduction

The most notable characteristics of vocational schools in Iran are to prepare skillful technicians to involve in the industrial development of the country. In this connection, the surveying course was offered to eleventh grade students in the vocational schools. The course introduces planimetry, altimetry, topographies, and other kinds of surveying, four hours a week during a semester. However, the planimetry is the main part of the course, which is called "plan map" with the following main objectives:

1. The student knows common terms used in the plan map construction and interpretation.
2. The student demonstrates skills in finding azimuth, scales, and other necessary variables in making plan map.
3. The student uses the theodolite device correctly.
4. The student properly measures leveling.

The students construct and make a proper plan map in a given area.

Background

In the past few decades many science program, has been available to represent science as a direct or laboratory – based experience rather than to present science as only a body of knowledge (Hudes & Moriber, 1969). "When students have direct experiences with materials & events, each comes from that experience with his / her own interpretations." (Marker & Methven, 1991). In the other words students construct their own concepts from their experience, that is why, it is a well established fact that theory is more understood and appreciated by the students when subjected to experimental techniques (simpler the better), and visual presentation is preferred to abstract lectures and mere statement of facts. The main part of course namely plan map was commonly offered in two components, with lecture typically once per week and practical work two times a week. The practical or fieldwork needs a complex device called theodolite. The theodolite is expensive and the schools can have just a few of them. As a result, learning experiences in practical work may have minimal impact on helping students construct understanding of plan maps' concepts, content, or relationships. As a result, practical work is now emphasized in school science. Hodson (1996), identified three justifications of practical work for learning of science:

(1) To help students learn science
(2) To help students learn about science and to
(3) Enable students to do science.

Also, Woohnough and Allsop (1985) have argued that practical work can be viewed as providing experiences, exercises, and investigations. Laboratory-based experiments are not necessarily needed for practical work. Out school activities can provide opportunities to learn and to do science as well. In this regard, Griffin (1998) pointed out the importance of informal settings of learning processes, and showed how carefully planned museum-based experience could provide a vehicle to achieve some goals of practical work in school science. Lock (1998), realized that "the limited available empirical research findings suggest that field work may be more effective than equivalent teaching carried out in laboratory." He further concluded "field work can make significant contributions to all three [objectives of practical work in science]." It is inevitable that science, vocational education, and practical work should be changed over time and be geared toward fieldwork. The work can be done in the schoolyard or in the wider environment. It is known that textbooks are used as an alternative to practical work (Lock, 1997). Even though practical work can include the design of experiments, and when the work goes according to the textbook, it may add little to conceptual mastery. Laboratory and fieldwork need not reasons for emphasizing the use of complex and expensive equipment. One area of Japanese superiority on test achievement and comprehension in school science can be seen on their teachers' emphases in "the experiment done with everyday simple equipments and materials" (Walberg, 1991). Kirschner and Huisman (1998), in designing non-traditional practices to replace traditional practices suggest that, "the use of simulations is advocated when: (1) the 'real' laboratories are unavailable, too intricate; (2) the experiment to be carried out is dangerous for the experimenter or to the object of experimentation; (3) the techniques which need to be used are too complex for the typical student; and (4) there are severe time constraints." Based on local reports and experiences in vocational schools, most of the students who take the surveying course, fail at the end of semester, and their achievement in the course is not adequate, particularly in plan map concepts. Generally, the framework and the theoretical orientation of this study were based on the following assumptions:

1. Students acquire plan map concepts through out- school activities
2. Use of simple equipment can reduce the complexity of the concepts.
3. Use of simple equipment can overcome the unavailability of real laboratory and reduce the students' fears of using expensive and limited tools.

Use of simple equipment causes teachers to do activities beyond the textbooks as a complementary plan without time consuming.

Purpose of the Study

The primary purpose of this study was to determine the effectiveness of two different types of instruction on plan map concepts: that involved simple equipment, and implemented traditional methods. More specifically the research sought data to answer the following hypotheses:

1. There is a significant difference in the students' achievement on plan map concepts between the experimental and control groups.
2. There is a significant difference in the students' level of understanding plan map concepts between the experimental and control groups.

Method

Procedure*This study was conducted using students enrolled in a the surveying course during the Fall 1998 in vocational schools of the East Azerbaijan Province in Iran. The course content included the main topic of making plan map concepts.A quasi-experimental design was employed. The subjects in both control and experimental groups received a traditional lecture method and practical work, using theodolite for an entire semester. Additionally during the semester the experimental groups used the simple equipment of plan map-making as an extra activity.The plan map as the main part of surveying course was, two-credit, 18-week course offered through the vocational high schools. The class met once a week in 50-minute periods and 100-minute practical work. Worthwhile to mentioned that the same teachers taught both control and experimental groups. However, 50-minute of 100-minute practical work of the experimental group was devoted to use the simple equipment.*

Participants. *The sample consisted of public vocational school students in grade 11, ranged in age from 17 to 18, of the East Azerbaijan Province in Iran. Five school districts were randomly selected to represent a variety of students in terms of demographic characteristics. Within the districts, six groups of students were randomly selected, three as experimental and three as control group as multistage cluster sampling (Borg and Gall, 1989). Therefore, the study was based upon 155 students, of which 65 students were in the experimental and 90 in the control groups. This sample was part of a total 534 male* *students who took the surveying course in vocational schools.*

Measures. *Forty multiple test items were used as pre-and post-test to measure plan map concepts. Four instructors and two specialists in surveying confirmed the test validity. The reliability of the test was measured by a split-half method, using Spearman Brown formula (r = 0.69). Since the current effort to reform science education emphasizes the importance of understanding for students (National Research Council, 1996), in response to such notion the author examined the subjects' understanding level in the plan map concept. For that reason the forty items were given to the instructors to select as being in a high level of instructional objective. As an aid for classifying the items, a table that is describing the major categories of each domain of taxonomy (Gronlund, 1976) was given to the instructors. The twenty items were selected as being in a high order level such as comprehension, application, analysis, synthesis, and evaluation of cognitive domains. These items were used to compare the understanding level of plan map concepts among subjects.*

Materials

The material consisted of the use of equipment such as a protractor, soda straw, measuring tapes and ropes, paper, and pin. With these materials a piece of equipment was made as shown in Figure 1. Before going into the field, the students of the experimental groups were asked to be divided into teams, keeping in mind that they could sight correctly and use the equipment. Then, the students were asked to use equipment according to instructions given by the teacher. Each team was asked to indicate the north on their paper and then sight on a distant object of their choice, such as trees or sticks. The following figure is used to illustrate this technique.

Results

Since the students in the control and experimental groups did not match according to their pre-test scores, any differences in these scores was done by assessing the D score (D=posttest-pretest) to obtain a more reliable difference between the two groups. A t-test model was used on the students' achievement scores. There was a significant difference between the D scores of experimental and control groups $t(154)=-12.95$, $p<0.01$. Thus, students who used the simple equipment achieved higher that the control group students. One-way analysis of variance (ANOVA) was also conducted to test the difference among groups of the study (Table 1, groups 1,2, and 3=experimental, and groups 3,4, and 5=control ones in range of mean scores). There was a significant difference between the achievement of the students in the control and experimental groups $f(5, 149)=8.0390$, $p<0.01$. Thus, the first hypothesis of this study, which was "there is a significant difference in the students' achievement plan map concepts between the experimental and control groups" was confirmed. A post hoc analysis was done by Tukey method to see the differences of the groups with each other. The results are contained in Table 2. Thus, it can be concluded that at $p<0.01$ there was a significant difference of the two experimental groups with the control ones, in regard to the subjects' level of understanding, but there was no significance difference of one experimental group (1) with the others.An ANOVA was done in regard to the students' higher level of plan map concepts in the groups of the study. The results are shown in table 3. *Thus, the second hypothesis of the research "there is a significant difference in the students' understanding plan map concepts among the experimental and control groups" was confirmed.In order to find out the difference between the groups a Tukey post-hoc analysis was conducted and the results were shown in table 4.It should be mentioned that the plan maps made by the subjects, are comparable by the ones that are made by the theodolite. The students used the formula of for calculating the given area. More figures of the plan maps are presented in appendix A and B.*

ConclusionThis study provides evidence that students' achievement were enhanced through using the simple equipment as an extra activity of plan map making. During the treatment period, the experimental groups, except one, were able to improve plan map concept and skills. While in comparing to the experimental groups, none of the control group could make an improvement of plan map concepts and skills. The most surprising result of this study is that the statistical analysis indicates a highly significant improvement in the students' achievements for all experimental groups, when those high levels of cognitive skills were measured.The theoretical framework proposed in this study appears to be consistent with the experimental data. The enhancement of the students' performance reveals that the simple equipment reduces the complexity of plan map concepts. This reasoning is in the line of Japanese superiority on test achievement on school science, which emphasized on using simple and everyday materials (Walbeg, 1991). This kind of activity provides opportunities for pupils to learn and acquire the concepts in informal setting (Griffin, 1998) of learning processes. As Lock (1998) identified, fieldwork such as this may be more effective than equivalent laboratory approaches. Finally, using the simple equipment overcomes the costs and time constraints associated with real laboratory experience (Kirschner and Willbord, 1998).

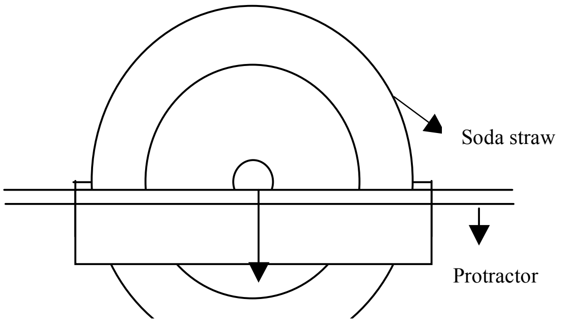

Figure 1. The simple equipment of plan map making

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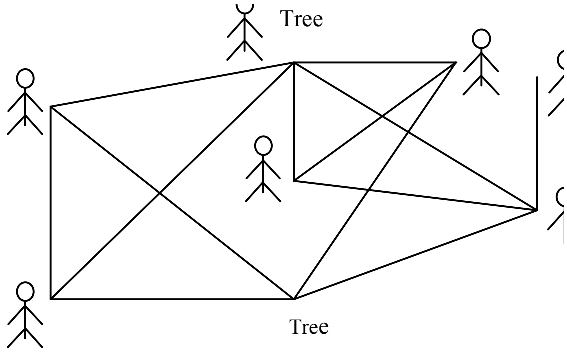

Figure 2. The illustration of sighting

Source of Variance	Sum of Square	df	Mean Square	F	p
Between	146.4437	5	29.2887		
Within	542.8563	149	3.433	8.0390	0.0001
Total	699.3000	154			

Table 1. Analysis of variance among the D scores of the subjects

Source of Variance	Sum of Square	df	Mean Square	F	p
Between	86.1660	5	17.2332	23.8785	
Within	107.5337	149	0.7517		0.0001
Total	193.6997	154			

Table 3. Analysis of variance results for high achievement plan map concepts among the subjects

Mean Score	Group	5	4	6	1	2
1.0333	5					
1.4667	4					
2.0000	6					
2.3571	3					
3.2308	1	*	*			

Mean Scores	Groups	6	4	5	1	2	3
1.0467	6						
1.3033	4						
1.4767	5						
2.7500	1	*	*	*			
2.7610	2	*	*	*			
2.7857	3	*	*	*			

$p<0.01$

Table 4. Tukey post-hoc analysis on the students' high achievement

Modern teaching methods in physics

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Abstract. *The perfectioning course "Modern teaching methods in physics" is an educational program for physics teachers, taking place at the " Teacher Training Center" in Bucharest, Romania, and was acredited with 30 credits, starting with the 2003-2004 school year, modulus I. The other moduluses will take place in the following years reffers to both the physical curricular area and the general area of integrated sciences. It implies both the speciality aspects and the methodical ones in accordance with science teaching. The proposed system reffers to a four-year modern thinking developing plan, each representing a speciality and a methodical modulus.*

Keywords. educational program for physics teachers, methods in physics , modern teaching, " Teacher Training Center".

1. The utility of the program of continuous developing in PHYSICS and SCIENCES

The proposed program for the perfectioning of physics teachers is acording to the policies and strategies of national developing of the educational system set by the Education Ministery.

This aspect refers to the fact that the proposed objectives in continuous formation is at first hand according to the standards set by the National Committee for Continuous Formation for personnel in pre-universitary learning. This reffers especially to the application of optimal algorithms in designing, organisation and evaluation of the teaching activities. Thus an accent is set on the adequate use of the general teaching methods and speciality teaching methods knowledge. Among others this means the integration and the proper use of auxiliary didactic materials in the process of learning. Common for physics are experimental and demonstrative activities. An other aspect is the developing of critical thinking and the use of the creativity developing techniques. As a result the teacher becomes more confident and this aspect is felt through a balanced behaviour thus setting an example through himself.

Not least what is searched for is the developing and actualisation of professional knowledge, of knowledge regarding aspects and techniques of statistical evaluation, which imply simple mathematical and docimology statistics knowledge. Finally, all these are discused in resembling conditions with those existent in competition situations.

As usual computer using capacities in class are developed. In this purpose Lab View moduluses utilisation is promoted, moduluses recently introduced in schools. On this occasion group studying is exercised and learned.

A few problems have been spotted and evaluated as being important:

I.) The dificulties that teachers have in the completing of laboratory works:

a. the way measurements are confrunted with

b. the employment of school kits;

II.) The experience of checking of correct behaviour of devices used in the laboratory, searching for causes of defectuous behaviour, the lack of imagination in the use of devices and in the conceiving of simple experiments with a maximum consciencious impact, the lack of the idea of theoretical results checking on experimental basis;

III.) The lack of experience in drawing conclusions from the experimental data as in the efficient handling of graphics, calculus and the necessary duration of measurements;

Younger teachers have dificulties concearning the way of solving of more sofisticated physics problems, that are less imployed, there is a massive lack of experience concearning open problems, the teachers don't even have the courage nor the options of a creative work, they don't have the horizon of physics problems abroad (there is a powerful provinciality, determined by the lack of information sources, information time, experience exchange and especialy thinking!).

IV.) The lack of documentation and daily information on both scientific and methodical domain.

In conclusion the following objectives and perfectioning ways are proposed:

a. the perfectioning must be made on experimental and practical basis especialy, and less on theoretical basis

b. the perfectioning of the teacher will also have an individual working component (home) which would extend on a large time period and would consist in solved homework, problems, questions or papers which the teachers would bring every month. This activity is marked, as the whole activity, through cumulated points throughout the study period.

c. during the perfectioning process a climate necessary for a relaxed, informal, open discussion between collegs must be set, because people of equal levels of cultural and professional qualities are discussing. This activity must begin to hold this aspect of intelectual discussion and interaction and debate, and not the aspect of teaching a specific number of classes, in a fixed and rigid timetable. The flexibility of intelectual work must be properly recognised, prepared, preserved, encouraged and institutionalised.

d. it is also obvious that the reform is not decreed, but it is "worked" daily, it is thought, experimented and better conditions for a more or less advanced future are created, partial results are evaluated, methods and directions are corrected, taught and retried and, in probably ten years'time, it could be said that the reform would have begun to materialise, but it would be certain that it would only continue. The reform is very much in relation with the material part of learning and also with the spiritual and cultural side of it and the people involved in it. It can not be hoped in a factual realisation of the reform without the moral, ethical and professional change of the people involved. In this direction an increase in the general knowledge degree of the teachers is required, and also the small scale setting of the climate we wish to accomplish on a national level and especialy believe in what we are doing and what we wish to accomplish.

e. a severe lack of scientifical, cultural and organisatory information in teachers is observed. The reasons are the lack of books, magasines and other documentary physics materials and learning materials in general (both basic books and new books and magasines) which can be substituted by the classes and discussions. The material and informative basis with which this course is prepared exists and is sufficiently abundant.

f. the purpose of the experiments and practical activities in physics classes and in classes especially elaborated (laboratories and laboratory technique classes is to allow the student to develop experimental skills, that is the skills necessary to work, experiment, measure and single-handedly build physics devices and experiments. It is thus possible to track the evolution of the student. This aspect cannot be acomplished if the teacher himself does not have this ability and practic. One of the proposed purposes is exactly this aspect.

g. general knowledge implies both humanistic and scientifical knowledge, both of them being human creations and thus proper thinking of these aspects must be instated. The fact that needs to be realised is that physics would have to be thought as a humanistic form of culture, which would mean that in the physics classes not only the formulas and the abstract aspects would prime but also the aspects that humanify physics as a science of nature. One of the proposed pourposes is the "humanisation" and the transformation of physics and science in pleasant and atractive study classes. In conclusion an accent will be set upon the scientifical culture and its integration in the general culture fund. The interdisciplinarity would be a continuous presence in these classes.

h. there are lots of aspects of nowadays science that need to be aknowledged by a teacher in order for him to perform an efficient teaching act and especialy knowledge from the adiacent sciences, which nowadays give the process of learning another image and a scientifical basis to lots of aspects considered in-transformable. These kinds of directions which will be discussed in the perfectioning classes are: information theory, neurology and cibernetics, the complexity theory, non-liniary dinamics, statistical thinking, etc.

i. the course is addressed to both gymnasyum physics teachers and teachers from highschools and in certain cases could prove to be useful to natural sciences teachers regarding an interdisciplinary view of natural sciences.

j. . in consequence, the proposed course as well as its acomplishment method, holds the entire range of problems which learning reforms and programs nowadays sustain in view.

2. The structure of the continuous formation frame-plan

The perfectioning course "Modern physics teaching methods" reffers to both the physical curricular area and the general area of integrated sciences. It implies both the speciality aspects and the methodical ones in accordance with science teaching. It is totally adequate and according to the purpose of the program.

The way the courses are organised reffers to the acomplishing of teaching courses and discussions with teachers in the form of thematic seminaries. It is also insited on practical activities, both experimental, and concrete ones realised in classes. Among others these imply solving difficult problems. The teachers reviece homework, which asumes the thinking and evaluation of some materials, as well as solving certain aspects implying creativity.

The proposed system reffers to a four-year modern thinking developing plan, each representing a speciality and a methodical modulus. The specialty and the methodical one are not concieved to be separately discussed and taught but to be in continuous transition from one to the other according to the theme, receptivity or difficulty which the students show.

The four large groups form a whole, but in the same time are independent from one another. The system is thought as to be chosen by the group of students as to be fitting their own proposed perfectioning process. Therefore a teacher may go through a modulus in a time span of four years or numerous modulusses according to interest and a posible resuming in the next four years alows the choice of other theme groups, according to desire and necessity. The themes of choice are general enough to have the flexibility of being taken over during the ongoing processes of modern aspects taking in consideration the rapid developing of science nowadays. The necessity of flexibility and adaptability of the program alows questions appearing on the way to receive a general frame in which to be introduced. The rapid pace of information sending towards the student and the teacher, through the media, requires this aspect.

The proposed objectives are:

I.) The actualisation of scientifical and methodical information;

II.) The acomplishing of experimental skills of the teachers; the returning of a certain freedom and confidence degree to the teachers regarding experimenting, the construction of simple devices, the increase in the observation and prime observation sistematisation capacity; involving the children in the pleasure of observing, discovering and free experimenting.

III.) The fortifying and the development of the scientifical spirit, of the scientifical thinking, of the reasoning both as a scientific mehtod of investigation in science and as thinking in daily life; the practical use of formal logic, specific to scientific reasoning.

IV.) The completion of math knowledge necessary to physics, especialy to the statistic aspects, which also imply at the same time the use of tests, correct evaluations of statistical results, uncertainties of statistic margins of some measurements (scientific or scholar) etc.

V.) Providing teachers with a certain interdisciplinarity in the direction of the spanning of the scientific horizon, the introduction of the global holistic thinking and the use of science in everyday life.

VI.) Knowing and experimenting different methods of information technology and computers as a complementary part of teaching activity; the knowing of both simple aproximation procedures and practical acomplishment of some multimedia materials and their corect use; using interfaces for data colecting and their automatic introduction in to the computer (virtual laboratory); using informatic environments on CD-ROMs or enciclopedia type of disks or other dedicated programmes; work on the Internet and search procedures, etc.

All these aspects create teacher competences but also enhance speciality and methodical knowledge and also ensure a live experimentation of the ideas discussed.

Working modalities are different and vary from one theme to the other. Generaly speaking, for a perfectioning course to be viable and provide results, it has to be a live exemplification of the ideas it generates and discusses. It is without a doubt an obvious affirmation, but practice shows that the majority of methodical courses are purely "theoretical" no methodical, psychological, or learning character, thus being taken as "lessons". Practical modalities will be, from case to case, the exposition, the seminar (discussion), the practical achievement of certain experiments – either frontally, eitherwith every group of teachers, and in the great majority of the cases homework corresponding either to searching materials or witing essays, either the continuing or materialisation of home experiments are provided. Generaly speaking the themes will emphasise the solving of certain current necesities of teaching in class of some teachers, at their own request. These situations are treated as examples of methodical or scientifical problems to which course students participate with their own points of view and an option considered optimal is reached. After the completion in class of the discussed themes, a discussion of the results and the analysing of methodical results are made.

Because of this working method, the evaluation is made gradually, it contains observations and grading to all forms of learning, including the activity in the discussions of current problems. Experience shows that this method of evaluation is the most efficient and the most correct for the level of the teachers because they do not need to be treated as simple course students, but as teaching activity collegs. This way of emphesising the problem not only increases interest and makes classes more dinamic, but in the same time gives the course teacher dignity and the results are excellent. The method complies to all aspects the reform imposes and especially ensuring a different learning climate not only in theory but also practically. Psychologically speaking, this method allows an open and relaxed attitude in teachers, with a maximum effect on the perfectioning process.

The time proposed to achieve this kind of classes, speciallity and methodical, is about a hundred classes divided in approximately 50% speciallity and 50% methodic. It is proposed to realise them in four hours a week (9-13), every Saturday of the month, except hollidays. The continuous evaluation will be made as reminded, during seminaries, practical works, discussions and correcting homework (ten extra hours at home). The completion of the courses will be made through a discussion on the way the teachers responded to the problems posed, with emphasising good or bad parts of each one and a grade "pass" (very good, good, satisfying) or "fail" (unsatisfying).

3. Specialised themes

Module I : 2003-2004

Physics history

a. Mechanics from Aristotel to Galilei and Newton

b. Structure of the matter: philosophical aspects

Physics experimenting methods

a. Using school kits

b. Using constructed devices

c. The homework method

d. Teaching methods

Module II : 2004-2005

Modern physics

b. New physics

c. Modern astrophysics

d. Physics as experiment and direct observation of nature

e. Descartes and "Speech about method"

The computer as a means for learning

a. Computer using methodics

b. Multimdia procedures methodics

c. Internet integration and distance learning methodics

Module III : 2005-2006

Physics, chemistry, biology and maths under interdisciplinary aspect

a. "Transformation, process, developing, evolution"

b. Modern physiology and psichological evaluation of children

Complexity science – a new way of understanding learning and education

a. Dinamic nonliniary systems and fractals

b. Hierarchycal knowledge structures – optimization of the learning process

Module IV : 2006-2007

Mathematical aspects involved in the description of physical phenomenons and also statistic thinking development

Models and modulation

a. Statistic aspects in drawing conclusions

b. Statistic thinking and the evaluation of knowledge

c. Grades and credits

4. Bibliography

This contains an informative role on existent books in the country that have been used on different ocasions at courses of :

a. perfectioning and recicling teachers in Bucharest, " Teacher Training Center", 1992-1994, *methodical conferences* with teachers from around the country (since 1970)

b. Physics teaching methods, at the **Faculty of physics** in Bucharest

c. Modelation, simulation and visualisation of physical phenomenon course, at the **Faculty of physics** in Bucharest

d. Research aspects regarding methodical and the teaching of physics as well as *studies regarding the educational system and knowledge theories through nonliniary and complexe Systems.*

The curriculum reform and the schools' ability to innovate

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Abstract. *The presentation is the summary of two-research projects developed in Romania – 2003 and Netherlands – 2005 on the traits of the educational policies, curriculum reform and the ability to innovate in the primary education. The project combines quantitative and qualitative methods of data analysis with valid results and an interesting inside on the human aspect of the process of curriculum innovation.*

The purpose of the project was to discover the actors, the steps and extend of innovation in primary education. In addition, the cultural and social contexts were considered in analyzing the development of the innovation process.

Keywords. Comparative research on the field of curriculum development and innovation in primary education, actors and institutions to sustain the process of top down change.

1. The context

In 1994 in Romania started an educational reform determined by the social, political and economical changes in the society. The outcomes of the educational system were not conforming anymore to the needs and the demands of the new democratic society. The system was centralized and mainly prescriptive. The main components of the educational reform were curriculum, textbooks, teacher training, school management and financing, quality evaluation system and many others. The curriculum reform was the main part of the educational reform and went through three stages: elaboration of the policy and principals of the curriculum reform, implementation and monitoring and finally evaluation. The new Law in Education in 1995 stipulated as ideal the *free, total and harmonious development of human individuality, to become a creative and independent personality.* [1] A national document called The National Curriculum was legalized in 1998 [1] and its goal was The New Curriculum is made for the students that are going to be active subjects in the social and professional life of the next century. In this case, *the educational system has the duty and the responsibility of preparing them for the changes that are going to happen in the economical, social and cultural field in our country and in the world.* [1] In 2002, even if the curriculum reform was officially ended and was evaluated, the changes in the educational system and process are following with a law for quality assurance system, qualitative actions of the national inspectorate, internationalization of the compulsory and superior education.

The curriculum reform in the Netherlands took place between 1985 and 1990 and it was a general reform in education called the *neoliberal reform.* [5] The concept of freedom in education was the main element, freedom of schools based on religious and cultural believes. A new policy for schools was introduced regarding founding, governance and free choice. The freedom of education is guaranteed under the article 23 of the Constitution, [5] *freedom of establishment, organization of teaching, of conviction.* The National Curriculum that was introduced established the national aims that should try to be achieved by all the students finishing the compulsory education. The core curriculum is a central document with the purpose of giving the same direction of actions of all the schools.

Looking from this perspective, the process of introducing the National Curriculum had opposite goals in the two countries. If in Romania, the purpose of the National Curriculum was to decentralize the system and to offer freedom to the schools to make their own teached curriculum, in the Netherlands the goal was to centralize the direction of the outcomes of the process, to offer the same final level of achievements to all the students. However, the process of introducing a top down change was the same and the influence of different actors and institutions on the quality of the implementation process can be compared.

2. The design and the methodology

The curriculum reform is part of the educational reform. Usually, the curriculum reform is defined as an innovation on the level of structure of the curriculum, the teaching and learning strategies.

There are some general principles of a curriculum reform, as:

- a very good integration of curriculum reform in the general context of the educational and the social global reform
- the educational reform has to reflect the general objectives of development of the society in that moment
- a curriculum reform has achieved his goals only if the changes are visible in school's practice and in the every-day process
- the curriculum reform has to be seen as a permanent and perfectible process
- the curriculum reform has to be implemented only in relation with permanent education [4, 1994].

The article intends to identify the quality of the curriculum reform process and the factors that influenced the level of quality and efficiency, the role of the support – materials as the guides for the teachers or the textbooks. The help needed in an innovation process is high, especially the help offered to the teachers that have to implement the change and make it work. In this case, I was interested to find out if there were institutions named to offer help, specialists to support the implementation process, training periods for teachers or meetings with the specialists. I focused mainly on the teachers in both countries and I intended to discover their roles in an innovation process, roles perceived by different educational actors. I had also as goal to discover if the teachers in both countries considered implementing an innovation into the classrooms is a difficult process and for what reasons.

The comparations is between two research projects, a qualitative data analysis using a questionnaire done in Romania in 2003 and a quantitative data analysis using an interview done in the Netherlands in 2005. The both projects focused on the process of implementing the curriculum reform and the role of the teachers in an innovation process.

The subjects questioned in Romania were selected in a representative sample for the all teachers population from Botosani County in the north of the country, population of two hundred sisxty five teachers. The sample of ninety-five teachers from primary education was representative. Fifteen educational actors from all other Netherlands, an representative equal number of actors from all the levels of the educational system's structure of authority. It was a equal number of teachers, headmasters, general directors, school inspectors and educational specialists, represented the subjects interviewed in the Netherlands also from primary education.

I took in consideration the organization of the institutions on the authority level, the context of the reform and the nature of change, the characteristics of the innovation process, the actors involved and the different institutions, the extend of the diffusion, the quality of the implementation process and the expected abilities of continuing the innovation process. From all this perspective, I analyzed the perceive roles of the teachers in an innovation process and identify the factors that could increase the quality of the process.

The questionnaire I used in Romania was elaborated and pre-tested by me. It contained thirteen items focused on the quality of the implementation of the curriculum reform at the local level, the use of the support materials for teachers, the help and was offered to teachers and from which institution came the help they needed. In addition, I focused mainly on the teachers and their roles in the curriculum reform.

3. The research projects

The objectives were to discover if the teachers felt the introduction of the new curriculum in the schools as a difficult process, if they received the help they needed, what kind of help they think would have been the most efficient. It was an objective to discover what roles they consider they had in the all process and which one was considered the main actor in a top down change.

From the answers, I received on the multiple choices questions; I could discover many dysfunctions in the implementation process, at the local level in Romania.

At the question if the implementation process was an easy or hard process, 65% of the teachers said the change was hard to implement and they found very difficult to work with the new curriculum in the classrooms. Interesting is that I identified significant differences between the answers of the young teachers and the experimented teachers as: the young teachers found the process of working with the new curriculum significant more difficult then the experimented teachers.

In this context, I wanted to identify if the teachers received the help they needed in implementing the new curriculum and I asked which one was the person that they asked for help and which was the institution that offered them specialized help when needed. 34% of the teachers questioned said that as person, they asked for help the local school inspector and 30% the specialist in curriculum (the function of the specialist in curriculum was a very new function and the responsibilities and duties of such a person were not clearly stated). Just 13% of them said they would ask for help the other teachers from their school. Moreover, when they had to point out the institution that mainly offered help in implementing the curriculum reform, 42% of them pointed out The Teacher Training Center and just 27% the Local School Inspectorate. There is no connection between the person that they said mainly helped them in the curriculum reform which was the local school inspector and the institution which was The Teacher Training Center. This makes me consider that the teachers did not received the help they needed to implement the school curriculum and could be one of the explanation why 65% of the teachers said that the change was hard to implement. Again, just 19% of the teachers pointed out the school with the school's headmaster as institution that they asked for help. We can see that the Romanian teachers do not ask for help or look for support in the school, working with the other teachers or asking the school's headmaster. However, this could not be a conclusion that can be generalized in all the innovation processes, because I asked only in the case of a reform, of a significant change, when no teachers know how to work with the new elements.

Another essential element in the curriculum reform was the materials-support for the teachers in working with the new curriculum as guides or textbooks. 72% of the teachers said that the materials-support were insufficient. They did not have guides to work with and the issue of the new and alternative textbooks is still on debate. They did not know which textbooks are made respecting the new core curriculum and which content had to be thought. Moreover, this was a big challenge for the teachers, because they were used to work mainly with the textbooks and to teach the content that was stipulated in the national documents.

Considering that the teachers affirmed that they had major difficulties in working with the new curriculum, I asked them what type of help and under what form, they consider would have been efficient in sustain their activity during the changing process. 28% of them said that special training activities as part of the continuing teacher-training programs, 25% said meeting and debates with the educational specialists, 24% said more information and explanation would have helped more and finally, 22% said the teacher training sessions focused on the curriculum reform. As we can see, the teachers cannot decide on one type of help that they needed the most in the changing process, all types of help proposed in the questionnaire would have helped them. I could say that all these types of help were missing and that the national policy makers in starting a changing process should consider them.

It is true that every process of change, especially reforms, will raise numerous issues and difficulties and I see the research I did as a step in identifying the elements that the national policy makers should focus more on the moment of starting the innovation process. They should point out institutions that can offer help to the teachers; they should define clearly, what are the roles and the positions of the teachers in the change, lobby about the change and offer support-materials that would improve the quality of the implementation process.

In the Netherlands, in 2005, I went into schools and I talked with the actors involved in the processes of change on a regular basis. In this analysis, I will mainly describe the teachers' answers, but not only, and try to identify the answers to the same items as I used in the questionnaire in Romania.

I talked with the teachers in the interviews about the difficulty of introducing the curriculum aims into the classroom's activity and they all said that it was a short and very easy process and everything went smoothly. It was felt like a natural change and they had enough time to implement it. I did not feel the pressure of change, not at all, say the teachers. Moreover, the teachers consider the process as very easy, with no big pressure and they all agreed with the change. They all consider that the main national institution involved was the Ministry of Education.

As an institution that mainly helped all the actors involved in the curriculum reform, is considered the Pedagogical Institute. They all agree, I mean all the fifteen subjects, that the Pedagogical Institute was pointed out to offer the help, explanations and support to the schools. During the curriculum reform, the schools did not have to buy the help of the Pedagogical Institute; the help was paid for a few years by the national institutions. During the curriculum reform, the government paid for these institutions, but the headmasters decided if the school needs the programs or not, say the general directors.

The answers to the question: which they consider is the most important actor in the curriculum reform and in an innovation process, in general, were very interesting. The teachers and the educational specialists have the same opinions: the teachers represent the most important actor, together with the community and its demands. In all three moments, the teachers should be more actively involved…The teacher has to feel that he has a real job, not just by sitting and doing what we say they should do. You should experiment, discover a way of teaching, think about it, and talk about it with everybody…says one of the headmasters interviewed. We have to give freedom to the teachers to discover how they are going to achieve it say the school inspectors. One of the educational specialists says definitely, in the all implementation process, the most important actor is the teacher… The teachers are the ones that have to do everything; they are the most important in a process of change. We can introduce a change in the political system, but the most important is the applied curriculum, so the teachers are the ones that make it possible. The curriculum reform took part, actually, when the door at the class was closed… The question is if the teachers can handle the process of change and what can we do to make the process easier. Therefore, we have to ask ourselves what we can do to grow the quality of our teachers and at of the process they develop.

Regarding the issue of sufficient materials to sustain the curriculum reform, one of the general directors says I think the relation is essential and that it was one of the secrets of the curriculum reform. The markets of the textbooks knew the curriculum by heart, so they knew they could not seal books that were not right for the new curriculum. Therefore, they were an important actor in the political aspect. They were very important in the process of the curriculum reform. Talking about the textbooks, the teachers say The textbooks are made in a way that at the end of the school's process, the children reach the level that is demanded at the national level, by the national aims... Textbooks are the most important thing that we have… The textbooks are important so you know what you have to teach in that year… I know about the national levels that the students have to achieve from the textbooks and guides, but I do not know about the national aims exactly… They all agree strongly that the textbooks are very important and the base of the curriculum reform. The teachers as the specialists consider that guides for the teachers were also important in the implementation process. For the teachers, the textbooks have many roles: support in preparing the lessons, important for both teachers and students, used to measure the level of achievement, as assurance in obtaining the success and in order to know what to teach. Based on the textbooks, the teachers were able to implement the changes in the school and at the classroom's level.

The teachers, the general directors, the school inspectors and the educational specialists affirm the process was well organized, the regulations were good and were sent in time and they could always talk about it with the school's team, talk about the change. In addition, they always got the help they needed from the helping institutions. The educational specialists played a main role in initiating the innovation and assuring the lobby and the support needed during the process. They take the decision and they built the instruments of the change. They have a very positive attitude towards change and they infuse a lot the importance of the social skills and the social changes and demands.

The actors that said they felt the curriculum reform as a hard process were the headmasters, at least at the beginning. In this case, the reform was not easy to implement for them. Yes, it was a very hard process for the schools, because it was not clear what we had to do, say the headmasters. However, the teachers perceive it as easy, which is the element of debate in this paper. The educational specialists interviewed said we had many meetings and we could talk about the process and maybe be initialization process was long, but not the implementation. As I think at the beginning, it was hard to accept the idea, because nobody likes to be told what to do and we like to decide for ourselves. It was a process of talking about the way of implementing the innovation and of trying to make everybody agreeing with the process of innovation.

If I want to point out explanations for the fact that the teachers perceived the curriculum reform as easy, I choose to present the patterns that I identified in all the interviews, the aspects that all the actors agreed on. The first and the most important pattern identified is we can talk about it. The teachers say they could talk about the change and the way of the change with the actors, they met, as the other teachers, the headmaster, the representative from the institution that helped the school during the curriculum reform. The second pattern identified was time and help. They agree that the teachers, the school's team, the general directors, they all had the time they needed to implement the change and they knew they can ask for extra help, if necessary. The third pattern identified is we worked together as a team. The pattern of working together as a team is present especially at the school level. The teachers choose to go and ask for help first to the other teachers in the school and secondly to the headmaster. They do not go to ask for help to the local actors or the local institutions. The use of the textbooks is also present as a pattern in all the interviews and by all the actors involved. They all start talking about the textbooks from the first questions of the interview. They identify multiple roles and functions of the textbooks in primary education and they are identified as the secret of the curriculum reform.

4. Conclusions

The teachers in the Netherlands felt the process of reform as an easy process, with an effective rhythm of change. The headmasters are the ones who felt the pressure of change and who had to make a plan for the school to integrate the innovations. The teachers did not felt the pressure of change, because they worked as a team, they talked about the things they knew how to do and especially about the things they did not know how to do, even with the headmaster of the schools. The national authorities pointed out clearly the institution and the persons that are going to offer the support to the schools. The teachers were perceived as the main actors in the top down change and the process of implementation was evaluated after sufficient time of practice. They all leaned on the textbooks and on the guides and the teachers could take courses to get familiar with the change. In a way, the teachers are protected from the pressure of change at the beginning and they are stimulated to talk about the things they do not understand with the other teachers.

In the Romanian top down change, these things were a little different. The teachers did not go to ask for help from the other teachers and they do not feel free to talk about the things they do not know how to do. It is clear from the percentage of answers that they did not have sufficient material and guides to sustain their effort of change. They asked for help and I guess they received it individually, because they pointed out persons and institutions that they could ask for help. However, there are no correlations between the persons and the institutions chosen. That infuses the idea that, at the national and local level, they did not named institutions and trained persons to be able to offer organized support and counseling. They should have considered more that the teachers were not used at all with the new working instruments and with the paper work that they had to do, so they did not offer sufficient time in order to avoid the pressure of change.

These elements should be considered when there is a structural and fundamental change and the teachers should feel more actively involved and as part of the change. They need to understand that the change is necessary, that it is going to make things better, and in this case, the change will be a success.

Doing quantitative research in Romania, I felt that it was easier to do quantitative research in Romania, because I could easily get the chance to analyze official documents than to talk to people. In addition, in Romania, the local school inspectorate has the role of schools' management and control, so it is easier to send and questionnaires to schools. I also considered that the people still do not feel comfortable to speak out, so I was taking the risk of not getting an objective response in a qualitative investigation.

I could also say that my impression was that the teachers were more interested to be a part of a research that is possible to affect them directly, in changing things and educational actors in Romania put a lot of trust in quantitative representative data in order to change things. There are a few quantitative national analysis and paper focused on the curriculum reform, but I consider that the Romanian educational policy still needs many quantitative projects, in order to compare outputs and to find solutions. The development of education is in a moment when it needs more quantitative investigation, comparations and specialists are interested on a national level for the results of different research projects.

Doing qualitative research in the Netherlands, I felt it was easier for me to talk to official educational specialists than to analyse official documents. In addition, I think I got an inside of the process. Moreover, it was very useful for my knowledge to get more information about the process of a top down innovation and make my own objective opinion. I consider it was very useful to start with qualitative investigation, having a great chance to get the human inside of the curriculum reform and the real pulse of the educational process. The qualitative research gave me the chance to focus more on the personal opinions or individual development processes. Moreover, talking to people I was able to identify other subjects interesting to research and causes or phenomena that I did not think of from the beginning.

After talking with the educational actors in the Netherlands and from my experience, I was able to identify after issues and themes that they were interested on and that would be interesting to research. Such themes of research could be: the textbooks – the process of changing the textbooks and the rhythm of change, the constructive role of the School Inspectorate and his role in stimulating the bottom up innovations and related, the importance of the school self evaluation process and the quality evaluation process. Some of the persons I talked to pointed out the role of the European tests and the impact of the results and the concept of the good teacher.

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Science, Technology and Society in Chemistry Learning

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Abstract. *The aim of this investigation is the use of STS methodologies in Chemistry and emerges from the question: What's the degree of satisfaction and motivation of the students with an educational strategy centered in the resolution of problems related to the local environment and whose answers might be used in the scope of social politician decision making?*

To answer the previous question this investigation developed different strategies of education learning with the following objectives:

- Evaluating the feasibility of a STS strategy of education in the current educative context;

- Evaluating the degree of satisfaction and motivation of the students to a STS strategy of education centered in problem-solving in real context;

- Evaluating the motivation and the performance of the students to a strategy of decision making based in previous investigations;

- Evaluating student's conceptual changes about description and characterization of Science and Technology and its Inter-relations with the Society.

- Contributing to the use and development of STS educational strategies in Chemistry teaching.

In this Work the methodology adopted is action-research and qualitative investigation.

The study took place in Chemistry class with 10th degree students. When STS strategy was implemented, a common subject allowed the students to formulate several problem questions. Afterwards the students conceived, planned and executed the activities that could lead to answers to the questions they had placed. Finally the students used the results of their investigations in a decision-making episode designed to this specific situation.

All the activities developed in this work and student's conceptual and attitudinal changes were diagnosed and evaluated through diverse questionnaires, interviews and direct observation.

With this study we concluded that the students positively addict to this kind of STS strategies and are able to verbalize and clarified their personal views of Science, Technology and Society.

It is thought that this research will be able to contribute to the use and development of strategies in STS education, including decision-making episodes in Chemistry teaching..

Keywords. Decision-making episodes, science, technology and society education.

1. Introduction

Formation for the citizenship in a global world, influenced by Science and the Technology and influencing these, it passes necessarily for the education of sciences that we made in our schools. It seems us, thus, of great importance, to develop strategies that promote the participation responsible in a world where great part of the decisions involves scientific and technological questions (Yager, 1990; Fensham, 1992; Fourezetal, 1994; Jenkins, 1994; between many others).

A person with scientific and technologic literacy is, second different authors (Solomon, et al, 1995; Millar, 1996; Martins, 1999, among others) one that is capable, in a conscientious form, to present a critical position in relation to subjects that involve science, technology and society and to understand that the relationship between science, technology and society involves moral, ethical, social and ambient aspects.

This critical position requires, among other learning, the construction of images adjusted on science and the scientific work, as well as of experiences of conflict that promotes the necessity to take wised decisions.

It seems us, therefore, pertinent to place the question of how to implement CTS education in education of sciences, with sight to reach the goals and purposes behind related. <u>What strategies can we use in our lessons to educate for science?</u>

Despite innumerable works of diverse authors who point and strengthen CTS or CTSA education in Portugal, its implementation has not been easy. As it relates Martins (2002), exist some constraints as diversity of meanings CTS, the organization of the education system and the purposes of the education in sciences in the some levels of education, the obstacles recurrent of the practical models and of formation of science teachers, the pertaining to school programs and the way as professors face them and, still, the school resources that translate visions of education and learning without a CTS orientation.

This situation took us to question about the viability of a work plan based on CTS Education where, without relinquishing the conceptual domain, could promote the development of citizenship abilities.

It is in this thematic framing that is developed this study. The component of Chemistry, in Chemical and Physical Sciences in 10th year class, was worked using diversified strategies, inside of which was presented a thematic project, "Water in Faial", from which the students had enunciated some problem-questions that had considered important for themselves, had designed activities in the attempt to find their answers, had developed those activities and had been citizens to an episode of decision-making. We intend to inquire the adhesion of the students to this type of strategies, as well as its viability about the level of difficulty, the management of time and the level of adequacy to the curricula goals.

Having in account the global context previously presented, relatively to importance and to the necessity of the education in science, on science and for science, we can specify the central problem of this study through the following question:

- Which is the degree of satisfaction and adhesion of the students on an educational strategy centred in the resolution of problem-questions about their local place and whose answers, for found them, harness and facilitate the taking of social and political decisions?

In agreement with the central question previously presented, for which we intend to find possible answers, they had been defined, for this study, the following goals:

1) To evaluate the one viability strategy of CTS education in the actual educative context;

2) To evaluate the degree of adhesion and satisfaction of the students to a strategy of CTS education centred in problem-questions on real context;

3) To evaluate the adhesion and the performance of the students to a strategy of taking of decision based for its investigative paths;

4) To evaluate the conceptual changes in the students in what concerns to the description and characterization of Science, of Technology and of its Inter-relations with the Society.

5) To contribute for the use and the development of CTS strategies in education, nominated of taking decisions.

Having in account the central question and the goals of the study, a inquiry-share plan was adopted on the basis of the following hypotheses:

1) The students involved in a CTS strategy of education will present attitudes more favourable in relation to Chemistry and to its learning.

2) The students involved in a CTS strategy of education will present a more structured vision of Science and Technology, as well as of its inter-relations with the Society.

3) The students involved in a CTS strategy of education will get better argumentation capabilities with a strategy of decision-making.

2. Methodology

2.1. Drawing and description of the study

This work was developed in Chemical and Physical Sciences class with a group of 10th year at the Secondary School Dr. Manuel de Arriaga, during the school year of 2002/2003.

The delineation of the action was made on the basis of the methodologies of the action-investigation processes. Thus, after diagnosed the problem, it were designed the strategies and was proceeded to their implementation. These phases had been succeeded in spiral, since new problems appeared that demanded new plans and other strategies.

Implementation of the strategies and development of the activities

Soon in the presentation lesson when we talk on the works to develop in scope of Chemical and Physical Sciences class, was related to the students that we would like to them to consider a subject of inquiry related with its experiences or with the local context and that it hugged subjects of chemistry.

Before initiating this passage to them had been presented transparencies and a Power Point with a summary of the phases about how to plan a project (Milk, 1989) and propose the analysis and discussion of the presented documents.

The subject proposal that we present was the "Water in Faial". The students had divided themselves in six groups of work, according with their preferences and had started to place questions that they liked to see answered. The work of group in this first phase was to delineate the excellent questions for each group, and to try to formulate them in a specific form.

In this phase they had initiated one work of planning their action, supported with documents, since contact to establish, research information, eventual laboratory work, asking for available resources, etc.

After the research of relevant information had been appearing some questions as: how to prepare a solution? What means concentration of a solution and how can we know it? What is a titration? What happens in a titration? How to use a burette? How to use a water analysis kit? What advantages and disadvantages have its use? How do we must proceed to collect the samples? Which are the characteristics of domestic water for consumption? Withes norms and legislation exist for domestic water for consumption? What it means VMR and VMA? What consequences for the public health and the environment if that norms and rules are not accomplished?, between many others.

These questions had been used as excuse for the exploration and discussion of the contents considered in official curricula and to search other information in agreement with students interests.

However, we made a meeting with their parents where it was explained to them what kind of work we are doing and that we wanted to share our work with them. A date was combined of presentation of the works with the parents, in agreement, also, with its availabilities.

The work was developed using varied activities and with diverse degrees of complexity, nominated, rank of hypotheses, drawing and/or accomplishment of practical activities, resource the diverse techniques to determine the concentration of ions, bibliographical consultations, planning and implementation of interviews, formal and informal contacts with local entities, research in the internet, consultation of norms of legislation and water analysis, etc.

Two extraction water holes were visited, the samples collected in these holes were analysed and other samples were collected in the taps of some points of the island.

They had been made diverse research in the internet on the consequences of the constitution of the canalizations to be, in its majority, of asbestos-cement and lead.

It was tried to establish contact with the responsible ones for the fish industry, situated in the Bay of Port Pim, to the exit of the city of the Horta, but these had prevented any contact.

After finding answers for its questions or to have concluded that they needed another one type of technical resources to get a reply, the students had initiated one process of writing of report of the developed work.

At this time, students had initiated the preparation for the presentation of its works to the parents. For this, they had made their presentation in Power Point to the parents, people in charge of education, professors and other people for invited them. The presentation elapsed in after-labor schedule and all the students had participated in the verbal presentation.

Finally it was presented to them an episode of making-decision elaborated from the problems diagnosed in result of their work. At this time, the groups of decision-making had been constituted by the teacher to be heterogeneous, with elements proceeding from different work groups with different questions so each one can gave complementary elements, arguments, information and experiences about their work.

In the end of these sessions of discussion and confrontation of ideas, all the group debated and made lists of possible consequences of each option; at this point they set a sequence of actions to the resolution of the problems of their local community.

Later, we invite the school community and three representatives of the Mayors Office: the Councilman at Entire Time and a Civil Engineer (both responsible for "waters") and one Engineer of the Environment. The students had proceeded, again, to presentation of the works and had requested to the invited people that tried to take the proposal decisions in the episode for them presented.

They had, thus, the chance to collate its decisions with the options of the three guests, who also they diverge between themselves. This process generated some debate and confrontation of ideas.

2.2. The sample

In this study, as already it was related, we use only one group of 10th year. Although we have appealed to another group in the same year to compare their answers on the questionnaire of “Attitudes to Chemistry as Science and the Learning of Chemistry”, we do not possess given enough to characterize in accordance with same items that the work group.

As already it was related, the twenty one students who constitute the involved group in this work are all ages between the 14 and 17 years, being that the majority of the students (61,9%) had 15 years what it means great homogeneity in terms of ages. These students were all boys in the Secondary Courses Predominantly Guided for the Continuation of Studies in Sciences.

2.2. The instruments

In agreement with the goals defined for this study, had been elaborated diverse instruments. We make, in this section, one brief description of the diverse ones.

To the long of this study they had been gotten elements of qualitative nature through the content analysis questions of descriptive reply, and quantitative nature through questionnaires.

The diverse instruments had been presented in the some phases of the process, as to follow if it indicates.

1. Questionnaire in the beginning of the school year

In the beginning of the school year, it was considered that each student filled a fiche of biographical register with some data staffs and with questions opened on its attitudes to discipline of Chemical and Physical Sciences (CFQ) and its conceptions of Science and Technology.

With this questionnaire, it was intended, for besides collecting personal data of each student, inventorying the conceptions they had, to the entrance of secondary education, on science, technology, chemistry, the education of chemistry, among others.

2. Questionnaire of Attitudes to Chemistry as Science and the Learning of Chemistry

The questionnaire of Attitudes was elaborated with the goal to try to evaluate the Attitudes of the students in relation to Chemistry as Science and to its Learning.

Since we intend to evaluate attitudes in relation to science, Chemistry as science in particular, and in relation to the learning of Chemistry, matters to clarify which dimensions, of predominantly affective nature, involved.

Some authors (Germann, 1998; Giddings, Hofstein & Lunetta, 1991; Sundberg, Dini & Li, 1994; Gogolin & Swartz, 1992) had used or suggested instruments multidimensional to measure different dimensions in the attitudes in relation to science.

Having in account it disciplines it, education subject and the developed strategies, we opted to elaborate one questionnaire to measure diverse dimensions. The questionnaire was composed for 25 items, all Likert type, with five reply options varying of *I disagree Totally* to *I agree Totally*. The majority of items were adapted of other instruments already existing (Araújo, 1995; Sundberg, Dini & Li, 1994; Gogolin & Swartz, 1992; Cardoso, 1998). The 25 items had been chosen in order to give indications on 5 attitudinal dimensions.

The dimensions of the questionnaire were grouped as follow:

A Sub-scale - Interest for Chemistry as science - it corresponds to interest of the students for subjects, programs, activities of Chemistry inside the school context and on professions related to Chemistry;

B Sub-Scale - Appreciation of the value of Chemistry in the society - disclosed by the attributed importance to Chemistry in understanding of the world and in the utility of its knowledge in people's life;

C Sub-Scale - Interest in relation to the learning of Chemistry - it corresponds to the interest and motivation of students in relation to the subjects, activities and time in the lessons of Chemistry and appraise for the tasks developed in the lessons - disclosed by interest of the student for the activities developed proposals and in the context of classroom.;

D Sub-Scale - Interest in relation to the laboratory work in Chemistry - it corresponds to the interest and motivation of students in relation to the laboratory work developed in Chemistry lessons.

E Sub-Scale - Judgment of the student on the personal capacity in learning Chemistry - what students feel in relation to its proper capacity in understanding the subjects treated in Chemistry lessons.

This questionnaire was applied first in one Another Group of 10th year (AG) and, then, in the Work Group (WG), to detect difficulties of understanding and to compare with our Work Group.

3. Questionnaire of Attitudes to our Chemistry Lessons

This questionnaire was elaborated in function of the developed work. The goal of this questionnaire was to know the students opinions about the utility or appraise for the developed tasks, concretely, during this work. Also we intended to diagnosis which the difficulties and the opinion of the students on the work of research and the episode of decision-making. In these two last questions, it was used same methodology that in the questionnaire related in point 2

4. The episode of decision-making

The episode of decision-making was conceived from the collection of concrete data gotten by the students in development of its work and other data for gotten us, next to Regional Secretariat of Tourism, the Regional Secretariat of Economical Activities, of elements of the Environment Department of the City and of the Department of Oceanography and Fisheries of the University of the Azores.

This episode was made with the same orientation that Shal(1995).

2.2. Methods of data handling

The central body of this study seats in picture of the qualitative paradigm. Some of the instruments used can be treated quantitatively, but without statistical relevance, given the small dimension of the sample.

As indicating, in the questionnaires "Attitudes to Chemistry and its Learning" and "Attitudes to our Chemistry Lessons" the values were arrange of 1 to 5 for each reply, of the following form:

- items where the agreement corresponds the considered attitude more positive, had been quoted of 1, 2, 3, 4 and 5, respectively for the answers *I disagree Totally, I disagree, I do not agree nor disagree, I agree, and I agree Totally;*
- items where the agreement corresponds the considered attitude less positive, had been quoted in inverse way (of 5, for the answers *I disagree Totally* , up to 1, for the answers of *I agree Totally*).

For the purpose of treatment of the data, to get the quotation in each item, we determined the average value in each item e in the global scale.

In these two questionnaires we will use the following classification already used by Araújo (1995):

Classification of attitudes	Average Score
Predominantly positive attitude	**>3,5 and <5**
Ambiguous attitude	**> 2,5 and <3,5**
Negative attitude	**1 and <2,5**

Table 1. Classification of attitudes

The questionnaires with opened answers, like the "Questionnaire Integrated in the Fiche of Biographical Register" implemented in the beginning of the school year and the "Questions of Revision and Reflection about the Episode of Decision- Making", had been treated from prominence of words or key ideas.

These two questionnaires were useful to compare the definitions of science and technology and its relations with the society,that the students had to the entrance of Secondary education and after the development of this work.

3. Results – analysis and a discussion

3.1. Results gotten through the diverse instruments of work

1. Analysis of questions presented in the integrated beginning of the school year in the register fiche biographical

In relation to the concept that students have of science and of technology, the following questions had been placed:

"Try to define your concept of Science"

In the answers to this question students had shown that they never had thought to much on this subject, at least, they never had attempted to define, for writing, their concept(s) of science. Comparatively with a study made with students of 8th year (Carvalhinho, Gomes, 2001), the reply had been very similar.

"Try to define your concept of Technology"

To this question, the answers had been divided in two groups:

- Technology depends on science contributing, also, for its development;
- Technology is associated to equipments.

Also here, they had shown difficulties to state their concepts.

We also collect the information that Chemical and Physical Sciences classes, such as Science, are useful to understand and to study the world around us.

2. Analysis and discussion of the answers to the questions of revision and reflection of the episode of decision-making

To the question **"Considering work developed during the Chemical and Physical Sciences lessons, tell the importance, in your opinion, of the knowledge that the common citizen must to have on these subjects."**, the students had answered, over all, *it is important to know and understand science and to be able to give opinion.*

They had still related that it was important: *To act in political decisions (...to) grow our quality of life (...to) have conscience, to be informed, to know, to be informed, to change attitudes, to have knowledge, to participate asset e conscientiously in the subjects day to day, to know what is the quality of water we drink, to be along with everything, to know what one becomes, to be the forward or against the decisions, to be alert, to have knowledge, to know.*

It appears, thus, new data, almost all the students had related that the importance of the chemistry knowledge for the common citizen it is that thus it can give opinions.

In relation to the question **"In your opinion, how the knowledge can become the citizens more participative in the decisions that affect the populations?"**, they had answered, over all, *that more knowledge implies greater ability to argue and greater capacity of intervention in public decisions..*

They had also related that the citizens: *(can) to save and not to pollute the water, they can complain, they can to disclose itself, to act in the life politics, they are felt more active, more knowledge implies greater to be able of argument, to make propagandas, more intervention in the decisions, to question the responsible ones, to demand that they improve, to be active, not to allow that if it constructs without being duly inspected.*

Almost all the students assumed, in this phase, that the knowledge promotes the development of interventions and argument abilities.

In relation to the question **" Present some considerations about science: its characteristics, its methods and others that you find important,** they presented the following considerations:

- *the mental, bred level happens for the Man, to decide problems, it subjects to the change, requires tests, analysis of the tests with conscience, it happens due to curiosity and dissatisfaction of the being human being, mental, dynamic activity, change, studies the things, contributes to the development, answers the questions, is based on facts, studies them, it compares them, it evolves, it helps to decide problems, it is an orientation of the thought, to understand the environment, use experiences, to think about the future of everything, curiosity is the base of science, experiences and very study, to know what we are, different areas, everything can be influenced by science, scientific knowledge is not absolute.*
- Over all, *it happens in the mind human being and is subjects the change*

Almost all the students had assumed one to character much more dynamic and humanist in its definitions of science and it appears, for the first time, a reference the values that can condition work in science.

In relation to the proposal **"Present, of summarized form, a technology definition: its characteristics, its methods and others that you find important.,**

- *physical and material resources, it serves to help the Man to reach its goals, forms to increase its physical potential, aid in the development of science, ways, processes of electronically aid in the performance of tasks, machines, things, a way of to work.*
- Over all, *devices to increase the human potential*

Although they continue to relate the technology only with material resources, the used language is more careful and they relate that the technology is related with devices that they allow increasing the human potential.

In that it says respect to the proposal "**Present a small text with possible relations between science, technology and the society.**", they had related, over all, *science is helped for the technology to benefit the society* and they made, still, the following commentaries:

Is necessary the science to the technology go more beyond in things that go to be inserted in the society,

Science is an assistant of technology that is made use to help the society in the resolution of problems and in the infrastructure creation.

The relation between science, technology and society always appear that we speak of ethical problems, or either, questions as the case of the cloning, abortion, etc. In these problems it is the science that made those existence or resolution, is the technology who develop them and create and, finally, it is the society that condemns them, criticizes or supports. Therefore, it is science and the technology that makes to evolve the world and tries to discover the extremities, but it is the society that has an important and difficult paper to define the ways.

In this last reply, it appears, for the first time, the society as regulating the science and of technology.

They presented a positive image of science and continue to consider that science and the technology depends one on the other for its development.

3. Questionnaire of attitudes face to the work developed our Chemical and Physical Sciences class

The activities that <u>students liked more</u> to develop were *field exits* and *laboratory work* . It is was not a surprise because therefore these contexts of learning are less frequent in their lessons and are, simultaneously, more informal.

But what they liked doesn't correspond to what they considered <u>more useful as a student</u>. The activities more related by them were "*the teacher purposed research work* ", "*the teacher did exercises on the board* " and " *they did exits field to collect samples and/or information* ".

It is interesting to verify that the students had considered of bigger utility the activities where the process was more centered in the teacher, what denotes, still, few habits of autonomous learning and little security on their individual work.

They liked too "*they had been argued in group the problems to investigate* ", "*activities had been developed laboratory to investigate the constitution of the collected samples* " and "*teacher explained subjects from de books*".

What they considered more useful for its personal formation was "*contact with local entities for collect information* "and "*discussion, using valid arguments, to find the best final decision* " (in the episode of decision-making) e "*discussion, in group, of the problems to investigate*".

Making a final rocking, considered activities more useful they had been, of followed "*the exit field to collect samples and/or information* " e "*the teacher purposed research work* " to follow it appears " *the teacher did exercises on the board* ". These two last ones had been considered useful as, but they had not been much appreciated.

The activities "*contact with local entities for collect information* ", "*discussion, using valid arguments, to find the best final decision* "also had been considered useful.

The considered activities less useful and that less they had liked they had been "*the students did exercises on its places*" and "*the teacher explained subjects of the book*".

It is interesting that the work group considered more difficult "*to design the activities* " and to follow , as well as "*to present possible consequences in the episode of decision-making* " of that "*to understand concepts* ","*defense of the arguments in the work of decision-making* ", he was not considered difficult, therefore, in this phase, the students already had made one listing of the positive and negative consequences.

In accordance with the data that they had been being collected to the long one of the study, these students never had developed works of this type and as, to develop them, it was necessary great capacity of organization, work and initiative, some had considered them difficult. We verify, also, in elapsing of the process, that the phases that had excited those greater difficulties had been the planning of activities and the writing based and organized of the report of the work.

4. Answers to questionnaires of attitudes to Chemistry as science and the education of Chemistry

To get some comparative information we applied this questionnaire to another group in the same school level. This group was the only one we have and we consider important to relate that its options were Chemistry Laboratorial Techniques and Biological Laboratorial Techniques, and our group options were Education Sports and Chemistry Laboratorial Techniques.

Of followed, we present table in table 2 the results that translates the score average to the 5 attitudinal dimensions evaluated through the questionnaire of attitudes face to Chemistry as science and to learning of Chemistry in the Working Group (**WG**) and in Another Group (**AG**) and the Difference between these two **V**alues (**DV**). Table 2 shows the predominance of attitudes (positive, ambiguous or negative) of each one of the groups in each dimension using the same criterion that Araújo (1995), related in section xxx of this study.

Sub-scale/ Dimension	Work Group (WG)	Another Group (AG)	Difference between Values (DV)
A - Interest for Chemistry as science	**3,81**	**3,15**	**0,66**
B - Appreciation of the value of Chemistry in the society		**3,60**	**0,47**
C - Interest/motivation to the learning of Chemistry and to the activities developed in Chemistry lessons	**3,82**	**3,24**	**0,58**
D - Interest/motivation in work Laboratory	**4,43**	**4,50**	**-0,07**
E - Judgment of the student on the personal capacity in the learning of Chemistry	**3,64**	**2,88**	**0,76**

Table 2. Predominance of attitudes in the 5 dimensions

In the Work Group (WG) all the dimensions present predominantly positive attitudes on the part of the students.

In Another Group (AG) only corresponding dimensions to sub-scales B and D present attitudes predominantly positive and in the other sub-scales they present attitudes ambiguous.

From the analysis of these data we cannot guarantee that the attitudes of the WG had modified after development of the works for considered us, but the collected elements to leave of the other instruments of work, nominated, the interviews, they point in this direction.

3.2. Discussion of the results

Comparing the elements collected in the questionnaire implemented in the beginning of the school year in the fiche of biographical register with answers given for the students in the revision fiche and reflection of the episode of decision-making, we can weave the following considerations:

a. In the end of the intervention they had related that chemistry provides knowledge that the citizens allow to be able to give based opinions and that it provides greater argument capacity to them intervention.

b. To the entrance of secondary education, these students, they presented naïve and very poor conceptions of science in a social context and without human values. In the end of this intervention they had assumed definitions much more dynamic and humanist of science and, in some cases they put values in scientific decisions.

c. Although they continue to relate the technology only with material resources, the language that they had used was more careful and they related that the technology is related with devices that allow increasing human potential.

d. In the end of the intervention they relate, for the first time, society as regulating of science and the technology.

e. They continue to present, of a general form, one very positive conception of science.

In that it says respect to attitudes face to the lessons of Chemistry, are interesting to verify that the students they had considered of bigger utility the activities where the process was more centered teacher, what it denotes, still, lack of security and habits of autonomous learning, or the more comfortable and less laborious fact of being not to have that to carry out the processes.

In relation to the attitudes face to Chemistry as science and to the learning of Chemistry, we consider that the works developed with the students, even so devotion e has demanded them sufficiently persistence, had also increased them the auto concept in the processes of teach-learning in Chemistry.

4. Conclusions

It is main intention of this study to find reply for the question enunciated in the beginning of this work: **Which is the degree of satisfaction and adhesion of the students on an educational strategy centred in the resolution of problem-questions about their local place and whose answers, for found them, harness and facilitate the taking of social and political decisions?**

Being conscientious of the meaning and implications of science as social construction e considering that the two great goals of CTS education are:

- The analysis and demystification of the social paper of science and the accessible technology to become them understandable and interesting to the citizens;
- The social learning of the public participation in the decisions related with technical and scientific subjects.

To find an answer to our central question, we implemented strategies and methodologies of work that, even so, were not strangers; we had never used in a consistent and based form. In this direction, we had that to define them, to characterize, to design and to apply and, thus, our study could contribute to reach a more general goal - *To contribute for the use and development of strategies of CTS education, using of decision-making episodes, in the education on Chemical and Physical Sciences*.

They are presented of followed the conclusions of the study, having in account the hypotheses and goals previously defined:

C_1 **-**Relatively *to the viability of a strategy of CTS education in the current educative context*, evaluated only for the difficulties of implementation of these strategies adjusting them it the programs in vigor and to the material and human resources existing, we verify that it is necessary a bigger involvement and investment of the teacher and, even so they are reasonable in the related context, create great difficulties in the management of the time.

C_2 **-**In relation *to degree of adhesion and satisfaction of the students to a strategy of centered CTS education in problem-questions in real context*, we feel, during of the process some distinct moments. First some students had shown some reticence e a certain discomfort for having to take initiatives and design its proper activities, but when we start to advance in the processes of inquiry in the land, to discover new problems and to collect information unexpected, the enthusiasm was generalized. These appreciations that we make here confirmed by the results gotten in the questionnaire of attitudes in relation to the lessons of Chemical and Physical Sciences.

C_3 -In that it says respect *to the adhesion and the performance of the students to a strategy of taking of decision based on their investigative works*, the students demonstrated great involvement in discussions in decision-making process, therefore being the heterogeneous groups of decision, or either with elements proceeding from different work groups, all wanted to share the information that they had collected and they wanted to know what the others "had discovered". These considerations on its adhesion to the process can also be confirmed through the results gotten in the questionnaire of attitudes in relation to the lessons of Chemical and Physical Sciences.

C_4 -In that it says *respect to the conceptual changes in the students in whom it says respect to description e characterization of Science, the Technology and its Inter-relations with Society*, we verify that their conceptions of science and relation between science, technology and society had become less naive, more dynamic and flexible, but we consider that it is not only in a period of few months of work that modifies and integrates so complex conceptions and relations.

C_5 -In relation to our hypothesis that *the students involved in a strategy of CTS education will present more favorable attitudes to Chemistry and its learning in Chemical and Physical Sciences class, in the set of the attitudinal dimensions*, this study took us to conclude that this hypothesis was verified, but we present many limitations, given here the differences between the groups and the lack of data relatively to our group of work before intervention. Any form, the results that we got in the questionnaire of attitudes to Chemistry as science and the learning of Chemistry can lead us to confirm our hypothesis.

C_6 -The hypothesis of that *the students involved in a strategy of CTS education will present greater capacity of argumentation in a strategy of decision-making*, was not confirmed, even so we noticed a significant difference in the answers of students given in the revision fiche and reflection of the episode of decision-making. They proper had related many times that knowing the subjects and discussing them can take them intervention citizens and bring to them a bigger capacity of argument.

In summary, with the results of this study, we conclude that the degree of satisfaction and adhesion of the students to a strategy of education centered in the resolution of problem-questions about local issues and whose answers, found for them by they work, was very good.

The particular context where our study was carried through, the very small sample, the access lack the groups equivalents for comparison of results, the short period of time where it elapsed, the characteristics of the instruments, are examples of some of the aspects that constitute limitations of this work.

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Environmental Issues on the Newspapers of HERAKLION - CRETE

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(*) Work done within the context of a PhD Dissertation

Abstract. *The present work reports on the role of the local mass media towards environmental issues. For this purpose, we examined the content of three daily local newspapers of Heraklion, Crete with the larger numbers of circulation (Patris, Tolmi, and Mesogios)for the time period 20-5 to 13-6-2004. at first, the material was classified into four categories: "news", "reportage", "comment" and "article of opinion". Secondly, it was classified thematically into categories with reasonable criteria. Thirdly, we recorded the sources for these publications. The results showed that in total 261 publications were included. This is an important fingure which indicates that newspapers may contribute substantially to the formation of social - ecological conscience, a basic component of sustainable development.*

Keywords. Behavior configuration, Environment, Environmental Education, Media, Sustainable development.

1. Introduction

The education for sustainability and for sustainable development constitutes a parameter of critical importance for the preparation of the individual to participate in a process of re-definition of existing course of societies and, consequentially, to the promotion of attitudes and behaviors that will contribute in the creation of a sustainable future. Important are, in this frame, the principles that were agreed in the Intergovernmental Conference of Tbilisi (UNESCO-UNEP, 1977) on the environmental education. Agenda 21 emphasizes the role of local societies in the base of ecumenical environmental questions, through the problems of local environment and their management. The role of local societies is decisive for the management of environmental questions and through the enactment of competences of local self-government and through the circumstancial expression of local societies on environmental questions in their region. The reference to the environmental problems was not presented simply and only, because of the deterioration of the conditions in the natural and in the manmade environment, but mainly because they are included in a wider cultural context of natures exploitation, in which new purposes and values are defined. This cultural context is not homogeneous and single precisely because it is a process that concerns the hegemony in the level of reason and action. There exist and rival different versions of nature and accordingly different versions of environment as social problem. Concretely for other the nature is considered as moral size, for other with terms nature, while for other as a new field social and political fights etc The himself happens also with the significance risk this significance was not foreigner in previous seasons, minus however today meaning differently. While before it had the meaning of the auspicious or voluntary individual undertaking of enterprising danger, in the current season of later modernity, is deemed as an involuntary befalling damage of social total. For the most part, the interest for the nature and the environment today is emanation of endangerments that is hatched and the processes that take place in the frame of "society of risk". Precisely because exists a permanent almost sense of threat, the interest for the environment or more precisely for the environmental problems is maintained high in the researches of common opinion [2].

In the configuration of climate of management of local environmental questions is decisive and mediatory the role of Media. The Media allocate access in big departments of population, can influence the personal behaviors, attitudes and perceptions and they constitute the main source of information round the environmental issues [11]. However it will not be supposed, neither we decrease the importance neither we ignore the possibility of Media of shaping new attitudes of (mainly young persons) and of influencing at least up to a point the existing attitudes [3a]. With base more it is obvious that the Media are in place they are included in the process of Environmental Education, make that is also confirmed by the international conferences on this.

Fluctuations exist in the extent and in the accent that they give the Media in America and Europe but also and other institutions of publicity in the environment. The projection of environmental issues are of course better than the decade the ' 70, when for first time ' was discussed the "human environment" in the world conference of UN in Stockholm and was publicised the report of her Club Rome for the limits of model of growth in the industrial states. Thus, one cannot see the environment as news means that beyond and except the process of social manufacture of reality via the Media [14].

In Greece, the Media began to deal systematically with the environment in the beginnings ' 80. In this helped, among others, his permanent henceforth installation clouds above Athens and the frequent arsons and other incidents of devalorisation of environment. Newspapers inaugurate ecological columns - or special insets, are published new magazines with specialized environmental issues, circulate books of proportional content and, naturally, the television cover each environmental news that are judged interesting by the persons in charge of program. However, official researches do not exist, worked out from the Academic Departments of Media. Nor official Journalistic Unions, that would record how the means handle the environmental issues, only individual and fragmentary recordings have become.

2. Study Purpose

In the present study, we will try to approach the role that possesses the environmental issues in the means of mass briefing, examining the case of three local daily newspapers of Heraklion. The significance environment him we approach in all her aspects and record anything it is reported as natural, social, structured, cultural and economic environment. More specifically, we will attempt to give answers in the following exploratory questions:

- How could be put on scale issues of environment from the daily local news papers.
- Contribute the relative publications with the content of messages in the change of attitudes and behaviors of common opinion in the direction of sustainable development.

3. Method

For the present study, we examined the content for each day of separately three daily local newspapers, Patris, Tolmi, and Mesogios. Then, we pinpointed and isolated relative issues with the wider significance of environment and other relevant significances. The period was studied is accidental and completely sampling from 20/5/2004 until 13/6/2004. This material divided in four categories "news", "reportage", "comment" and "article of opinion" and the pages included recorded. In addition, it categorized according to the source of (institution) that it provided the relative issues. The material classified in thematically categories with reasonable criteria.

4. Results

With regard to the hierarchy – importance that gave the local press, the 261 total publications that we studied they divided as follows: news 138, reportage 70, comments 23 and articles of opinion 30. Analytically, Table 1 presents the centralized picture of publications.

Table 1. Newspapers Publications per Publication Category

Publications	Newspapers		
	Patris	Tolmi	Mesogios
News	37	41	60
Reportage	44	7	19
Comments	8	15	0
Article	19	7	4
Total	108	70	83
Percentage (%)	41,38	26,82	31,80

As it appears the bigger percentage of publications on three newspapers occupies also the news, follows the reportages and then the articles of opinion, with last the comments. Remarkable it is also that do not exist main articles in all the newspapers with environmental issue. However, the environmental information represents a very small percentage from the total of information that the Media offer. The big mass of environmental information confirms that offer in Greece mainly in national level. The over hierarchy is justified from that the small journalistic organisms, as the daily local newspapers of Heraklion, cover mainly the important issues of topicality (hard news) and cannot realize research in-depth, neither use a lot of sources, one and it should and should they cover a lot of news with limited personnel. In addition, they allocate limited economic resources and they do not allow in the journalists to deal with a subject for major interval while, is provided limited space for environmental issues and equivalents is decreased also the sources of pumping of news. While the environmental problems are, complex and they need enough explanation with sufficient information and details. Even if such type cover it is useful, however, it presents the environmental problems surface and it leaves from outside ecological, political and social interactions that led to their appearance.

The environmental briefing however by the Media should not limit itself in the simple transmission of information round the environmental issues, but present in the public the real socio-economic and ecological side of environmental problems and the possible ways of action for their resolution. Thus, the citizens are in place they recognize the gravity of these problems and they mobilize in favor of them.

With regard to the small presence of comments and articles from journalists this is probably justified by the make that the journalists often do not know that would seek the right sources of knowledge for the issue that cover, what them will help they interpret and they appreciate the information that they have already. Still, because they are not all educated in environmental issues, they ignore main parameters of environmental issues so that they repeat the material of source, without evaluation [10]. In the particular point, it deserves is marked the insufficient or absence of environmental education or simple briefing on the environment and his problems from the different levels of study journalistic faculties.

With regard to the issues mentioned in Table 2, the daily local newspapers of Heraklion presented the issues relative to the environment, at the examined period. The publications divided in 20 categories of issues.

From Table 2, it appears that publications exist on many environmental issues from the anthropogenic environment up to news with reference on the urban environment and the quality of life. Generally exists an equivalent presentation of the thematic units between and the three newspapers but however and their fragmentary presentation thus the issues tends they are presented as self-existent incidents without past and future. On the contrary we remind however, that the leading undeniably make the Conference of Rio in 1992 "On the Environment and the Development", where the environment became first issue of international publicity for big time interval. Their analysis confirms the tendency that they had and they continue having the Media mentioning negatively events of daily life that transformed easily in news, if they include the element of unanticipated and satisfy the rhythms of production of newspaper. On the contrary, a positive make of daily life, or is considered obvious by the means and consequently is downgraded as news, or from the things requires time for his concretization and consequently again loses his news value.

Table 2. Publications Issues

Items	Newspapers		
	Patris	**Tolmi**	**Mesogios**
Anthropogenic environment/culture	23	5	13
Urban environment	1	1	
Biological agriculture	2	1	1
Sustainable development	1		1
G.M.O.'s	1	2	5
Forests		1	2
Diet/Health/Starvation	16	8	7
Dangerous radioactivity wastes		4	1
Climate	2	1	2
Politics	2	3	4
Ecosystems	7	3	4
Fauna	11	8	9
Environmental protection	8	3	3
Pollution	3	5	
Solid/Liquid waste management	3	2	3
Technology/Media	4	4	7
Environmental friendly technologies	3	7	6
Aquatic resources		3	1
Flora	6	1	2
Environmental actions	15	9	12

In addition, it does not become report in the causes that cause this devalorisation of environment and is not disputed the existing model of growth. A photograph that we often met appear the local newspapers framed with a small comment of journalist (casuistic framework of news) [5] can activate in a given moment the citizen, but the configuration of such environmental conscience, that correspond in the needs of season, requires a overall approach of problem. It is also remarkable that there has been recorded action for the environment that has taken place from various institutions that provide informal environmental education. In addition, a collaboration of institutions recorded in the frame of concretization of these activities. From the analysis of issues daily local it results that it should are given bigger accent in the confrontation of issues with regard to urban environment, forests, biological agriculture, renewable sources of energy, the management of all nature of waste with friendly methods to the environment and the rational management of aquatic resources. With regard to the sources of relative publications, these presented in Tables 3 and 4. At this categorization, we include in a category, publications that emanated from institutions of optional environmental education apart from the schools. In the other category, we only include publications that reported in activities that realized in the frame of programs of optional environmental education of schools.

Table 3. Publications Sources

Publication	Newspapers		
	Patris	Tolmi	Mesogios
News	34	40	57
Reportage	29	6	16
Comments	6	14	0
Article	18	7	4
Total	87	67	77
Percentage (%)	37,66	29,00	33,33

From informal environmental education sources (museums, local authority, media, and other sources)

From Table 3 it results that are appeared relatively enough publications from activities of institutions of optional environmental education. With regard to the categorization of publications, first they place possesses the news in all the newspapers, while it appears exists a differentiation between the newspapers with regard to the number of presented reportages and comments. The newspaper Patris at general acceptance because the bigger circulation in the prefecture Heraklion appears that it appears most publications and all the categories concerning the other newspapers.

Table 4. Publications Sources

Publication	Newspapers		
	Patris	Tolmi	Mesogios
News	3	1	3
Reportage	14	1	3
Comments	2	1	0
Article			0
Total	19	3	6
Percentage (%)	67,86	10,71	21,43

From informal environmental education sources (Primary and Secondary Education)

From Table 4, it results that they are appeared in relative publications a small number of activities in the frame of programs of optional environmental education that is materialized in the schools. The newspaper Patris possesses the first place in number of publications and in particular covers the activities with relative reportages. It appears from a first regard that is required a narrower collaboration between school environment and journalistic organisms for bigger diffusion of environmental information that emanates from concretizations of programs of environmental education.

The sources that used were mainly institutional public and government owned institutions and presented in the Tables 5, 6, the 7. Scientific community it plays secondary role, as the private sector and the not-governmental organizations. From this categorization, we conclude that the journalists can more easily cover issues of more general interest despite concrete facts, which require knowledge but also include controversial sides. This indirectly emerges from the entire lack of articles of himself journalists but also minimal comments. The simple however diffusion of environmental information from Media do not constitute Environmental education, however when the information is transmitted with suitable way thus, so that it attributes real dimensions of environmental problem and it provides his possible ways of resolution, it strengthens the degree of environmental sensitization of public and is changed in mobilization for environmental action.

Memorandum for tables 5, 6, 7.

1. Central government
2. Local authorities (Municipalities, port-office, Prefecture, Region of Crete, etc.)
3. Schools
4. Church
5. Universities – Research Institutions
6. Museums
7. Professional Clubs, companies, e.g. Engineers, Economists, Hotels officers, etc.

8. Environmental organisations, native associations
9.Non-governmental organisations at national level, e.g. Greek Ornithology, Company for the Protection of Nature, etc.)
10. Non-governmental environmental organisations at international level, e.g. *Greenpeace, W.W.F.*, etc.
11. Scientific companies and unions for the protection of environment in local, national and international level e.g. Union of Greek Biologists, etc.
12. Media
13. E.U./U.N.
14. Political parties, politicians
15. Private individuals
16. Autonomous environmental groups for environmental protection.

Table 5. Sources from Informal and Non-formal Environmental Education (Newspaper Patris)

Source	Category			
	News	Reportage	Comment	Article
1				
2	1			
3	3	15	2	1
4	2	5	1	
5	5	3		
6	4	4		
7	5	4		1
8	4	6	1	1
9	1			
10		1		
11	3		1	1
12	5	1	3	
13	2			
14	2	1		2
15		4		4
16	3			
Total	**37**	**44**	**8**	**19**

Table 6. Sources from Informal and Non-formal Environmental Education (Newspaper Tolmi)

Source	Category			
	News	Reportage	Comment	Article
1			1	
2		1		
3	1	1	1	
4	1	1	1	
5	1	1	1	
6	5	1	1	
7	3			
8	3		1	
9	1			
10	3	1		
11	7	1		1
12	5		9	
13	3			
14	3			
15	2			6
16	3			
Total	**41**	**7**	**15**	**7**

Table 7. Sources from Informal and Non-formal Environmental Education (Newspaper Mesogios)

Source	Category			
	News	Reportage	Comment	Article
1	4	1		
2				
3	3	3		
4	3			
5	2			
6	14	5		
7	4	2		1
8	4	3		1
9	3			
10	4			
11	3	1		1
12	8	2		
13	1	1		
14	5	1		
15				1
16	2			
Total	**60**	**19**		**4**

5. Discussion

A critical question is if how much the cover of environmental questions in the issues of mass means influences also the attitudes and the representations of citizens on one side for the environment and thereafter, for individual special environmental questions. Despite the appeared force to have the Media in the configuration of attitudes, the change of solidified attitudes is particularly difficult. Their supposedly absolute force, as presented from behaviorism, is substantially a fable [3b]. Evident it is, that the cognitive theories of attitudes, according to which the change is question of creation of some cognitive no agreement, with the personal contacts with individuals that respects no one, present a more genuine picture of parameters that influences the change of attitudes [3b]. The effects of news reports in the public are an immense and difficult question, which is susceptible of multiple methodological approaches. Nevertheless, we will attempt his firstly approach with base the results of present study. For the export of completed conclusions it is required a big extent research where will be asked the opinions of citizens but also himself journalists for the local Media. According to a study of Centre of Environmental Information Studies [1], for the offer and the demand of environmental information in European level, is recorded between the other and the insufficiency of actual model of transmission of environmental information, while are marked the basic characteristics and the negative elements in the way of diffusion and her distribution, in Europe. Klapper who is mentioned by Georgas [3b] leads in the conclusion that according to the results of various researches, that the means of mass communication simply strengthen the existing attitudes, opinions and behaviors of individuals. That is to say, that the individual is not careful the messages that are disagreeably, as it is forecasted by the theory of cognitive no agreement of Festinger, with his existing attitudes. On the contrary, the individual is careful particularly the according to his existing attitudes messages. Right environmental information does not mean essentially a simple increase of environmental news that Media diffuse, even if this increase strengthens the probability of providing information the public about the existence of such messages [15], [1]. The aid of flow of environmental news, even if useful, it does not fight the ideological base of problem, that is consolidated, among citizens, attitude is ignored the factor environment in the process of decision-making daily [15]. The real and essential environmental information becomes action when that the citizens are provided, through suitable methods, sufficient information thus, so that they are in place to shape a completed opinion and to decide for real action regarding environmental issues [1]. However despite the existence of increased environmental conscience, the inquiring data show that the environmental knowledge and the environmental conscience are men essential terms on the event of one friendly to the environment behavior, no, however, sufficient and unique prognostic indicators of such behavior [8]. From an international research [9] have resulted dissenting results. Thus, certain they have diagnosed powerful cross-correlations between the environmental issues of Media and the conscience of public round corresponding issues. At other analysts, however, such type cross-correlations not argued sufficiently.

Generally, they appear to be the following basic factors that affect, so that changes the attitudes and the representations of public for the various issues that are presented in the daily provision of Means:

- the sources of information
- the nature of presentation
- the frequency with which they present the same issue
- the affinity of issues with the daily life of citizens
- obvious the issues that are appeared
- the degree of environmental sensitization of journalist

The sources of environmental information determine largely her content, but mainly the objectivity and her correctness. The main sources of environmental information are the responsible public services and governmental institutions, the academic institutions as well as, the special scientists and the non-governmental environmental organizations. However, they are not the few times where the above sources come in opposition between them, with regard to the material that provides in the Media for a concrete environmental issue. For instance, for the opening up of new street through a forest, the public institutions will diffuse in the Media material in favor her application of work, while a not governmental environmental organization tries for opposite. Consequently, the objectivity and the correctness of environmental information can be evaluated from the degree whom's it accomplishes to incorporate and join the various opinions that are found in adversity, in each social environment and through an open process. Thus, all the sides of environmental problem appeared and no one of them not excluded or marginalized [1].

Important role in the environmental sensitization of public plays the transformation of environmental information in effective knowledge or differently from information on consumption in information on use [1]. The continuous negative correspondence and over simplification of environmental problems, without the least report on their likely ways of resolution, it removes the citizens from the environmental questions, after they feel unassisted towards them and decide him they ignore. From enough researches, it has been observed that are increased the probabilities changes the attitude of public for a issue, when this is presented by the means of communication with not ambiguous way, with dramatic style and persuasiveness [12]. Now, we would say that the environmental issues in the daily newspapers of Heraklion not presented general with ambiguous way, however no with dramatic style and their persuasiveness is satisfactory.

Nevertheless, the explicit way of presentation of issues is not enough from alone him in order to change the attitudes of public. To this direction, the contribution of factor of frequency is essential, with which deal the Means with the particular issue. It is acceptable that the repeated issues, because the accumulation of information and the familiarization that creates, practices smaller effect in the transformation of attitudes. On the contrary, the issues that presented for first time and acquire exceptional character have bigger probabilities they change or they shape the attitudes of public. This happens because the small "cognitive mass" on which they had been shaped the initial attitudes of public, supplied now with new elements and enriched with knowledge, which dictated by the issues of Media. This news, enriched "cognitive mass" sweeps along with her line the attitudes of public, his changes, that is to say, to the "desirable" direction that engraved by the issues of Media. In the study of our local newspapers, on the minor interval that him we examined we even realized that existed and not repeated publications on the same issue. More specifically existed publication only on a time where it had as title the viable growth. This together and with other publications that emit the same message it is possible to lead to the configuration of behavior of certain citizens to this direction.

The citizens, independent from their educative level and their socio-economic situation, in their majority sensitized in a question that transmitted by the Media, when this question they believe that them it concerns immediately. A message of Media, that is considered that it is related with the needs of public, will constitute the reason in order that the public gives bigger attention in this and he seeks more information, despite when the message is more general and vague [11]. In the newspapers that we analyzed enough issues concern the everyday routine of citizens, potential however could be more.

From repeated studies, it realized that the abstract issues, because they are obscure, have smaller effects in the change of attitudes. On the contrary, as "concrete" is fixed in the relative bibliography a issue which becomes easily intelligible, finds, that is to say, immediately affinities and equivalences with preexisting cognitive forms of recipient, in order that easily and uncut it is included in the network of his knowledge. The issue, which concreted, requires small only intellectual treatment so that it registered in the long-lasting memory and it retained.

The degree of environmental sensitization of journalist depends on many factors, as ontological, his epistemological and value admissions but also his cognitive interests. When, therefore, it is called to cover a issue the perceptions and the attitude that the journalist allocates towards him, little until very, deliberately or no, proportionally and with the degree of elasticity of each form of influences of (pressures) that accepts in his work, they influence the syntax of final text.

Logically the environmental sensitized journalist led to an environmental friendlier attitude than his part, in a disposal for mobilization of acquisition of dexterities and essential faculties for active attendance in the decision-making environmental. This reflected in the way of distribution of environmental information, where the journalist attributes or tries she attributes a completed picture of environmental problem, with his possible ways of resolution. When a journalist allocates a high degree of sensitization opposite to the environmental problems, in the frames of his work and concretely in the distribution of environmental information, he tries to present to the public a completed picture of environmental problem with its likely ways of resolution. So that to strengthen the environmental sensitization of public and to change the mobilization for environmental action. Moreover a environmental sensitized public has the possibility improves the quality of cover of environmental issues from the Media the relation of Media with the public is interdependent and influencing each other, that is to say, the Media they have the possibility of influencing the public, but also the public it can and influences the Media. Despite his all dependence from the means of briefing and the issues their, public seldom remains permanently passive. He is also active; the issues constitute meaning through their report in the news reports, as much as if this is vague and distant from the concerns of everyday routine. This rendered explicit for a long time, in the frame directed in the public of critical regard of media (audience-oriented criticism). This regard has many common points with the Pedagogic Faculty of dialectic of social interaction and growth, approach that finds, among others, right moment in the analysis of environmental issues, [7]. In a research of Swedish Media confirmed, many of the places of theoretical model of effects of daily provision [4] certified that in local, everyday, ecological problems the means of briefing and particularly the regional newspapers that in Sweden have big circulation, very little influence with their news reports the public. The last one develops environmental conscience through his direct experience, as well as from the interpersonal communication. However, the issues of media very often determine the content of interpersonal communication for questions of public interest. When the public they are environmental sensitizing, requires an in detail and qualitatively better environmental briefing. This requirement becomes obvious with the increase of circulation of newspapers and magazines that fill the above requirements. However are today cultivated sufficiently by the local Media the idea of sustainable development by the present work but also at our personal opinion no and the causes are many. Typically, we report:

- The Media do not check sufficiently if the central authority legislates and applies the national and Community legislation on the questions of environment.
- The Media do not appear systematic programs of informal environmental education that the local self-government, the schools etc. plan and achieve
- In the local Media, systematic "champagnes" briefing do not become for the readers, so that they will make environmental friendly choices.
- The Media do not check sufficiently, if the industries, the tourism, the rural enterprises replace the old technologies with new "clean" ones, but are simply limited in the recording of consequences from each form pollution.
- In the Media, an environmental problem only recorded or its dramatic sides more stressed, despite the environmental problem itself, its generative causes and consequences.

Deductively the local Media with all the sources that he provides, it is possible under conditions they contribute substantially in the configuration of social - ecological conscience, basic component of sustainable development.

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Technologies in School

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Abstract. *The technologies of information and communication are tools that more and more should integrate our classrooms and, consequently, excellent options for science teaching. The continuous evolution of the society forces a constant looking for new information be the teachers, because in his classroom there are students familiarized with the new technologies and used to a constant use of theirs. Therefore, if they are in a school that presents classes in a perspective, essentially, "traditional" it will drive to a lack of motivation and interest in school, by the students. So, for the teacher to promote a motivate atmosphere and pleasant to teaching/learning inside the classroom, one of the ways of getting is the use of new technologies of information and communication.*

In this perspective, it's presented, here, a different approach, viewing a methodology, at the same time, inductive and constructive. Recognizing the importance of the experimental work in science teaching, concretely, in a class of Physics and Chemistry Sciences it was provided to an 11th grade, in the teaching/learning of contents concerning the uniform movement, the accomplishment of an experimental activity of investigative nature, having in mind the concepts learned until the moment. The developed activity took the students, wend confronted with a problem situation, they add to make there previews for a possible answer to the initial subject, plan out one or more experimental activities that allowed testing the hypotheses. Then, the students, executed those activities, analysed it and interpret the data collected with the purpose of finding the answer to the problem, which will be, or not, concordant with the initials forecasts (hypotheses), in other words, a investigative course.

The didactics materials available, to the students, were a computer simulation and a sensor of movement, CBR (Calculator Based Ranger), two examples of technologies of communication and information.

After the execution of the experimental activity the obtained results were analysed and interpreted by the students. They were able to verify that the data obtained by the sensor of movement, CBR, differ a lot of the obtained by a computer simulation.

This is part of an article developed during my last year of degree at the Azoren University follow up by Dr. Carlos Gomes.

With this new work, the aim is think of new things we can do in yours classrooms that will promote the interest and motivate even more the students. So why not use robots (constructed by the students) to study Classic Mechanics.

In this case, conclude that the speed, in this movement, is constant and the acceleration null. So that, the analytical expression of the law for the uniform movement consists in a 1st degree equation for the position order time ($x=x_0+vt$), in SI units.

Keywords. 1st degree equation, CBR, computer simulation, ICT, investigative experimental activity, problem situation.

1. Introduction

The information and communication technologies (ICT) began some years ago a revolution in the society whose end is still for pulling the curtain. The improvements and innovations in this field have been of such order, that every day opens up new evolution perspectives and discovery roads.

Therefore, it makes no sense that, these aren't tools of great use in the classrooms, or everyday of larger use. There's been verifying through several recent studies (Bulla et al., 2002; Ehmke & Wünscher, 2002; Kocijancic, 2002; Mendonça et al., 2002; Vasylevska et al., 2002) that ICT are great tools for Science teaching. They have the advantage for allowing a direct exploration, for the students. The acquisition of data is accomplished in real time, it allows a graphic data storage, that's, the data are exhibited, to the students, in a graphic representation and consequently they can have a vision of the data in a way easily understood. Since, the data are collected and exhibited quickly, the students can examine the consequences of a great number of experimental variation conditions, in a small period of time.

Due to the small time interval for the data collection, it allows, the students, to spend more time in observation of the physical phenomenon, in study, to interpret, to discuss and to analyse data, the main objectivity wend we accomplishment an experimental work. It is also of mentioning, the fact, that different types of problems use the same hardware forms and software, allowing to the students to investigate varied physical aspects without the need of learning, again, to use the didactic material.

It is important to refer that the authors consider the present students, of our days, as much the primary level as secondary, are qualified to use a great fan of tools (technologies of information and communication) to investigate the physical world, and if they still didn't have any contact with this type of tools, they have sufficiently developed competences to learn quickly. A lot of times the teacher "gives" an excuse for not using ICT, the fact, students not knowing them. However, is usually the own teacher that is "afraid" of learning is handling, preferring to continue doing the "traditional" experiences with the "traditional" materials. However, it is essential to develop and substitute didactic materials for the accomplishment of the "traditional" experiences. The teacher that works like this will see immediately results, when looks at his classroom and sees motivated students in the accomplishment their works.

CBR is a sonar detector of movement that can be used together with the graphic calculators TI. This makes data collects and the analysis of concrete situations of the physical world, turning possible this study in the classroom. It is of easy use and doesn't need programming.

With CBR and a calculator, the students can collect, see and analyse data to any movements.

CBR allows exploring the mathematical and scientific relationships among distance, speed, acceleration and time of any data collection.

It allows to the students to explore contents, as for instance:

- Movement: distance; speed; acceleration; time.
- Graphic representation: axes of coordinates; dependent and independent variables.

The use of computer interactive simulations has an enormous didactic potential for the learning, in a constructive vision. In agreement with Jon & van Joolingen (1998 *apud* Ehmke, 2002) "the definition of a computer simulation consists of a program that copies a process or a dynamic system, with their certain parameters, and it allows to experience and to simulate procedures in an atmosphere of virtual learning."

According these authors, the use of computers to simulate a complex and dynamic nature phenomenon, were the devices are of high costs or inaccessible, haves a solution the use of multimedia material. Because the interactive simulation allows the exploration and manipulation of these types of atmospheres supporting the student's learning. And this strategy turns possible, for the student, to tie the new information with the knowledge existent, a constructive vision of the learning/teaching process. It's also understandable that a good use of the learning atmosphere is necessary to adapt the cognitive demands and give an effective and appropriate orientation. In other words, to plan out the practical work appropriately.

One of the main purposes of the Science teaching is to give explanation of the nature's phenomenon through mathematical models.

In many cases, students are trained to develop competences to solve problems manipulating, sometimes, mathematical equations.

According to Kocijancic (2002: 381) even for the students, that are not particularly interested in Science, such approach is difficult and causes certain "hate" or fears Science. Even for students, that easily work with equations, doesn't usually understand and notice that there is a relationship between mathematical models and everyday atmosphere.

According this author, "the purpose of computer simulated experiences is usually used to visualize mathematical models and turn the learning more interactive and attractive [...] Computers equipped with an interface for on-line measurements with a sensor, it's increasing at Sciences school laboratories. The computer is used to measure and to monitor physical phenomenon, such as, temperature, electric potential, pressure, etc."

Though, for a real learning, several tools and concepts have to be integrated and the applied methods must be chosen in agreement with learning aim.

2. Main text

In the extent of teaching/learning of contents concerning straight line uniform movement, in a 11th grade, in the of Physics and Chemistry Sciences class, an experimental work of investigative nature was developed.

The students, at that the moment, already characterized a particle movement, using the position, the speed and the acceleration. They, also, know that in uniform movement the sum forces are null.

Consequently, when the resulting forces, that act on a material particle of mass *m*, is null, be the inertial law (1st Newton law), the particle is in rest (v=0 *m/s*) or she moves with uniform movement. By the 2nd Newton Law, since the resulting forces are null the acquired acceleration is also null.

$$F_r = ma \quad (1)$$

$$ma = 0 \Leftrightarrow a = 0(m/s^2) \quad (2)$$

Therefore, the speed is constant, there is no variation of the speed vector long time, because a straight line path is described be travelled the same space in the same time, that is, the position is directly proportional to time.

$$a = \frac{\Delta v}{\Delta t} \quad (3)$$

$$\frac{\Delta v}{\Delta t} = 0 \Leftrightarrow \Delta v = 0 \Leftrightarrow v = \text{constant}\,(m/s) \quad (4)$$

$$v = \frac{\Delta x}{\Delta t} \Leftrightarrow v = \frac{x - x_0}{t - t_0} \Leftrightarrow x - x_0 = v(t - t_0)(SI) \quad (5)$$

Considering t_0=0 *s*, in equation 5 the analytical expression for the uniform movement, in SI units:

$$x = x_0 + vt\,(SI) \quad (6)$$

The developed activity intends that the student's, starting with a problem situation, make

Than the interpretation of the data, below some examples are presented, of the possible obtained data.

a deduction of the analytical expression for the uniform movement.

For the problem resolution, the students had a computer simulation and a movement sensor, CBR (Calculator Based Ranger).

After an activity application, the class has divide in three work groups. Later, it was read a small text about Nature regularities, where contains the problem question. The subject problem was: Walk is an activity that you do everyday. Could this common situation be represented by a mathematic law? Study the simplest case, when we walk in straight line, travel the same space in the same time.

The students had to plan, accomplish, explore and discuss in group an experimental activity that allowed the resolution of this problem situation and, in the end, construct one Gowin V. In first place, the several work groups, confronted with the problem question, they launch several hypotheses, as for instance:

- When we walk, in straight line, same space in same times, it's a uniform movement.
- The total forces are null.
- The position is proportional to time.
- We have constant speed.
- Acceleration is null.
- When we stood back of the sensor the position increases, in time proportion.
- When we approached the sensor the position decreases, in the same time proportion.

For elaboration of the work the students possessed a system that allows collects and analysis data, CBR, as well as, an interactive simulation. CBR bases in the use of a linked graphic calculator to a movement sensor, through an interface.

Figure 1. CBR.

The function beginning of this device is the technical acquaintance of sonar for the detection of aquatic systems as, for instance, fish shoals. Sound waves are emitted than reflected in two the system again. Through the time round trip time and the propagation speed, it's possible to detect what depth is the system. The ultra-sonic movement detector that accompanies the CBR system bases on a similar beginning sends hundreds of electronic pulses that knock in the object and return to the detector.

After the hypotheses emission, the groups planned out and executed an experimental procedure.

We can observe, from the graph, Fig. 2, that initially the object was in rest, reason for which in the first instants the graph presents a straight line. The small presented flotation can be due to oscillations happened in the beginning of the movement, since the sensor is an extremely sensitive detector. After, we have a straight line with a certain inclination. Some oscillations appear and can be due the student's arms movement, or any swinging by is body.

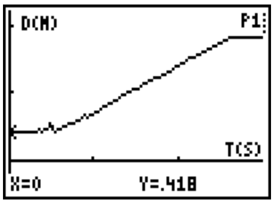

Figure 2. Position *versus* time.

The Fig. 3 resents another position graph order time. It's again verified that object is in rest initially and at the end. However, it presents an appreciable difference in the inclination, because the student walked faster.

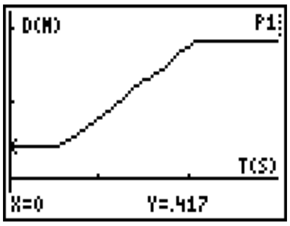

Figure 3. Position *versus* time.

Fig. 4 presents a graphic, when the object approaches the sensor. Initially it's in rest, as well as, the end. A significant difference is that the inclination is negative, because the position in relation to CBR, decreases along the time.

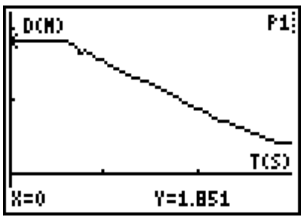

Figure 4. Position *versus* time.

The graph, Fig. 5 presents the speed order time, it would be of waiting a constant value, however that's not revealed by the obtained graph. These discrepancies mean that perfect uniform movements don't exist in Nature, but good approaches. However, if a lineal regression had been accomplished, it would probably be obtained a constant value.

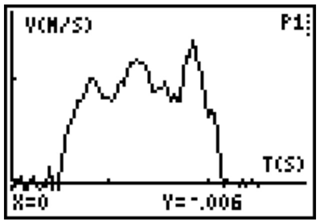

Figure 5. Velocity *versus* time.

Obviously, as a consequence speed isn't constant along time, the acceleration doesn't present null value. In a similar way, to the case of the speed graphic, doing a lineal regression maybe we obtained a null acceleration, for this movement.

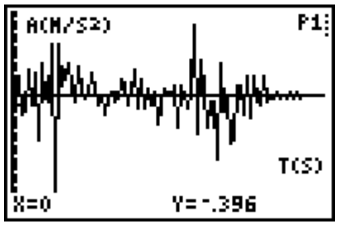

Figure 6. Acceleration *versus* time.

A computer simulation in computer used, it can be found in the Internet, it consists in a object that moves I a straight line. Where he can manipulate speed values. When the movement is simulated, in simultaneous, the graphs position-time and speed-time are drawn. Examples of the data are presented below.

It is verified easily that the graphic representation collected by the simulation doesn't present any type discrepancy. From the graph, Fig. 7, it is perceptible that the object occupies same space in same times, for that the graphic representation is a straight line.

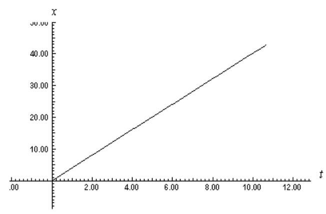

Figure 7. Position *versus* time.

Wend we select a negative speed value, the straight line inclination is also negative.

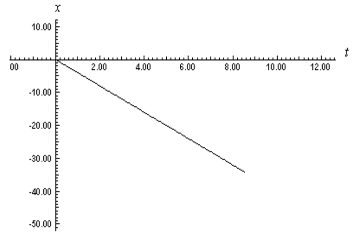

Figure 8. Position *versus* time.

Relatively to the graphic of the speed *versus* time is obtained a constant function, as was waited, since it's a uniform movement uniform.

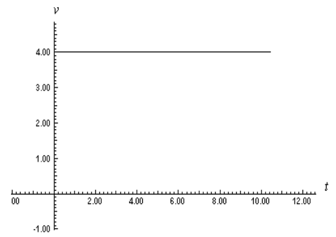

Figure 9. Velocity *versus* time.

Finally the graph acceleration *versus* time is a null function.

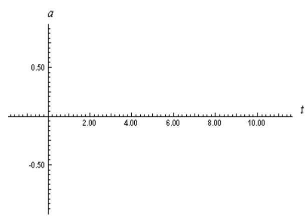

Figure 10. Acceleration *versus* time.

From the analysis of the graphics obtained with the use CBR and interactive simulation, the students could verify that position is proportional to time. As well as, the speed is constant and the acceleration null. That's easily observed by the graphic obtained by the computer simulation, however, the graphs obtained by the sensor CBR, already present some discrepancy. Such happens, because perfect uniform movements don't exist in Nature, only good approaches.

With some problems, work groups associated that the position $x=f(t)$ it represented by an 1st degree equation.

The general equation $y=mx+b$, where y is the dependent variable, m inclination, x the independent variable and b the origin coordinate.

Therefore the independent variable is time (t), the dependent variable is position (x), the origin coordinate consists in the initial position (x_0) and inclination, as observed from the graphs of Figs. 2 and 3, is velocity. Then, analytical expression for uniform movement is the equation 6.

It's of pointing out, that this is a sensor extremely sensitive, but we can resolve this by using robots and for instance, to the movement of the subject's arms that accomplishes the movement is here solved.

It's also verified that the students snow a big interest wend using the ICT, so the construction of robots to accomplish the study of uniform movement will promote more interest and motivation, the main objective of a teacher.

It's also important to mention that this investigation, from the physical world, allows the students to notice that the contents learned in the classroom, are situations that happens daily in their life.

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Learning science towards a sustainable development

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Abstract. *The quality and effectiveness of youth's education will ultimately determine their future behavior as citizens. Therefore, it is of utmost importance that students learn to value and how to preserve their environment so that, in the future, as citizens eventually even in decision-making roles, they can assure that society's development is made in a sustainable manner.*

In this communication we present a project whose main objective is to get students of Vieira do Minho high school involved in actively learning science while integrating the principles of sustainable development.

Different subjects related to their neighborhood in particular of the mountain region they live in will be explored. Those include renewable energy and rational use of energy, pollution, water resources, biodiversity, recycling, geological landmarks, and others to be dealt within the classes of Physics, Chemistry, Biology and Geology, in the classroom but also in extracurricular activities at school and in their community.

Through observation research and experimentation our students can simultaneously awaken to the idea of sustainable development and learn in an easier way the contents of their curriculum. Other arts and humanities classes will contribute enlarging the interdisciplinary of our project. Using scientific approaches the high school students will be induced to relate their observations and experiences with their daily life. Group work, critical thinking, and being responsible in the execution of their activities will be expected. Whenever possible, experiences related with this topic will take place in the classroom.

This will be a cooperative European project backed up by local authorities. We hope that students by exchanging ideas and cooperating with students of other countries can improve their learning experience while improving their sense of European citizenship. This project will include exchange visits from teachers and students the participating schools that will be prepared by the students within the project's activities.

Keywords. Sustainable development, Science Education, School, Hands-on experiments.

1. Introduction

The learning of sciences can be very stimulating. One cannot say there exists a perfect pedagogical method but our experience proved that actually going through the situations makes it possible for the students to learn the concepts more effectively and efficiently. Concrete experiences help students acquire knowledge with more ease [1].

The objective of the project herein reported is to get the students to learn science and simultaneously awaken to the principles of sustainable development. In the context of the programs of various disciplines, the use of a general and globalizing theme will allow to integrate various areas of knowledge and contribute to better learning.

As collateral objectives, this project also intends to promote the level of literacy of the students and consequently of the society they belong to [2]. The United Nations entitled 2003-2012, the Literacy decade. Scientific literacy is fundamental for the development of our societies and humanity.

The project will be implemented in other schools, located in mountain regions, in different European countries, that will share our experiences and knowledge. A number of exchange visits of groups of teachers and students will be organized in order to enhance the sense of European citizenship among the participants in the project and there schools. Science fairs will be organized where the work developed will be presented to the community.

2. Characterization of the coordinating school and its region

The village of Vieira do Minho is located in a mountain region, in the foothills of the Cabreira mountain range, a few kilometers away from the Peneda do Gerês National Park in the interior of the northwest Portuguese region of Minho. The whole region has vast natural and patrimonial resources. The region has excellent conditions for production of electrical energy by ecologically safe methods: wind, water and solar. The people live of agriculture, small commerce, services, tourism and industries. In general, they have little access to culture and the level of iliteracy is high.

Figure 1- Panoramic view of the Vieira do Minho region.

The Vieira do Minho high school is frequented by 715 students, divided into six year levels from 7th to 12th grade. The teaching staff consists of 85 teachers, most of which with a permanent position in the school. Throughout various years several projects, directed toward furnishing the laboratories with the equipment necessary for the teaching of science, have been elaborated in the school successfully. The annual fair has been repeatedly successful and has counted with the participation of school students of the region, especially from primary schools. Special attention is given to the latter because they have limited contact with experimental practice.

One of the major concerns of the board of directors of the school is the fight against failure and dropping out. For this reason certain measures have been taken to promote and value all the competences acquired by the students and introduce methods of diversifying its evaluation.
This project will involve students from the 10th 11th and 12th grades. The disciplines more directly related with this project will be Physics, Chemistry, Biology and Geology. The school curriculum will be covered, always focusing on the principles of sustainable development.

3. Topics of the project covered in the Physics classes

3.1. World energy situation and energy degradation

After an individual study of various sources of informative text, tables and graphics containing technical data and opinions about different energy consumptions in various human activities, the yield of different processes and use of energy sources, the teachers will stimulate the students to make a critical analysis with a scientific foundation about energy problems and the rational use of energy.
The students are invited to analyze the situations of energy consumption on their daily life and suggest solutions for a more rational use of that energy. The growing consumption and daily energy waste will be discussed, especially the energy consumption associated with transportation. Therefore, a comparative research on energy consumption in the transportation sector will be requested. The Superior Technical Institute will be contacted so as to be able to use in our school a driving simulator that they have developed which allows the user to know at the end of each "trip", and in function of each form of driving, the consumption of fuel and the emission of pollutants.

3.2. Energy Conservation

The general law of energy conservation is one of the most important laws of physics. In the particular case of thermodynamic systems, the 1st Law of thermodynamics calculate the variation of internal energy through work, heat and/or the absorption/emission of radiation.
The most recent formulation of the 1st law of thermodynamics distinguishes heat from

electromagnetic radiation and implies a calorimetric definition for heat (energy transfer due to a difference in temperatures).
For a better understanding of this law and of its implications, our students will be asked to analyze systems well known to them: computers, game consoles, household appliances, mobile phones, etc... By doing so they will identify the transfers of energy that occur in each system in the form of work and heat, always keeping in mind that in each transfer there is energy that is dissipated and consequentially the yield is always less that 100%.
It is important to emphasize the idea that energy is something that is always present in our lives and, when referring to the mountain regions in particular, that are colder in the winter, it is fundamental that the houses are energetically efficient. They should be thermally isolated and the material used in their construction should be chosen in accordance with the characteristics of the area, i.e. solar exposure, relative humidity, etc...

3.3. Making use of solar energy

In this particular subject various activities will be organized that involve the use of solar energy. The students will learn about the conditions necessary for the use of solar energy for heating or even for the production of electricity.
The students will therefore be led to conclude that the use of solar panels has a positive yield. This way the student will relate the total potential irradiated by a surface with its area and the fourth potential of its absolute temperature (law of Stefan-Boltzmann) and to identify the zone of the electromagnetic spectrum where the potential irradiated by a body is at its maximum.
An educational visit to a school or institution that has these systems installed will take place and the installation of similar systems in our school will be studied. A competition between the participating schools will be held to construct solar collectors. In the end the best work will be rewarded and will be exhibited in all the schools involved in the contest.

3.4 Wind energy

The geographic configuration of Portugal, and in concrete of this region, allows the installation of aeolian parks only in high mountainous places. In the plain regions the wind has very low average speed and therefore the energy produced is in such a way low that it makes it an economically impracticable project.
A wind generator gets its energy by converting the force of the wind into a binary one that acts on the helices of the rotor. The amount of energy transferred to the rotor by the wind depends on the air density, the area scanned by the rotor, and the speed of the wind.
The kinetic energy of a body in movement is proportional to its mass and to the square of its speed thus, the kinetic energy of the wind depends on the air density. The denser the air, the more energy received by the turbine. The colder the air the denser it is. At great altitudes, such as mountain regions, the air is colder thereby being denser.
A typical wind generator of 1.000 kW has a rotor with a diameter of 54m, which implies an area of 2.300 m^2. This determines the amount of wind energy that a wind turbine can capture. Since the area of the rotor increases with the square of the diameter of the rotor, a turbine that is twice as large will receive four times more energy.
The speed of the wind is very important for the amount of energy that a wind generator can transform into electricity; the amount of energy that the wind possesses varies with the cube of the average speed of the wind. If the speed of the wind duplicates the amount of energy it contains will be 4 times greater.
After a study visit to the Cabreira mountain range wind collector park, the students will learn the concept of kinetic energy and energy transfer with greater ease. Small wind generators will be constructed to test the variation of electrical energy produced in function of the speed of the wind.

4. Topics of the project covered in the Chemistry classes

The Chemistry program for high school student's deals with certain topics related to this project, thereby integrating itself perfectly.

4.1 Atmospheric Pollution

The identification of the atmospheric pollutants is very important because it helps the students to understand that they have many opportunities to avoid erroneous behaviour in favour of the atmosphere. The region in question has, as a common practice, the burning of all types of domestic garbage many times without knowing the harm that is being done. It is not only illegal,

but also responsible for the emission of toxic gases to the atmosphere and the cause of many fires.
The students will find the explanations for the reason why some natural agents, as well as some human activities, alter the concentrations of the troposphere constituents that normally exist in trace amounts [3]. Carbon monoxide, one such constituent, results from the combustion of carbohydrates and, in certain conditions, makes the atmosphere toxic and lethal to human beings.

4.2 The ozone layer

In a practical activity the students will be invited to observe, using protective eyewear, different light sources: solar light, ultraviolet light, and infrared light. Following these observations they can compare the effects of irradiation on different objects (i.e. minerals, white clothes, bank notes, and detergent dust). In this same activity they can observe the protective effect of glass filters, perspex, and solar creams against UV radiation and compare the effect of mechanical filters and chemical filters (the case of ozone) on radiations.
In the process of dealing with the results of this activity, each group will analyze documents relative to the ozone in the atmosphere, systemize information on the consequences of the rarefaction of the ozone in the stratosphere, and interpret international recommendations for its preservation.

4.3 The chemical composition of water and pollution

The high-school chemistry program gives special attention to the study and analysis of water and aqueous solutions. Particularly, with respect to acid rains, experimental activities will be carried out that promote the study of the effect of atmospheric pollutants (CO_2, SO_2, etc.) on the pH of the rainwater. River water will also be analyzed. There will be an exchange of the water samples collected between the participating schools.
In the laboratory the students will analyze the pH and the conductivity of the samples:
– pH, translates the acidity of the samples (more or less elevated depending on the amount of acid dissolved in the solution);
– Conductivity is the parameter that indicates the mineralization, this is, the amount of ions and particles dissolved in the water.

5. Topics of the project covered in the Biology classes

5.1 Biodiversity and protection of species at risk.

Field studies will take place for the identification of the different species, and their characteristic habitats, that belong to the biodiversity of Cabreira mountain range. An exposition panel will be created in order to show photographs of the species in their habitats. After making this inventory, the students will carry out a bibliographical research in order to identify the species that are at risk or in danger of being extinguished, as well as some possible causes for this situation.
Since this region has dams, special attention will be given to fishing. Considering that there exists the Law of the Minimum Sizes for Fishing, an inquiry will be elaborated to determine what kind and amount of fish exist in the region, what sizes when captured, and the evolution of the fishing activity in the past years. After analyzing and processing the data, a brochure will be elaborated with this information that will be distributed to fishing associations, tourism posts, etc...

5.2 To collect, recycle, and reuse

In the present school year a campaign to sensitize students to garbage separation will be elaborated. The first phase will include the display of posters with messages alerting to garbage problems. The posters will be renewed every week and after a month, one day will be dedicated to workshops organized by the students for the students of the school.
Containers for garbage separation will be placed in various locations of the school. These will be constructed by the students under the supervision of the Braval-Valuation and Treatment of Waist Company, whose participation in the project will be requested.
The decomposition of vegetable or animal matter, that is essential to the fertility of the earth, is a common practice in rural backgrounds. This practice will be implemented in the recycling of the organic garbage produced in the school using a chemical and biological approach. This process can be defined as a controlled aerobic decomposition of organic substrate under conditions that reach temperatures high enough for the growth ofthermophilic micro organisms.

The temperature increase appears as a consequence of the release of heat in the microbiological degradation of the substrates. The result of this process is a product called compost that is stable enough to be applied in the ground, with advantages over synthetic fertilizers [4].
The decomposition of residues can also be obtained in the absence of oxygen, being at times incorrectly called of anaerobic decomposition. The resulting product of this process has characteristics very different from those of the compost.
The stabilization of the organic substance is done slowly and the temperature reached is not very high. The residue produced needs to be treated subsequently before being accepted as an organic additive of quality [4].
The students will construct a *compostor* that will be installed in the school. The container chosen most be of wood, containing two spaces, each one with approximately 1 m3. Chemically treated wood (i.e. varnish) not be used.

Figure 2 - *Compostor* to be constructed and installed in the school [4].

6. Geology topics

6.1 Geological landmark of the Cabreira mountain range

Earth is a dynamic planet. If the earth's internal heat had ended, and tectonic forces consequently stopped, the external geodynamic processes, driven by solar energy, would long have leveled the continents and an equilibrium would have been achieved [5]. But internal and external forces continue to interact resulting in disarrangement, i.e. dynamic equilibrium.
Volcanic or seismic phenomena are of general knowledge but other less spectacular events, like constant rock transformations, also evidence that dynamism.
The rock cycle shows that each one of the three main rock groups: sedimentary, igneous, and metamorphic rock may be formed at the expense of others under new climatic or physical conditions and as the result of either internal or external forces [5].
The Cabreira mountain range is a granite massif that shares with others some characteristic landforms, but the most important features of this region are the periglacial landforms, granite pseudo-stratification very well defined, maybe the best on national ground [6].
The top and western hillside of the highest Cabreira mountain, Talefe, is covered by granite slabs. These slabs originate from endogenous factors (structural and mineralogical characteristics of the granite) and exogenous factors (climatic conditions, particularly the frozen/thawed effects from the würmian glacial and post-glacial period).
The combination of these elements resulted in granite pseudo-stratification (Figure 3), which is still visible in the major massifs (Montesinho or Estrela). The breaking of these blocks covered the Cabreira hillsides with rocks 10 centimeters thick and sometimes a few meters of long [6].
The students will be induced to acknowledge the idea that the top and western hillside of the highest Cabreira mountain is, in fact part of the local geomorphologic heritage and needs to be protected.

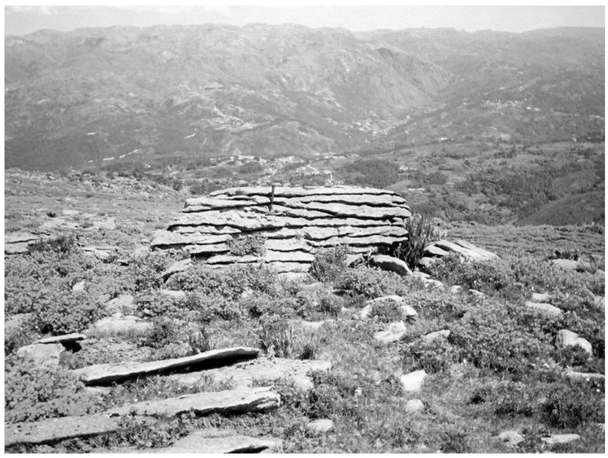

Figure 3 – Cabreira granitic pseudo-stratification

Activities

1. Cabreira field trip, that took place during the present year, to observe the referred features and elaboration by students of a field trip guidebook.

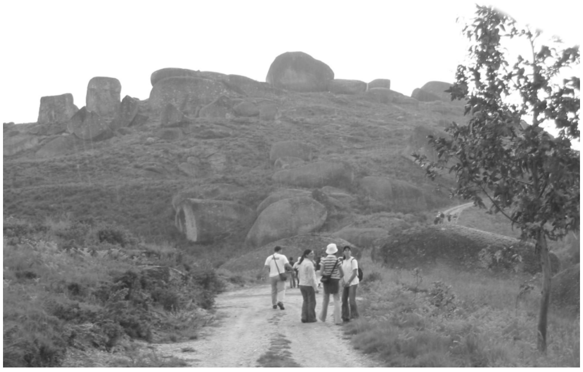

Figure 4 – Students on the field trip in the Cabreira mountain range (Talefe).

2. Geological exchange between the schools with field trips whenever possible, that in Cabreira will be organized by the students. Students will have to collect rock samples covering national ground as well as photographs of local landforms.
3. Granite, from several places marked with pseudo-stratification, comparative study at mineralogical, textural and chemical levels. This study will be made in partnership with Geosciences Department of Minho University.
4. Preparation of one proposal to the European Association for the Conservation of Geologic Heritage to classify Talefe as a geo-monument.

7. Conclusion

Many of the questions that affect the future of the society must be approached in the school, making the students want to find out more about various topics such as: the increasing energy necessities, the climatic changes, biodiversity, the scarcity of spaces and resources, Man's interventions in the terrestrial subsystems and its negative impact in our environmental and thus to a sustainable development. It is of utmost importance to change the attitudes of the common citizen and society in general.
So that this change of attitudes is verified, solid scientific literacy is imperative so as to assist us in the comprehension of the world we live in, to identify its problems, and to understand the possible solutions. Awareness and critical reflection on these challenges should be promoted.

Our students will profit this opportunity of exchange of experiences and knowledge with other fellow students of other cultures.
The participation in this project of schools of various European countries will give the project a fundamental European dimension.

8. Acknowledgement

The authors would like to acknowledge the support of the director of the Vieira do Minho high school, Jose Braga Fernandes, for his support and interest shown in the implementation of this project and the local authorities for their promise to participate in the development of this project, to Arcélio Sampaio for the information he kindly offered and for his work in the graphic arrangement of the presentation, and specially to Alda Ferreira for her support and comprehension.
The activities and plans herein reported are inscribed in the frame of activities of the Hands-on Science network.

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Chemistry and Robots

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Abstract. *The last decennium was the decennium of computer science, but now we are approaching a new era of new machines, called robots. We these thoughts in mind we had started, about 3 years ago, a very successful pedagogic experience, based on learning by doing robots, and participating on robotics competition. In this communication we will show that this pedagogic approach allowed for an significant increase of student's self-esteem, an increase for the motivation and the study for other subjects rather than robotics. The national and international competitions established in a increase number of countries, gives to students new challenges and unique opportunities to learn by doing, and co fraternize with other students and teachers. In a world more and more competitive is necessary to have a multidisciplinary knowledge, and in this competitions for doing a competitive robot it's necessary to the student to obtain skills, on electronics, mechanics, physics, maths, chemistry, and lots of more subjects…*

Keywords. Robotics, Science Education, Hands-on experiments, New Pedagogic approaches

1. Introduction

NID (Investigation and Development Department) of the Vocational School Gustave Eiffel was created in the beginning of the year of 2004. One of the objectives of this department is to promote in our school the pedagogic approach of constructivism. In this approach the learning process is centred in the process of building or constructing something [1]. We had chosen the area of robotics as the centre of our projects, by the simples reasons that this area covers a lots of subjects and there are well established events at national and international level. For this kind of pedagogic approach to have success is necessary to exist some strong incentives. One of the incentives was the participation of the project build in robotics competitions, were our teams obtained some significant prizes at national and international level. One of the most important was the a second position on Dance competition in Padua, on Robocup Junior 2003, when we were the first Portuguese team to participate on Robocup. This prize opens the doors for more projects and allowed to create a structure to support a larger number of students to participate. Actually there are more than that 30 students directly involved in the activities of the group, but many more indirectly. In 2004 on Lisbon, we were the schools with more teams present all over the world on Robocup Junior. In this competition we had win the competition of Rescue and another second place on Dance.

However more important than the prizes, was the fact that this results brought a new life and new way of teaching in our school. In 2004, we began to involve in this project some mathematics, physics and chemistry teachers. Why this areas? Because these are subjects were the Portuguese students traditionally have major difficulties. Through the calculation of components and structures for the robots, in the case of the mathematics and physical, of special effects in the case of the chemistry, we get a significant increase of interest from students for these areas. More with the objective to enlarge and to consolidate this project we had established partnerships with English and German schools for 2006, through a Comenius I project for the development of soccer robots. It's our intention to expand this kind of projects in our school and create new partnerships with other European schools in the area of robotics and chemistry. In this communication we intend to demonstrate that it is possible to join these two areas of the knowledge in an easy attractive and easy way for secondary level students. By joining together robotics and chemistry, we can achieve in an innovative way a greater motivation from the students for the study of a group of matters extremely vast, covered by this two areas.

2. Learning with robots

We had organize our electronics course in a way that the students have is first contact with robotics immediately in the first year of their courses. This is done by showing them some movies and put then in contact with older students that already participated on robotics competitions. Some of then start immediately to build some very simple robots using Kits like Mindstorm [2] from Lego or even by doing something in the robots from students from last years. One of the most important things that we obtain with the construction of an robot is that, is obligatory to the students to work in group to achieve the goal of a competitive robot. But there are many more aspects that we had win by promoting this pedagogic experience on our school. Nominally:

- A greater motivation who leads to better school classifications… and not only on the disciplines directly connected with the area of electronics!
- A better and practical understanding of the subjects taught on the electronics courses;
- A great success, in the terms of the appetence by the students to stay in the school and participate on school activities;

But this kind of project has not only advantages from the point of view of the students… Indeed:

- The teachers win immense in his relationship with the students. One of my colleagues after one competition told me: "What you are doing with this kids, is the dream of any teacher!". Sometimes they are more friends than students

- But the school as an identity wins a lot. The very good work that is done many times is not recognized simply because is to known. With the participations and prizes win in robotic competitions, the interest of the social communication has increased and took to a series of interviews and actuations on TC. This publicity, and we don't have to pay!

By this three experience we can conclude that this practical approach with the goal of competition is one of the best way to increase in the students the appetence for learning new matters and to develop their skills in a wide range of subjects, like mathematics, physics, mechanics electronic, actuators , sensors, programming, IA, etc..

2.1 Type of Robotics Competitions

The robotics competitons are organized at a national event, in Portugal the "Festival Nacional de Robótica", and at a international level the Robocup. In the two types of events, the competitions are divided in senior leagues (students with more than 19 years old) and junior leagues. There are basically three types of robotics competitions: Soccer, Rescue and Dance.

In soccer there two robots on field with the dimensions of 122cmby183cm with the floor painted with a greyscale. The ball is a very special kind of ball that emits infrareds for an easy detection by the robots.

Figure 1. Soccer Game, Robocup 2004

In rescue the robot must follow a black line and identify some "victims" with two different colours placed randomly across the line. All of this competition have the intuit to introduce the students to the world of robotics. The same kind of competitions exist in the senior league but with a great level of difficulty.

Figure 2. Rescue competition, Robocup 2004

The dance competition is the one that offers more opportunities to make original robots. In this competition the robots must dance on stage with the dimensions of 10mx5m (6mx4m in 2005, for the robots) synchronised with a music chosen by the team. The students could dance with the robots, but not touch them.

Figure 3. Dance competition, Robocup 2004

3. Robots and Chemistry

The project "Robots and Chemistry" that we will present on 2nd HSCI conference intends to show that it is possible to join these two knowledge areas to motivate the students in their school activities.

This project explores the are of oxidation and reduction reactions to obtain some special effects and apply them to dance robots. This digression on the "chemistry of the fleeting perceptions", begins with the legend of Promised, when he gives the fire to the humans, and the man's fascination for the fire.

Since immemorial times, the man wanted to dominate the fire... But the art of the pyrotechnics, just as we met her today, has born with the discovery of the black gunpowder, in China in the IX century (in spite of some references many years before, to the “Greek” Fire).

Nowadays, the most recent pyrotechnic technology is used to do spectacles full of light and colour, a lot of times happening in simultaneous with music and… with our dance robots.

The amazing of fireworks hides the complexity of the Physical and Chemical reactions that happens on the most simple firework.

The fireworks is basically composed by gunpowder and a salt that it determines the shine and colour of the light produced in the explosion, for instance. By example the use of a strontium salt turns on the emission of red light:

$$2SrCl + O_2 \rightarrow 2\,SrO + Cl_2$$ (it shines red)

However, they can happen undesirable and/or dangerous secondary reactions as, for instance, the hydration of substances hygroscopic or the reaction of the chlorate with the products originated starting from the sulfur:

$$8\,Mg + 16\,H_2O \rightarrow 8Mg(OH)_2 + 8\,H_2 + \text{Energia}$$

$$8\,H_2 + Ba(NO_3)_2 \rightarrow Ba(OH)_2 + 4\,H_2O + 2\,NH_3$$

$$S + H_2O \rightarrow H_2S_nO_6 \rightarrow H_2SO_4 + SO_2 + (n-2)\,S \xrightarrow{+KClO_3} ClO_2 + \text{Bum}$$

The introduction of polymers in this area, revolutionized the manufacture techniques fireworks, products as the polyvinyl chloride will substitute the traditional and dangerous potassium chlorate. In this project we move many times back to the time of chemist's and metallurgist Alexander Parkes, that is one of the founders of the modern industry of the plastics. One of the substances that we use is cellulose nitrate - substance designated by gunpowder without smoke and used in some special effects in our robots. By recreating this discover and taking advantage of the redox effects of this substance, we can easily motivate our students to more complex experiences.

Figure 3. Some fireworks on public presentation of one of our dance projects “The pyramidal Dragon”

In the same area of oxidation-reduction reactions will be had start last year an cooperation with an company that develops fuel cells. This allows us to show the viability of the hydrogen as a alternative source of energy to the traditional batteries, by using then in our robots.

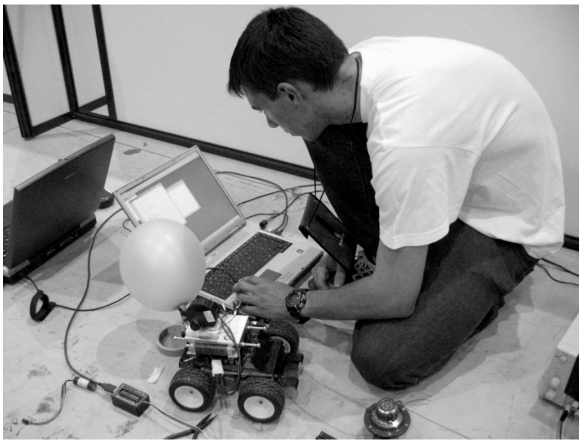

Figure 4. One of our projects powered by hydrogen fuel cells

4. Acknowledges

The authors would like to acknowledge the support of Ciência Viva on the projects PR08 e PR09. The support from our school director Adelino Serras, that has comprehended that an school need this kind of activities to be really a school! The support of the “Hands On Science” Comenius 3 network in particular the intensive course “School Robotics” Held on April on Pontevedra, Spain.

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Potenciality of an integrated approach to teach the topic Improving Life on Earth to 9th grade students of Physical and Natural Sciences

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Abstract. *This research had the following objective: to develop a didactical approach to teach the topic Improving Life on Earth including concepts of Physical and Natural Sciences, by using the strategy of problem-solving. We proceed to a comparison of the efficacy of an integrated teaching approach when compared to the conventional disciplinary approach.*

Preliminary results indicate that the integrated approach to teach science is efficient in developing learning skills and the interrelation of scientific concepts.

Keywords. Problem-solving based learning, integrated science teaching

1. Introduction

The disciplinary model that has persisted in the Portuguese Educational System seems to have failed to deliver citizens capable of entering the labor market as well as an active and responsible participation in social life. To

The experimental design of the study included two 9th grade classes with 46 students. The treatment group was taught the topic with an integrated approach and the control group was exposed to the disciplinary approach.

contribute to an integral education experience for his students, a teacher must go beyond the borders of his subject matter and look at science with a multiplicity of viewpoints. Therefore, problems must be approached in an integrated way, by using teaching methods that promote the students' critical thinking and, consequently, their capacity for autonomous decision-making [2]. We need to see science teaching in an integrated way in order to relate scientific concepts, as reality does not function in isolated parts but as part of a complex web of inter-dependencies. The strict disciplinary approach implies a narrow and partial view of reality. Integrated approaches promote a better comprehension of phenomena and problems, while promoting a critical and inquiring mind. Furthermore, problem-solving based learning, promotes, according to Margedson [2], a better understanding of reality while facilitating the integration of learning of different disciplines. Knowledge, regardless of the subject matter it belongs to, is identified during the process of problem solving as opposed to being previously determined. It was in this context that we decided to plan an integrated teaching approach for physical and natural sciences, taking into account the current Curricular Guidelines [5].

The focus of our study was on the development and evaluation of a teaching approach that not only integrated the contents of Physical and Natural Sciences related to the topic "Improving Life on Earth", but also emphasized teaching strategies for problem-solving based learning.

2. Research methods

The research consisted of an experimental study to compare the initial and final stages of a sample of 9th grade students divided into a treatment and a control group. An integrated approach was used with the treatment group and a disciplinary approach was used with the control group. The two teaching approaches were compared in terms of developing students' skills, namely at the level of interrelating scientific concepts, problem-solving and the promotion of an holistic view of the following topics: quality of life, road safety, options for a balanced health behavior and actions to promote the health quality of the community. We also tried to promote in the students the development of discussion skills and a more conscientious stand that fosters active and participative citizens.

3. Teaching methodology

In the control group, we opted for a conventional teaching methodology given that this was the only one known by the teacher of Natural Sciences. Thus, in Physics and Chemistry we started with the following concepts: road safety, movement, frame of reference, trajectory, average velocity and instant velocity; in the discipline of General Sciences we covered the following contents: indicators of the health status of the population, measures to promote health and prevent alcoholism. The latter were used to solve practical problems.

Though the teaching was centered in the teachers, the discussions and the exchange of ideas abounded given the nature of the topics address. This favored the restructuring of some alternative conceptions.

The treatment group was exposed to a methodology that was guided towards learning based on problem solving [3], as a vehicle to the integration of knowledge we wanted to achieve. We sought contexts related to news articles extracted from magazines and periodicals, one related to the environment and the other one fictitious, based on a road accident. The goal was to develop competencies at the level of understanding reality and solving problems, and at the level of citizenship given that an informed citizen ought to be able to analyze information originating from any field of knowledge [5]. This is especially the case concerning information made available by the different media. The role of the teachers was to assist students in overcoming obstacles and to answer clarification questions. As they related to the problem-solving process, knowledge of Physical and Natural Sciences was introduced or researched.

Each group of students was given a worksheet that included the aforementioned concepts, which asked them to posit problems they thought were important to solve. The groups defined the following problems according to the two disciplines under study (Table 1).

Table 1- Problems defined by students.

Group	*Subject*	Problem
1	Natural Science s	How can we reduce the pollution caused by traffic in the city?
	Physical Sciences	What are the causes of traffic accidents?
2	Natural Sciences	How does alchool affect the human body?
	Physical Sciences	Why is alcohol one of the main reasons for traffic accidents?
3	Natural Sciences	Which institutions are devoted to the treatment of alcoholism and how do they do it?
	Physical Sciences	What is the relationship between speeding and accidents?
4	Natural Sciences	Which drugs can affect your capacity to drive?
	Physical Sciences	How does the seat belt work in case of accident?
5	Natural Sciences	What is the opinion of citizens regarding the effect of alcoholism on human behavior in the cities where students live?
	Physical Sciences	What is the opinion of citizens on the causes of traffic accidents and the measures that ought to be taken in the cities where students live?
6	Natural Sciences	What are the causes of pollution in the cities where students live?
	Physical Sciences	What is a measure of safety distance?

The teaching and learning process developed in the following phases as shown in Table 2.

Sources of research: internet, library, population in students' cities, newspapers, journals, CD-ROMS, books, textbooks, bus drivers and policemen

4. Sample of students

The study involved 46 students, between the ages of 13 and 15, from two classes in the ninth grade from a school located in Northern Portugal. Students in this school shared similar socio-economic and cultural characteristics. They all belonged to middle to low income families, with all parents – with the exception of one student- being fully employed in a technical or factory type of job. The groups under study were selected due to their similar socio-economic characteristics and because they were taught by the teachers participating in the study.

Table 2. Phases in the process of teaching and learning

Phase	Curricular Area	Activities
1. Defining Problems	Physical Sciences	Defining the problems raised by the situations under hand
2. Deconstructing the problem	Physical Sciences and Natural Sciences	Deconstructing questions in order to assist the problem-solving process.
3. Problem solving	Physical Sciences and Natural Sciences Guided study Civic Training Portuguese Language	**Planning**: defining strategies, possible sources of information, distribution of tasks. **Research**: information gathering in several local sources **Implementation**: Selection and organization of the information available, interpreting results, finding solutions and applications to other contexts.
4. Presentation and discussion of results	Physical and Natural Sciences	
5. Synthesis and evaluation of the process	Physical and Natural Sciences Civic Training	Synthesis of the results and evaluation of the problem solving process.

5. Description of the study

The study was organized in the following way:

1 – The teacher-researchers reorganized the contents of the relevant subjects under the topic of *Improving Life on Earth*, in accordance with the Curricular Guidelines.

Due to problems of scheduling, we circumscribed the study to contents related to the sub-topics: Equilibrium in the Human Body – options that interfere with the equilibrium of the human body; Individual and Community Health-Measures to promote health (Natural Sciences); and Road Safety and Movement (Physical Sciences), with special emphasis on the issues of alcoholism and environmental preservation.

2 – The researchers devised three plans: two for each disciplinary approach (Natural Sciences and Physics and Chemistry) and the third one integrating a common approach to both disciplines.

3 – Selection and characterization of the cultural and socio-economic background of the students.

4 – Data collection.

5 – Analysis of the results (learning and students' reactions) using combined qualitative and quantitative methods.

6. Data collection and processing

The efficacy of each approach, in terms of the development of students' competencies and their reactions, were evaluated through the results of the tests (pre and post tests) and direct observation taking into consideration their interest and efforts (Table 3).

The questionnaire was adapted from Gandra [3], considering the contents under study and the school context in which it was applied.

The goals were to assess the development of students' competencies concerning the topic of *Improving Life on Earth* . The questionnaire was particularly aimed at testing discussion and problem-solving skills as well as their ability to become active and engaged citizens.

The questionnaire consisted of six questions related to the respective disciplines as well as non-disciplinary contents of an area of project called Guided Study and Civic Training. Following its adaptation, the questionnaire was validated by three specialists in Science Education.

We proceeded to a qualitative analysis of the teachers' journals to detect students' reactions to both methodologies. The quantitative analysis [1] concerned the pre and post test answers. We calculated the percentage of answers for each category and the average for all questions, before and after the implementation of the teaching unit, so as to compare treatment effects in both groups and define their reactions to the two methodologies.

Table 3. Objectives evaluated through the tests.

Topic/Concept	Objective	Question
Transportation (Integrated Knowledge)	Brainstorming on the advantages and disadvantages of using the different modes of transportation.	1.1
Environmental Preservation (Integrated Knowledge)	Taking on the role of a judicious and engaged citizen. Propose and justify solutions for solving environmental problems.	1.2
Pedestrians' safety in public roads (Problem-solving)	Solving everyday problems related to citizenship and road safety.	2
Average and instant velocity (Physical Sciences)	Distinguish average velocity from instant velocity	3 e 4
Effects of excessive consumption of alcohol in the human body (Natural Sciences and integrated knowledge)	Indicates the effects of alcoholism in the human body.	5.1
	Indicates the average alcohol level tolerated by the human body	5.2
	Relates the laws in effect with the consequences of excessive alcohol consumption on the human body.	5.3
Safety Distance (Physical Sciences and Integrated Knowledge)	Relates safety distance with the several factors that determine alcohol consumption.	6

7. Results

Table 4 presents the results from the treatment and control groups in all questions with the exception of question 2. In both groups, in all questions exceptuating 5.3.2, the results evolved successfully.

This evolution was, as expected, more considerable in the treatment group than in the control group, granted however that the former had a better starting point with regards to all categories in the questionnaire. In the control group, the reduction of the average percentage of "answers not scientifically accepted" was more pronounced from the pre to the post-testing. Progress was superior in all parameters (integrated knowledge, contents of Physical or Natural Sciences, problem-solving) in the treatment group.

Table 4. Average Percentage of answers to the questions in the questionnaire

Categories of Answers	Pre-test		Post-test	
	Treat ment	Con trol	Treat ment	Con trol
	% of replies		% of replies	
Scientificaly accepted	36	28	63	47
Incomplete	23	26	19	23
Not scientifically accepted	17	27	9	15
Not applicable	5	5	4	14
No reply	23	9	8	8

Another aspect that was taken into account was the qualitative nature of the answers. In question 1, for instance, while in both groups in the pre-test the questions (the correct ones) were centred only on issues related to "speed", "comfort and schedules", in the post-test, the treatment group in particular, brought forth more questions related to "environmental preservation" and "road safety". In question 2- not illustrated in table 4-, which addressed the assessment of competencies in problem-solving, the treatment group clearly reached much higher levels in the post-test. Some students reached the point of conclusive reasoning, while both groups in the pre-test had been limited to the level of prediction and identification of sources of research. This was the most visible accomplishment of the experiment. Nevertheless, the results obtained in the control group were also quite satisfactory.

According to the teachers involved in the experiment and considering the journal of the class, the control group was inevitably also somewhat exposed to the type of discussions engaged in by the treatment group. Both teachers could not limit the scope of some of the discussions given their relevance to the students' everyday lives.

8. Conclusions

Concerning the proposed objectives, we can conclude that the integrated approach was successfully implemented. The best results were achieved in the integrated approach compared to the disciplinary approach with regards to the development of competencies in integrating knowledge and problem solving.

9. Policy Implications

In light of the results presented in this study, we would recommend an integrated teaching of Science as proposed by the current Curricular Orientations [5]. One such vehicle of integration can be teaching based on problem-solving, given its impact on the development of competencies that are indispensable to deal with the challenges faced by citizens today as agents in a technological society. Education and inter-disciplinary understanding are therefore the pillars of progress for all.

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Practical Work to Promote Interdisciplinarity Between Physical and Natural Sciences: A Teaching Experiment with 7th Grade Portuguese Students

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Abstract. *The paper describes a teaching experiment carried out with thirty 7th grade students, in which practical work made possible an interdisciplinary approach between Chemistry and Natural Sciences.*

The practical work corresponded to the construction of a model of a volcano, under the topic volcanism in the discipline of Natural Sciences, and the topic chemical transformations in the discipline of Chemistry. We also present the evaluation of the teaching experiment taking into account the teachers' and students' point of views.

Keywords. Interdisciplinarity, practical work, teaching and learning of physical and natural sciences.

1. Introduction

Two main ideas are central to the Portuguese curricular reorganization of Basic Education initiated in 2001, including the subjects of Physical and Natural Sciences. The first idea concerns the attempt "to value the experimental learning in different areas and disciplines, [being] compulsory in the case of the teaching of science, to promote the integration of its practical and theoretical dimensions…" [2]. The second concerns the interdisciplinary approach to some topics and contents with the objective of "demonstrating the unifying character of possible themes, emphasizing phenomena that require scientific explanation from different areas of knowledge" [7].

2. Practical work in the teaching of science

The importance attributed to practical work in the Portuguese Science Curriculum is aligned with the main beliefs shared by experts in science education. A brief review of the literature on practical work in Science Education [11, 3, 5, 6, 10], can illustrate its importance. Practical work can motivate learning; develop scientific and analytical skills; enable an improved acquisition and comprehension of concepts; develop a solution-driven pragmatic mindset; develop discussion and critical analytical skills as well as introduce more rigor in Science Research. The issue of motivation is nowadays of particular concern [9], given that a significant portion of the students have little incentives to learn, exiting the schooling system prematurely. Therefore, the teacher should emphasize the emotional sphere and resort to experiments that go beyond simple and mechanistic implementations in order to become more fun and rewarding for the student. This value added in the emotional sphere can also represent a way to obtain better performances by the “least capable” students [9]. Reid and Hodson [9] explain that “this increasingly emotional response causes in itself a feedback movement leading to the accumulation of more cognitive abilities that can stimulate learning”. The goal is to engage students in interactive teaching methods, so that science can become real and relevant in their eyes. Hence, emphasis should be placed on activities in which students have a high chance of succeeding and in which they can interact and find meaning in their experiments.

The key concept is that of “motivation”, which can also take place through the curriculum itself. The latter should include three types of goals, in order of priority:

The first concerns the goals centered in the student such as overall motivation and the development of certain attitudes of self-esteem.

The second refers to the goals centered in society, enabling the framing of the contents through an interaction between science, technology and society. (stressing everyday issues, promoting an equilibrium between scientific/technological criteria as well as economic, ethical and social considerations).

The third concerns the goals that are centered in science, such as the knowledge and comprehension of scientific concepts and theories (the study and experience of phenomena); the acquisition of cognitive and psychomotor competencies (scientific practices, problem-solving); the development of a scientific attitude [9].

Together with the aforementioned potential for practical work, there are also critical perspectives with relation to how it can be conducted and consequent efficacy in teaching scientific concepts. Some authors [4, 3] consider that practical activities instead of promoting learning can sometimes promote conceptual misperceptions and thus become useless. Others [5], share the thought that in many classrooms practical training is mis-conducted, confusing and unproductive, thus contributing very little to science students’ learning. Others still [6] consider that in many situations, practical work is done in an excessively hasty manner, managing the equipment in a very carelessly, so that students fail in the production of the phenomenon they were supposed to observe. Moreover, even if that is not the case, the observed aspects may seem obvious to the teachers and not to the students. Therefore, practical activities can quickly turn into a routine with no objectives for the students. Rendering practical work more efficient requires the need to think carefully about the way it is going to be used as well as the type of activities that will be adopted given the objectives and the students it is aimed at. In fact, this recommendation is explicitly reflected in the Portuguese Basic Education Curricular organization when it mentions: “the experimental activity should be planned with students, deriving from problems intended for analysis, as opposed to the blanket application of a cookie cutter approach. All cycles of schooling must privilege the formulation of hypotheses and prediction of results, as well as their observation and interpretation.” [7].

3. Interdisciplinarity in science education

The definition of the role of Science in the Portuguese Basic Education Curriculum reinforces the idea that Science cannot be applied in a self-contained way, with contents that are detached from the real world. It should instead favor an integral and global perspective on Science [10]. Under this assumption, the curriculum should not be the sum of several parts but an articulated whole corresponding to an enriching dialogue between the different sources of knowledge that lie at its core. Herein rests the importance of a horizontal articulation of concepts, themes, contents and skills. In this context, the goal is for students to develop a more global understanding that goes beyond a limiting disciplinary approach. This fact requires information to migrate from other fields of knowledge, and for it to be reinterpreted in light of the problems that cannot be solved purely within the realm of classical disciplines. However, this is not to mean that as stated in the document about “curricular orientations”, that disciplinary individualities will not be respected. Instead, it enables teachers to organize their classes, or at least some of the contents, collaboratively. The goal is to expose the unifying content of possible questions, stressing the phenomena that require scientific explanations originating in different areas of knowledge.

Taking these ideas into account we conducted a teaching experiment in Physical and Natural Science, which corresponded to practical work through an inter-disciplinary approach.

4. The teaching experiment

The Basic Education National Curriculum, enacted in Portugal since 2001 defines 10 areas of general competency that should be developed during Basic Education. The first consists in "mobilizing cultural, scientific and technological knowledge in order to better understand reality and to address everyday situations and problems." All competencies foresee a transversal operationalization. As far as the aforementioned competency is concerned, the curriculum suggests an emphasis on: the context and the problem so as to encourage the student's involvement and curiosity; on questioning the observed reality; on identifying and articulating knowledge and information that can enable a better understanding of the situation or the problem at hand; on the application of the necessary procedures to understand reality and solve problems; on the assessment of the adequacy of knowledge and procedures used while adjusting when necessary.

Taking these suggestions into account, we conducted an experiment in teaching on the topic of "Earth under Transformation", which is shared by Physical and Natural Sciences.

4.1. Subjects

Thirty 7th grade students, as a class, participated in this experiment.

This is the year in which students start to study the subjects of Natural Sciences as well as Physics and Chemistry, under the Natural and Physical Sciences grouping.

4.2. Description of the experiment

During the first phase, the teacher of Natural Sciences approached the students with the topic of "Volcanic Activity: risks and benefits". The study began with a discussion of news of volcanic eruptions, some referring to historical events. Then, the teacher proposed that the students build a model of a volcano as practical work to explore the issue of volcanism (Fig. 1 and 2).

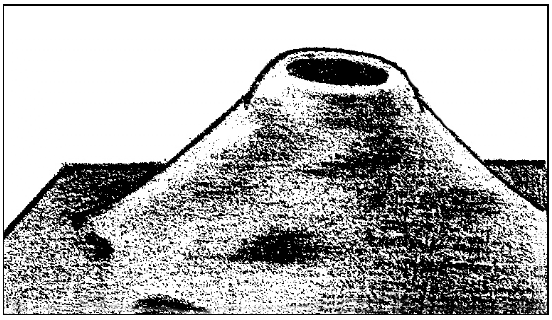

Figure 1. Model of the construction of a volcano

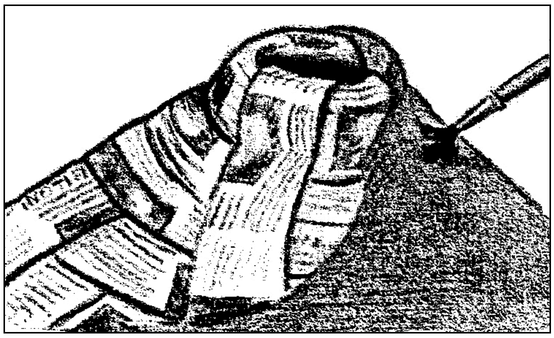

Figure 2. Final model of the volcano

Simultaneously, the teacher of Physics and Chemistry worked with students on the topic of "Chemical and Physical Transformations." In the realm of chemical transformations the question posed was: "How do some substances transform into others?". To solve this problem several day-to-day situations were analyzed and the practical work was undertaken.

During a second phase, a session of ninety minutes took place with both Natural Sciences and Physics and Chemistry teachers present. Teachers and students discussed the type of volcanic equipment as well as the type of volcanic eruptions and their main causes. They also simulated a volcanic eruption by using heated solid ammonia dichromate (Fig. 3), relating it to the study of the topic of chemical transformations and to the particular case of chemical transformations through heat.

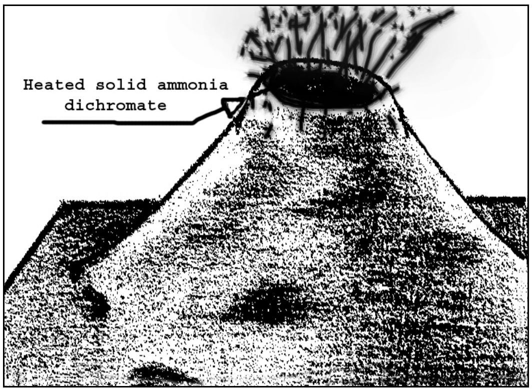

Figure 3. Simulating a volcanic eruption

In this context, both teachers and students used practical work as an opportunity to reflect upon, discuss and integrate knowledge.

5. Assessing the experiment

The techniques used to assess the teaching experiment corresponded to a direct observation of students while they worked in the classroom and responses to a questionnaire. One of the evaluations reported by a teacher, based on the perception derived from observing students, mentioned the following: "A brief and critical analysis of this experiment reveals very positive results. Firstly, not only for me but for the entire teaching body, the connection established between the programmatic contents of both disciplines was extremely important, due to a dynamic approach to both topics. As far as students were concerned, because they became active agents in the process of learning through the exploration, manipulation and observation of the phenomena, they achieved the objectives of the class and were able to adopt a critical view of the articulation of contents belonging to the different curricular areas".

The learning experience was valued by students and expressed in some of the answers given to the questionnaire. In response to the question: "Did you enjoy this experiment?", students stated that " It was fun because we were able to see - through chemistry - what happens in nature, without too much effort. The entire class was interested and that is always very good"; and that "Yes because it was different and we were able to picture moreless how a volcano works while learning Chemistry."

In response to the question – "Do you think that this strategy contributed to a better understanding of the contents of Natural Science and Chemistry?" - we obtained answers such as: "Yes, to some extent it did because it helped us learn chemical transformations much better as well as the "functioning" of volcanoes" and "Yes, because by connecting the disciplines we were able to better understand everyday situations".

Regarding the question – "If you had to compare this strategy to another one in which teachers would teach these contents separately, which one would contribute more towards your understanding of the materials?" - the students replied that "I think the strategy of integrated teaching is better. For instance, to understand Chemistry, we need knowledge of Science and other disciplines"; and that "I think that this strategy is better because it creates incentives for us to be engaged in these activities and understand the subject matter better".

The fourth question asked: "If you could influence your teachers regarding teaching strategies to use in the classroom, what advice would you give them given the experiment with volcanism?". To this students answered that "These activities should be more frequent" and "I would advise them to teach more practical classes and co-teach with other teachers when the topics overlap".

The last question, asked whether " a strong connection between teachers and disciplines was beneficial for students' learning", elicited the following responses: "Yes, because we learn more about a subject if different teachers are teaching it" and "Yes, because students can learn more concepts that can be applied to other disciplines".

All things considered, an analysis of students' answers reveal that they have developed a very clear perception of the importance of practical work and of a global approach to phenomena. This is evident when they allude to more practical classes and the need for more cross-disciplinary knowledge.

We strongly believe that this teaching experiment is very simple without requiring sophisticated equipment. It also represents an approach that enables students to investigate real world problems, relate them to their daily lives and better understand the phenomena they are confronted with in the mass media.

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Kolb's Experiential Learning Model: Enlivening Physics Courses in Primary Education

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Abstract. *Kolb's experiential learning model involves the group as well as the individual, stresses process as well as content, is active rather than passive, and emphasizes participant rather than instructor responsibility for outcomes. Kolb's model presents a way for structuring a session or a whole course using a learning cycle. The different stages of the cycle are associated with distinct learning styles. This paper discusses how Kolb's model can be linked to effective teaching in the primary education physics classroom. Following presentation of the model, an effort is made to apply Kolb's ideas to the phenomenon of evaporation.*

Keywords. Kolb's experiential learning model, primary education, the phenomenon of evaporation.

1. Introduction

The diversity of learning styles which characterizes student populations makes it necessary for teachers to constantly look for variety in the methods they use [1], [14]. The full involvement of students in the learning process could be achieved through active, rather than passive, learning approaches. Active learning, as opposed to passive learning, involves students directly and actively in the learning process. This means that instead of simply receiving information verbally and visually, students are receiving *and* participating *and* doing [11]. Active learning includes everything from listening practices which help students to absorb what they hear to complex group exercises in which students apply course material to "real life" situations or / and to new problems.

Numerous writers in physics education point out that active learning has many positive outcomes: it can enhance motivation, increase inquisitiveness, facilitate retention of material, improve classroom performance, and foster development of critical thinking skills. Furthermore, active learning promotes the personal relevance and applicability of course material to students and often improves overall attitudes toward learning [5], [7], [12], [13], [15].

Kolb's experiential learning model [8] is regarded as one of the best ways for both addressing diversity of learning styles and for engaging students in active learning approaches. Kolb's experiential learning model is used and recommended for use in a variety of disciplines [2], [4], [6], [10], [14]. However, there are teachers who are not aware of [4] or do not use or ignore this method of work [3], [14], and for this reason it is important to find ways of informing them as to how this strategy can be used in educational activities. The goal of this paper is to apply Kolb's model to the teaching and learning of the phenomenon of evaporation in the primary education physics classroom.

2. Kolb's Experiential Learning Model

In Kolb's model, the process of learning is divided into four stages, all of which must be gone through for learning to be most effective. A brief description of these stages follows.

Concrete experience provides the basis for the learning process. Lessons at this stage engage the individual personally and learning relies on open-mindedness and adaptability rather than a systematic approach to the situation or problem.

Reflective observation makes sense of the experience. In this stage, students consider their concrete experiences from a variety of perspectives and articulate why and how they occurred. Learning occurs as a result of patience, objectivity, careful judgment, and observation. Reflection helps students break their experiences into parts and to categorize them for use in the next stage of learning.

Abstract conceptualization assimilates and distills the observations and reflections into a theory or concept. In this stage, students come to understand the general concept of which their concrete experience was one example by assembling their reflections on the key parts of their experience into a general model. Abstract conceptualization requires students to use logic and ideas to understand situations and problems. Students can require considerable help from the instructor to proceed through this stage.

Active experimentation tests the theories and leads into new experiences. In this step, students use the theories they developed during the abstract conceptualization stage to make predictions about the real world and then act on those predictions. Students' actions, of course, are a new concrete experience. The learning cycle begins anew.

The key to planning lessons that take students full cycle is to note that the second word in each of the four stages' names indicates what the learner experiences. The learner begins by having an experience that involves him or her in a situation (experience) and then reflects on the experience from several perspectives (observation). From those reflections, the learner draws concepts or conclusions and formulates them into theories or models (conceptualization) that lead them to experiment or act (experimentation).

Kolb found that learners typically did not use all four learning stages equally, but preferred to concentrate on one or two of them. He identified four learning preferences, each of which shows learners being most comfortable in a different pair of learning stages. Based on responses to a set of questions called the Learning Style Inventory, Kolb described the four learner preference groups as divergers, assimilators, convergers, and accommodators. Understanding the preferences is critical to understanding how students may respond to lessons designed specifically for each stage.

Divergers prefer learning through concrete experience and reflective observation. They may be particularly adept at viewing a situation or problem from many perspectives and developing imaginative solutions. Assimilators favor abstract conceptualization and reflective observation. These individuals are often able to pull together very different observations into an explanation or theoretical model. Convergers learn best through abstract conceptualization and active experimentation. Their strength lies in the practical application of ideas. They tend to organize their thinking to use hypothetical-deductive reasoning to focus on specific problems. The dominant learning preferences of accommodators are concrete experience and active experimentation. Accommodators tend to be risk takers who thrive on action and new experiences.

Teaching techniques that provide opportunities for concrete experiences include experiments, observations, simulations, fieldwork, films, storytelling, jokes, cartoons, newspaper articles, examples, problem sets, taking a survey, or reading texts. Techniques that provide opportunities for reflective observation include logs, journals, discussion, brainstorming, thought questions and rhetorical questions. Listening to lectures, seeking out and critiquing models in texts or articles, building models and construction analogies, generating hypotheses, papers and projects draw upon abstract conceptualization. Doing simulations, case studies, fieldwork, homework, projects, conducting an experiment in the laboratory or in the field require students to engage in active experimentation [2], [4], [6], [8], [9].

3. An Application: The Phenomenon of Evaporation

The proposal which follows simply offers some basic guidelines on the content and techniques which could be used in each stage in order to successfully apply two sequences of Kolb's experiential learning cycle regarding the teaching and learning of the phenomenon of evaporation. The amount of time which will be made available for the completion of this process is a decision which depends on many and various factors such as number of students, length of teaching time, or total available time for the completion of the specific course.

Lesson 1

Stage 1: Concrete Experience

The teacher wipes a damp sponge across the chalkboard. The class should watch and notice the streak slowly disappear.

Stage 2: Reflective Observation

The students answer questions such as: Where does the water on the board go? What happens to puddles after it rains? Where does the water go? Have you ever seen clothes hung out on a line to dry in the sun and wind? Where does the water from the wet clothes go? The teacher writes on the blackboard the answers given by the students.

Stage 3: Abstract Conceptualization

The teacher with a view to showing the basic attributes of the phenomenon comments on students responses, emphasizes and retains significant points raised by them, but, also, if necessary, he / she adds information, which is scientifically important, but was omitted by the participants. The final product is copied on a flipchart for future use. In preparation for the next stage, the teacher provides guidelines as to how the students will find other examples of the phenomenon from sources such as the Internet or their everyday life.

Stage 4: Active Experimentation

The students find their own examples of the phenomenon.

Lesson 2

Stage 5: Concrete Experience

The students present to the class the examples they found.

Stage 6: Reflective Observation

The students point out and discuss similarities and differences among the examples presented.

Stage 7: Abstract Conceptualization

The teacher, following the discussion on the examples presented in the previous stage, makes comments on the strengths and weaknesses of the discussion. However, if important and representative examples were omitted, he / she will have to cover that gap. The information copied on a flipchart at stage 3 is available for reference purposes with all new information being promptly added. Finally, the teacher gives the students guidelines as to how to prepare themselves for the activities to be carried out at stage 8.

Stage 8: Active Experimentation

The students apply what they learned in previous stages through such activities as experiments or role-playing.

As can be seen from the above sequences, opportunities are provided for all four learning stages and that students with each of the learning preferences have the opportunity to use their preferred learning style and develop the other three. At each learning stage, students with the corresponding learning preference will excel. This has the dual benefit of allowing students to serve as role models for each other and of increasing individual students' self-confidence for learning the new skills. Students learn to value their own gifts as well as those of their peers. The Kolb model stimulates students regardless of their learning preference and challenges them to develop and build all the skills necessary for effective thinking and problem solving.

4. Conclusion

Two of the biggest challenges facing the contemporary teacher are to respond effectively to the diversity of learning styles which characterizes student populations and to successfully engage students in active learning approaches. This paper presented the basic characteristics of Kolb's experiential learning model and proposed a method of applying the model to the teaching and learning of the phenomenon of evaporation in the primary education physics classroom. However, beyond the phenomenon of evaporation, the proposal put forward in this paper may prove useful to other subjects in the discipline of physics, other physical sciences and even to life itself.

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Forms of Energy: Cooperative Learning in the University Classroom

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Abstract. *The present realities and the uncertain future regarding energy sources and use make the subject of educating people on this issue, a subject of paramount importance. If tomorrow's leaders are to be born in today's universities then university classrooms are probably among the best places we can use to prepare ourselves for the challenges ahead. This paper describes the use of cooperative learning activities in teaching and learning about forms of energy. Different ways of using cooperative learning activities are described along with reasons for implementing this type of instructional method. The paper also identifies the barriers that should be overcome in order to ensure success.*

Keywords. Cooperative learning, cooperative learning activities, forms of energy

1. Introduction

What will happen when the world can no longer rely on non-renewable energy sources, especially oil? Are we doing enough to take energy efficiency and conservation in our own hands? What should we do to confront the negative consequences of our excessive reliance on fossil fuels, such as air pollution, destruction of pristine areas, global warming and political and economic instability around the globe? What are the possible alternatives to oil? Can any of them or all combined fill the gap left by the depletion of oil? Are energy sources easily interchangeable? What are their advantages and limitations? Will scientists be able to think of solutions? How can we expand our alternative energy horizons?

There are no easy answers to such questions. Yet, we need to confront them. And if university students are tomorrow's leaders then the university classroom, along with the necessary techniques of student engagement, is most likely one of the best places to use. This paper attempts to tackle the concerns raised by the above questions by putting forward appropriate cooperative learning activities. Characteristics of good activities are followed by actual examples along with reasons for implementing such activities. The paper also identifies the barriers that should be overcome in order to ensure greater application of such methods in the University classroom.

2. What is cooperative learning?

"Active learning" is anything that students do in a classroom other than merely passively listening to an instructor's lecture. This includes everything from listening practices which help students to absorb what they hear to complex group exercises in which students apply course material to "real life" situations or / and to new problems.

The term "cooperative learning" covers the subset of active learning activities which students do as groups of three or more, rather than alone or in pairs. Cooperative learning is a structured, systematic instructional strategy in which small groups of students work together toward a common goal.

Cooperative learning is to be distinguished from another now well-defined term of art, "collaborative learning", which refers to those classroom strategies which have the instructor and the students placed on an equal footing working together in, for example, designing assignments, choosing texts and presenting material to the class.

3. Why Use Cooperative Learning Activities?

Use of cooperative learning techniques in the classroom is vital because of their powerful impact upon students' learning. Those who employ cooperative learning methods do so with a number of key assumptions in mind

- Learning in an active mode, e.g. in a small group, is more effective than passively receiving information, e.g. in a lecture setting.
- Participation in small group activities develops higher order thinking skills and enhances the ability to use knowledge.
- Accepting responsibility for learning as an individual and as a member of a group enhances intellectual development.
- Articulating one's ideas in a small group setting enhances a student's ability to reflect on his or her own assumptions and thought processes.
- Developing social and team skills through the give-and-take of consensus building is a fundamental part of liberal education.
- Appreciating diversity is essential for the survival of a multicultural democracy.
- Teaching and learning can be a shared experience between teachers and students.
- Teachers may be effective as facilitators of learning. That is, they can promote learning by being a "guide on the side", rather than a "sage on the stage" [8], [10], [11], [12].

As can be seen from this list, cooperative learning activities offer good opportunities to raise awareness on energy issues and foster the action needed to handle them.

4. Characteristic Features of Good Problems

The characteristic features of good problems are:

- They tell engaging stories in settings to which the students can relate, thus solidifying the eventual connection between theory and application.
- They are open-ended, challenging students to make and justify estimations and assumptions.
- They engender controversy or require decisions, so their solutions require students to demonstrate thinking skills beyond simple knowledge and comprehension.
- They are complex enough for students in each group to recognize the need to work together to succeed in arriving at a satisfactory conclusion [2].

5. Some Cooperative Learning Activities

There are over fifty forms of cooperative learning. Each has its appropriate application depending on the nature of the student population and the type of educational outcome to be fostered. Ultimately, each teacher must decide which of the cooperative-learning techniques to use and the relative amount of total in-class and out-of-class time devoted to cooperative learning [9]. Some examples of cooperative learning activities:

Scenarios. Scenarios are a way of analyzing today's choices from the point of view of the future. Scenarios are not predictions. Their utility as learning tools has to do with the fact that they help people visualize alternative situations and that they encourage the questioning of often deep convictions as to what is going to happen in the future [5].

The class is divided into groups of 5 or 6. When the groups are assembled they are told to elect a spokesperson who will be prepared to share the findings of the group with the class later on. This person should record the findings of each group.

The class is given the following scenario: A great explosion has occurred in the Middle East and all the known oil reserves have been wiped out there. Existing supplies in other parts of the world are in limited supply and are subject to governmental rationing. How will this situation affect: (a) the types of jobs you will be getting into; (b) relations with family members including parents and grandparents; (c) forms of recreation? [6].

True or False Questionnaire. This activity is especially useful when participants are likely to have major misconceptions about the topic(s). Some examples of such misconceptions:

“Alternative energy sources can readily replace oil”. “Alternative energy sources can simply be plugged into our present economic system and lifestyle, and things will go on as usual”. “Alternative energy sources are environmentally benign”. “There are no great problems in switching from one energy source to another” [14].

The teacher prepares a list of statements related to common misconceptions about the selected topic(s), half of which are true and the other half false. Copies of the list are distributed to the students. After students have responded to the questionnaire individually, they are asked to discuss their answers in teams of four or six. When the groups have finished the task the teacher reads the first statement aloud and asks the elected spokespersons from each group to announce their group’s decision and provide the necessary justification. If no satisfactory explanation is provided by the spokespersons the teacher provides it. The procedure is repeated with each statement.

Jigsaw Group Projects. In jigsaw projects, each member of a group is asked to complete some discrete part of an assignment; when every member has completed his assigned task, the pieces can be joined together to form a finished project. For example, after students have been divided into groups each student group could research a different form of power generation i.e., nuclear, fossil fuel, hydroelectric, etc. Then the groups are reformed so that each group has an expert in one form of power generation. They then tackle the difficult problem of how much emphasis should be placed on each method [13].

Panel Discussions. Panel discussions are especially useful when students are asked to give class presentations or reports as a way of including the entire class in the presentation. Student groups are assigned a topic to research and asked to prepare presentations. Each panelist is then expected to make a very short presentation, before the floor is opened to questions from “the audience”, which may be assigned various roles. For example, if students are presenting the results of their research into several forms of energy, you might have some of the other students role play as concerned environmentalists, transportation officials, commuters, and so forth [13].

6. Barriers to Cooperative Learning

While the activities described above might seem appealing, they often seem appealing for other instructors or other disciplines – but not for our own. The most common barriers to cooperative learning are the following:

Many instructors feel uncomfortable losing their role of being on center stage, performing in front of appreciative students. In using groups, the teacher’s role in class is more in the background, where they may observe, listen, and assist students when needed. They also take the role of questioners, asking members of the groups about their conclusions or solutions to problems, asking them to justify what they did and why [4].

Many teachers feel that if they use cooperative learning they will not be able to cover as much content in their lectures. Time spent in cooperative learning groups is time away from the lecture. Many instructors feel that they already have too much content to teach in the limited class time available per term [7].

Also, as a result of promotion pressures, many teachers avoid experimenting with their teaching, since any experimentation takes thinking about – thereby taking time away from their research and writing [1]. Regarding assessment of their staff, most universities and colleges tend to place more emphasis in the publication achievements of their faculty and not in their teaching successes.

Another barrier to the use of cooperative learning activities is student resistance. Students may not perceive the value of cooperative learning, they may be used to being told what to learn and how to learn it, they may not want the responsibility for their own learning, they may not appreciate that learning is ongoing, or the students’ environment may discourage the adoption of some ways of learning [3].

The above problems can be overcome. Academic administrators can help cooperative learning initiatives by recognizing and rewarding the efforts of those who adopt such methods. Instructors may cover less material through cooperative learning than with lectures, but subjects taught using cooperative learning result in content being learned at a higher level of mastery and being retained longer than it is the case with more traditional teaching methods. Further, the pleasure of watching students actively engage in solving problems is so exciting that it makes the time required for the effort seem like time well spent.

7. Conclusion

This paper highlighted the importance of cooperative learning theory in environmental education through the presentation of selected activities on issues related to different forms of energy. Planning and implementing may actually increase the workload of faculty but the rewards will be enormously satisfying. Through working together to learn conceptual information and master knowledge and skills, students learn more and develop many other skills, such as learning how to work with one another and how to handle a very important environmental issue. These are, after all, the ultimate aims of good pedagogy.

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CONNECT: Designing the Classroom of Tomorrow by using Advanced Technologies to connect formal and informal learning environments

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Abstract. *The main objective of the CONNECT project is to develop an innovative pedagogical framework that attempts to blend formal and informal learning, proposing an educational reform to science teaching. The project will create a network of museums, science centres and schools across Europe, to develop, apply and evaluate learning schemes by pointing to a future hybrid classroom that builds on the strengths of formal and informal strategies. The proposed approach will impact upon the fields of instructional technology, educational systems design and museum education. It will explore the integration of physical and computational media for the design of interactive learning environments to support learning about complex scientific phenomena. The project will be implemented on an advanced learning environment, the Virtual Science Thematic Park, developed upon emerging technology that will allow for ubiquitous access to educational and scientific resources. The CONNECT project will evolve through a systematic, multi-step assessment process involving the collection and interpretation of data. The current paper presents the project's framework, the initial ideas and the future plans of the consortium.*

Keywords. Formal/Informal Learning, Contextual Learning, Instructional Technology, Augmented Reality

1. Introduction

During the last decade some attempts have been made to evaluate the impact of efforts and investments made in Science and Technology Education worldwide, for example the Third International Mathematics and Science Study (TIMMS, 1994) and the Programme for International Student Assessment (PISA, 2000). These two large scale studies have explored the achievement and the attitudes towards Science and Technology (S&T) of the students' population in many countries of the world. The main findings of these studies are that the average achievement of the students' population is relatively low in most of the Southern European countries. Additionally while the vast number of students hold positive attitudes towards S&T at the early schooling stages (70-80% of the 4th graders in all countries), this situation is considerably moderated at the latest stages (8th grade). These findings suggest that the educational systems need to shift from the traditional paradigm of the teacher-directed learning and the dissemination of knowledge to the learner-centered curricula that promote the development of lifelong learners who can think critically, solve problems and work collaboratively (King, 1996). Sfard (1998) argues that learning becomes a process of discovery and participation based on self-motivation (informal learning) rather than on more passive acquaintance with facts and rules (formal learning). The importance of visualisation and of hands-on experiences as vital components to the learning process has also been stressed (Bransford et al. 1999).

From the beginning of the nineties there has been a considerable growth and development of the research on learning in science museums. Changes in accepted paradigms and definitions of learning have resulted in studies that point to the considerable richness of learning that have the potential to emerge from experiences in informal settings. There was widespread acceptance of the cognitive, affective and social value of experiences in museums and similar institutions (Rennie & McClafferty, 1996), and Falk and Dierking (1992) had drawn attention to the physical, social and personal contexts in which learning occurs.

Exploring the integration of informal learning experiences within the formal school curriculum could make an important contribution to the field of science education by helping students to develop critical capacity and deeper understanding of the concepts underlying scientific investigation. It will further provide students with first-hand experience of the ways that technology can both serve and inspire scientific investigation. This will later affect their career choices and will provide a scientifically qualified workforce (Falk, 1999). It will furthermore significantly enhance the learning of science for diverse and heterogeneous populations of future citizens, promoting the public understanding of science and the development of lifelong learners who can think critically, solve problems and work collaboratively (King, 1996).

2. The CONNECT Project

The CONNECT project [17] is a step towards an ambitious comprehensive educational reform, pointing to a future hybrid classroom that builds on the strengths of formal and informal strategies. It is an innovative approach that crosscuts the boundaries between schools, museums, research centers and science thematic parks and involves students and teachers in extended episodes of playful learning.

The CONNECT project is a joint initiative of pedagogical, cognitive science and technological experts, museum educators and psychologists, that research the possibilities of using advanced technologies for educational purposes. The CONNECT project develops an active learning environment the Virtual Science Thematic Park that functions in two distinct and equally important, from a pedagogical point of view, modes: the museum mode and the school mode.

The Virtual Science Thematic Park allows for ubiquitous access to educational and scientific resources and will incorporate all the innovative use of technology for educational purposes. The partnership aims at providing students with a variety of learning methods that will incorporate experimental, theoretical and multidisciplinary skills that will eventually enable them to become independent learners. The suggested educational scenarios include field trips (virtual and conventional visits to science museums and parks) that are tangential to the curriculum, pre- and post-visit curricular activities (including the use of internet resources), 'minds-on' experiments and models of different kinds into everyday coursework heavily involving 'real' remotely controlled experiments in the "student-friendly" and engaging environment of a thematic park or a remote observatory.

The working hypothesis of the CONNECT project is that the amendment of the traditional scientific methodology for experimentation with visualization applications and model building tools will help students and learners in general to articulate their mental models, to make better predictions and to reflect more effectively. The CONNECT project will take advantage of the fact that students enjoy visits to museums tremendously and that the resulting increased interest and enjoyment of science activities constitute extremely valuable learning outcomes that persist over time (Ayres & Melear, 1998). The CONNECT project will provide students with observations and experiments that have the potential of showing to them that some of their beliefs can be wrong; will create the circumstances where alternative beliefs and explanations could be externalized and expressed and design activities that give students enough time to restructure their prior conceptions.

2.1 Pedagogical innovation of the CONNECT project

The CONNECT project is developing a new science learning scheme by introducing a technologically advanced approach for teaching and learning and by connecting a wide range of learning environments (school, home, science museums, research centers, science thematic parks exhibitions) and bridging the theoretical and applied aspects of every day personal activities.

In order to learn science in meaningful ways students need to see connections to familiar problems relevant and important in their daily lives. Additionally, situated learning fosters the ability to transfer acquired knowledge to a variety of different situations. Situated learning is an essential component of acquiring the ability for self-organised and self-regulated learning. The schools of the CONNECT project will provide opportunities for the development of a competence to learn and an ability to be an autonomous learner in the future. This includes the development of meta-cognitive learning competences like e.g. elaboration strategies or learning strategies and their application and usefulness. The learning processes are embedded in communicative situations where teaching science offers good conditions for fostering communication and cooperation in students' experimental practices. For the content orientation the planned teaching topics are based on a broad field of knowledge and applications. The teaching sequences are built up in a way that student knowledge can increase and link, in other words be "constructed" by them.

The educational material and the adopted instructional strategies are tailored to the abilities and aptitudes of different types of learners. The development of the educational scenarios aims at providing materials and instruction that gives reality and concreteness to scientific concepts (Hofstein & Walberg 1994).

In the light of the above the "basic scenario principles" of the CONNECT project can be summarized as follows:

(a) Personalization: The learning tasks need to be related to the interests and background of a wide variety of different learners and facilitators and to built upon these individual differences, tapping into intrinsic motivation and providing opportunities for choice and control.
(b) Interactivity: The tasks should be "learner-centered" and should provide learners with opportunities to engage actively in the experience.
(c) Collaboration: Learning is often enhanced by collaborative efforts. The tasks should promote such collaborative learning, through opportunities for collective work on problems or challenges.
(d) Self-regulation: Teachers should help students to plan and monitor their learning, to set their own learning goals and to correct their errors.
(e) Authenticity. The learning tasks should be as real-world and authentic as possible.
(f) Learning Strategies: When possible, the learning tasks should employ effective learning strategies, e.g., the use of advanced organizers, the use of dynamic explanations, making explicit connections between visible and invisible phenomenon, making explicit connections between linked-phenomena which take place on different scales (micro vs. macro), etc.

Another important aspect of the CONNECT project is the promotion of ubiquitous access for students and teachers that will be able to access to the Virtual Science Thematic Park; to visit the exhibits and the experiments; the research laboratories and the advanced scientific instruments. Thereby science education will act as the mediator among people in different countries reducing at the same time prejudices and stereotypes and increasing social cohesion. The direct interaction with science or the doing of science reflect a fundamental pedagogy of the museum to provide learners with personal and direct experiences which can build upon in their own ways. Students will experience the phenomena presented in their own terms, freely choosing what to attend to and interact with, depending on their prior knowledge, interest and expertise. It is important also to note that in the science museums and science centres the exhibits and the related phenomena are embedded in rich real world contexts where visitors can see and directly experience the real world's connections of these phenomena.

Finally, a virtual learning community of learners, students, teachers, museum educators and researchers who are involved in the project has been created and will have the possibility to communicate and to collaborate via the CONNECT system.

2.2. Scenarios of Use

The Virtual Science Thematic Park requires the use of augmented reality tools which visually explain with the help of virtual objects projected onto the real setting the physical phenomenon manifested by an experiment inside the museum. By this way many "invisible" parameters in physical phenomena (e.g. forces, fields, waves, charges) will be visualised and presented in the eyes of the students augmented on the real experiments. Haptic feedback could add to the experience of complex physical phenomena. An example is the representation of Lorentz force in space. Other scenarios include, giving life to static exhibits by animating parts of it (e.g. the cloud creation in the water cycle, meteorological movements, tectonic plates movements, sea currents, the propagation of sound waves, etc.) or performing on-line astronomical observations (Sun movement, planets and stars, solar and lunar eclipses, etc.) with the use of a robotic telescope. Furthermore, wearable systems will provide an additional wealth of information, linked to dedicated databases.

The add-on of the augmented exhibit, compared to a conventional exhibit, is that the students wearing the CONNECT system have at their disposal additional wealth of information. The real exhibits are mixed in their optical view with the 3-D visual objects and representations that the system is producing and embedding into this augmented world through their glasses. In this way all the important parameters of the experiment, all the abstract symbols, which are normally represented in drawings after the experiment, can be visualised. This interactive hands-on experience is recorded on the students' wearable computer for later use. The next day at school (post visit procedure) the students are sharing their personal experience of the visit to the museum with their fellow classmates by projecting it onto a video screen. The fellow students will be able to make a virtual visit to the museum and follow a different tour or make different choices to the same tour through the Virtual Science Thematic Park. Various collaborative activities (discussion forums, mini-projects, writing reports etc) follow the visit in order to provide students with the necessary time and the appropriate tasks to better understand the new information

3. Expected Impact

The goal of the CONNECT project is to redefine the conceptual framework of education, by designing learning environments and implementing pilot experiences that use state-of-the-art digital technologies. Such environments would encourage reflection and collaboration and draw their pedagogical value from the cross-over between education and entertainment.

The CONNECT approach will impact upon the fields of instructional technology, educational systems design and museum education.

- In the field of instructional technology, our research will examine alternative instructional systems that attempt to blend informal and formal learning and to situate learning in real-world contexts.
- In the field of educational systems design, the CONNECT Virtual Science Thematic Park represents an example of designing new systems from the ground up. As such, it may inform current burgeoning theory in the process of educational systems design and in systems theory-such as the SIGGS theory (King & Frick, 1996). Additionally, the CONNECT approach will provide information for one of the key processes of educational systems design, transcendence: it will create knowledge regarding a new class of alternative schooling that will be informative to future educational designers.
- In the field of museum education, the CONNECT project will correct three deficiencies that are restricting current reform efforts to expand the educational role of museums: the limited number of model programs, the absence of a body of professional literature, and the lack of contact with the broader field of education. Indeed, the CONNECT project provides a framework for a closer and more effective collaboration between museums and schools, while keeping intact the strengths of these different educational environments. By describing and analyzing the functionalities of the virtual thematic park and by creating operational terminology, the CONNECT projects aspires to guide the design of future museum-school collaborations and to document efforts that seek to bring the worlds of formal and informal learning closer together.

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Teaching for Conceptual Change in Science Laboratory

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Abstract. *In this paper, I will present a conceptual change instructional model in laboratory settings based largely on the conceptual change model initially proposed by Posner, Strike, Hewson and Gertzog in 1982 and also incorporating fundamental tenets of Vygotsky's constructivism and Papert's constructionism.*

Keywords. Conceptual change, conceptual change model, Vygotsky's constructivism, Papert's constructionism.

1. The theoretical origins of the conceptual change model

The conceptual change model is based on the Student-As-Scientist metaphor, on Thomas Kuhn's description of scientific revolution [7] as well as on Piaget's notions of adaptation and organization.

1.1. The Student-As-Scientist metaphor

According to the Student-As-Scientist metaphor, students have strong similarities with the scientists.

Students possess alternative frameworks that often differ from those of scientists and that are coherent, robust and difficult to extinguish. *"The term "alternative frameworks" indicate that students have developed autonomous frameworks for conceptualizing their experience of the physical world"* [2].

The Student-As-Scientist (SAS) metaphor reject a type of cognitive development that has been characterized as "global restructuring", that is, changes in the structure of thought brought about by child's logical capabilities (e.g. Piaget's stage theory). The Students-As-Scientist metaphor accept that *" there are no across-the-board changes in the nature of children's thinking"* [4].

The SAS metaphor is compatible with Carey's domain-specific theory of cognitive development *" According to this view children begin with a few theory-like conceptual structures (e.g. a naïve psychology and a naïve physics) that, though restructuring, give rise to new theories (e.g. biology, economics, a theory of mechanics, of heat, etc.). This type of restructuring is conceptualized as a product of the child's increased knowledge of a domain (brought about by the child's experience and/or by instruction), rather than as the result of child's logical capabilities per se)"* [12].

1.2. Thomas Kuhn's description of scientific revolution

Kuhn divides scientific activity into two distinct categories: normal science and science revolution.

According to Kuhn, normal science means research firmly based upon on a dominant paradigm that some particular scientific community acknowledges for a time as suppling the theoretical framework for further practice.

Science revolution occurs when the scientific community puts away the existing dominant paradigm and adopts another one. According to Kuhn, a science revolution is very likely to take place when two condititions coexist. First, a dominant scientific paradigm fails to provide solutions or explanations to significant problems identified by the scientific community. Second, an alternative paradigm with the potential to solve these problems is available.

1.3. Piaget's notions of adaptation and organization.

Piaget believed that people have an innate need to be at a state of cognitive balance or equilibrium between their understanding of the world and their experiences.

1.3.1. Organization

In response to this need of equilibrium humans have the natural tendency to organize their experience into related, interconnected structures. The most basic structure is the scheme. Schemes are the building blocks of thinking [5]. Organization is the process of forming these schemes.

1.3.2. Cognitive conflict

We say that humans are in cognitive conflict when their understanding of the world can't explain their experiences.

1.3.3. Adaptation

Humans maintain equilibrium through the adaptation process. Accommodation and assimilation are both part of the process of adaptation. Accommodation and assimilation function together and are complementary to one another.

Accommodation is a form of adaptation in which the existing mental structures are modified and new are created when new experiences does not fit into existing schemes.

Assimilation is a form of adaptation in which new experiences are incorporated into previously existing schemes.

2. The conceptual change model

2.1. The analogy

According to Vosniadou [13],
"*Posner, Strike, Hewson and Gertzog drew an analogy between Piaget's concepts of assimilation and accommodation and the concepts of "normal science" and "science revolution" offered by philosophers of science as Kuhn and derived from this analogy and instructional theory to promote "accommodation" in students' learning of science".*

2.2. Four conditions of conceptual change

These researchers derived from this analogy the following conditions that need to be fulfilled before conceptual change can happen:

(i) There must be dissatisfaction with a currently held conception.
(ii) The alternative conception must be intelligible.
(iii) The alternative conception must appear plausible.
(iv) The alternative conception must appear fruitful.

2.3. Central concepts of the model

The central concepts of the model are status and conceptual ecology.

The status that a conception has for a person is determined by its intelligibility, plausibility and fruitfulness to that person. Thus, the more intelligible, plausible, and fruitful an idea, the higher the status.

Conceptual ecology comprises all knowledge and beliefs that a learner possesses.

2.4. Critisisms of the model

According to Vosniadou [13], the conceptual change model described above *"became the leading paradigm that guided research and practice in science education for many years but also became subject to a number of criticisms that have not yet been answered".*

Pintrich, Marx, and Boyle [8] argued the conceptual change model put too much emphasis on the rational and, neglected affective and social issues of conceptual change. Furthemore, it does not consider how other participants in the learning environment influence the pathways from students' pre-instructional conceptions to science conceptions.

Strike and Posner [10] suggested that affective and social issues affect conceptual change.

2.5. Success of conceptual change model in science education

According to Guzetti and Glasss [6], the research findings show that *"Despite recent self-criticism of their earlier positions (Strike & Posner, 1992), the genre of instructional strategies described earlier by Strike and Posner (1985) that produces dissatisfaction with current conceptions and shows the scientific conception as intelligible and applicable, has been effective".*

3. Fundamental notions of Vygotsky's constructivism.

3.1. The More Knowledgeable Other (MKO)

The MKO refers to someone who knows more than the student, with respect to a particular task, process, or concept.

3.2. The Zone of Proximal Development (ZPD).

Vygotsky [14] defined the ZPD as *"the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers"*.

3.3. Scaffolding

The MKO and the ZPD form the basis of the scaffolding. Scaffolding is the process of guiding the student from what she already knowns to what is to be known

3.4. Piaget vs Vygotsky

According toThomas [11], some central problems to the cognitive development are the following

"(i) Are changes in cognitive ability domain-general or domain – specific?
(ii) Are there qualitatively different stages or is change gradual and smooth?
(iii) Is development just learning or does something change in the brain to make children cleverer.
(iv) Is development "genetically controlled"?"

Vygotsky and Piaget approach these central questions from a different point of view.

Piaget viewed cognitive development from biological perspective. Piaget's stages theory is a domain-general theory. He argued that development is affected by both environment and genetics and the stages of cognitive development are qualitatively different.

Vygotsky viewed cognitive development from historical and social perpective and *"does not deal with fixed stages of development but describes "leading activities" typical of certain age periods around which intellectual development is organised"* [11].

Unlike Piaget who maintained that children's development must necessarily precedes their learning, Vygotsky argued that effective learning is the learning that precedes development.

Vygotsky agree with Piaget learners must be active constructors of their knowledge and development is stimulated by cognitive conflict.

4. Papert's constructionism

According to Bruckman and Resnick [3], *"The term "constructionism," first coined by Seymour Papert , involves two types of construction. First, it asserts that learning is an active process, in which people actively construct knowledge from their experiences in the world. (This idea is based on the theories of Jean Piaget.) To this, constructionism adds the idea that people construct new knowledge with particular effectiveness when they are engaged in constructing personally-meaningful products. They might be constructing sand castles, computer programs, or virtual objects. What's important is that they are actively engaged in creating something that is meaningful to themselves and to others around them."*

5. A conceptual change instructional model in laboratory settings.

5.1. Describe the experiment

5.2. Probe students alternative frameworks with predict-observe-explain tasks

(i) Ask each student to record an individual prediction on the handout sheet.
(ii) Ask the class to engage in small group discussions in order to decide on a group prediction.
(iii) Ask each student to record a final prediction on the handout sheet.

5.3. Create a cognitive conflict

Students or the teacher carry out the experiment. Student must encounter a problem which she cannot easily solve by herself, but which, she can solve with carefully structured help from the teacher or a more able peer (scaffolding) [1]. Student must reconcile any conflict between prediction and observation.

(i) Ask each student to record what she sees happen on the handout sheet.

(ii) Ask each student to record an individual explication on the handout sheet.

(iii) Ask the class to engage in small group discussions in order to decide on a group explication.

5.4. Encourage and guide restructuring

Teacher presents the scientific explication. He must show it is intelligible, plausible and fruitful. Students must construct their own knowledge. Conceptual change will occur only if the status of scientific conceptions is higher than the status of students' pre-instructional conceptions. The process from srudents' initial models to scientific models is gradual (through synthetic models [13]) and time consuming.

Students and teacher construct something that others will see, critique, and perhaps use (i.e. simulations, powerpoint presentations) to express their conceptions (constructionism).

5.5. Encourage metacognition

Metacognition means "thinking about your own thinking". Students must encourage to reflect how they explicated the experiment, what they found difficult about it, what sort of reasoning they used, what sort of help they needed, and how they sought help [1].

5.6. Encourage bridging

Discuss analogous physical situations. The sort of reasoning students developed in the laboratory context must be bridged to other contexts [1].

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Science Process Skills in Hands-on Science Activities

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Abstract. *This study intended to give information about teachers' opinions on science process skills in hands-on activities. For this purpose, a qualitative case study was performed in two elementary schools, each of which is implementing different programs. The reason to select these schools was to understand whether the teachers' opinions on hands-on activities differ according to the curricula. This is the second aim of the study. The first school is an ordinary school whereas the second is designed for gifted students, aims to nurture them as the future scientists and artists of Turkey.*

Keywords. Hands-on science, science process skills, teachers' opinions.

1. Introduction

As it is known science process skills are the skills and knowledge students use in scientific inquiry, whereas hands-on science activities help students to understand the science phenomena while manipulating the objects. The instruction which bases each method makes the students active. Science process skills of inquiry activities include the skills of observation, classification, measurement, interpretation of data, formulation and testing hypothesis, and experimentation, etc (Temiz & Tan, 2003).

On the other hand, hands-on activities develop students' observation, hypothesis, inference, prediction, and experimentation skills (Willison, 1996 as cited in Hardal, 2003). In addition to these developed knowledge and skills, inquiry and hands-on activities help students to gain positive attitudes toward science.

As summarized beforehand, the research studies on hands-on science activities have found that students' cognitive, psychomotor and affective characteristics improve as they engage in these activities. However no such study focused on how teachers develop hands-on activities considering science process skills in mind was found.

This study investigated teachers' opinions about science process skills mentioned in hands-on science activities. For this aim, a qualitative case study was done with elementary teachers from two Turkish elementary schools, each of which is implementing different science programs, representing each case. The first school is using the current science curricula, whereas the second is in fact a science and arts centre in an elementary school. Science and art centers (SAC) are for education of gifted children (Gokdere et al., 2003 as cited in Gokdere & Cepni, 2004) and their teachers are selected from the teachers who are successful at the oral exam taken after a seminar.

The reason to select these schools is whether the participant's opinions on hands-on activities differ according to the curricula implemented. This is the second aim of the study, because each curriculum expects teachers to use different methodologies to achieve the outcomes predetermined by the Ministry of National Education in Turkey. It can be said that the first school is close to student-centered education. On the other hand, the third institution is designed for gifted students, aims to nurture them as the future scientists and artists of Turkey, and as it is thought does not have a corresponding place when we considered its philosophy in terms of the continuum of student- and teacher-centered education.

This study intended to give information about what teachers think about science process skills mentioned in hands-on activities, how these opinions differ from or resemble to each other. Additionally it was expected to understand how curricula make a difference in the way teachers think about science process skills mentioned in hands-on activities.

2. Literature Review

There are several factors that influence science teaching: It has been stated that the system and school context of curriculum control science teaching practices mostly in negative way (Appleton & Kindt, 1999).

Another factor affecting science teaching is lack of science teaching resources. This could result in a topic not being taught, determine how a topic was taught or determine the actual activities children engaged in (Appleton & Kindt, 1999).

3. Methodology

Two classroom teachers from one elementary school and two science teachers from a science and art center were interviewed after the semester was over with respect to their opinions on science process skills in hands-on science activities and the aim, content, materials and evaluation of the activity.

The limitation of the study was triangulation, use of other data sources, since the schools were closed and in summer holiday, we only interviewed with the teachers.

Data analysis required reading of the field-notes that taken during the interviews. It started with predetermined list of coding, determination of more broad categories and ended with interpretation of phenomena being studied. Moreover the cases, two institutions, were compared with each other and conclusions were done.

The analysis of data was given as subtitles in the results section.

4. Results

4.1. How teachers see hands-on activities?

The teachers of elementary school stated that they see the hands-on science activities as either a concrete material to be done by the students or a cause and effect relationship developed in the students. For example, in the activity that included making a tape measure and measuring length was stated by these teachers as a concrete material, whereas another activity which involved falling of an iron and a plastic balls from the same height was seen by these teachers as an activity cause and effect relationship.

On the other hand, the teachers of SAC see the hands-on activities as an opportunity to make the students love science.

4.2. How science teaching resources effected implementation of hands-on science activities?

For especially the elementary school science program, it can be said that text-books serve as teacher materials because hands-on activities included in these resources (in fact, the interview with these teachers were made according to the hands-on science activities found in the text-books).

However for the SAC science program, the teachers stated that they should find the hands-on science activities, since there is no text-book to use.

4.3. How program effected implementation of hands-on science activities?

The teachers of elementary school use both the program and the text-books in implementation of hands-on science activities.

On the contrary, the teachers of SAC stated that they use the subjects outlined in the gifted education program they used in their center. As they stated, the program begins with Adaptation, goes with Support and Individual Abilities, and ends with Project. When we interviews with them, they were doing Support education, therefore they selected activities suitable to this subject, but considering their own subject areas. For example one of the teachers, originally a chemistry teacher, said that she made “acid and base in foods” activity, while another teacher, originally a biology teacher, preferred her students to watch a n educational CD showing experimental researches that studying adaptation of animals to changing environment.

4.4. Which science process skills addressed in hands-on science activities?

The teachers of elementary school made use of observation, inference, measurement, experimentation in hands-on science activities.

On the contrary, the teachers of SAC stated that they made use of observation, classification, measurement, experimentation, inference, application and generalization in hands-on science activities.

5. Conclusion and Suggestions

This research showed that the degree of science program on teachers' use of hands-on activities is considerable important.

Affective characteristics of teachers should be studied by future researches. Self-confidence, sense of self-as-teacher, for example as stated by Appleton & Kindt (1999) is a factor that influences effectiveness of science teachers and the topics and teaching style they choose.

Textbooks should serve as a good teacher and student reference and detailed information about science process skills.

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Contemporary Scientific Concepts in Primary Schools: A Test Case on the concept of Systems.

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Abstract. *One crucial parameter of the effectiveness of Science and Technology teaching in schools, especially in Primary schools is the syllabus. The modern approach and contemporary scientific concepts are missing, one reason quoted to this being that the children cannot understand them. In this work we test this excuse using the concept of systems. The results from a test teaching in a primary school show that, properly taught, complex concepts may be well understood by children.*

Keywords. Systems, Science Teaching.

1. Introduction

The importance of Literacy in Science and Technology (STL) as a basic parameter for the welfare of modern, technology dependent societies has been repeatedly stressed. The effective teaching of Science is an important parameter towards this end and many works have been appeared, mostly on a constructivist approach some also focused on the scientific inquiry approach [1]. However, to our opinion, a crucial parameter towards an effective Science and Technology Literacy, the syllabus content, seems to be ignored. Not only contemporary concepts and modern scientific achievements like systems and chaos, fuzzy logic, etc, are missing from the school Science syllabus but also the century or more old concepts of the theory of relativity and quantum mechanics [2], stochastic processes, etc. only superficially make a hit to the school program [1]. Possible (excuses and) causes of may be:

a. The general trend of Science achievements paths into the school program is a "top-down" process; a new research concept finds its way to post-graduate studies, sometime later to undergraduate studies, then to high school, to medium school and, hopefully, into primary school. Mostly, this is done as an add-on separate theme of a technical descriptive nature without any real integration into the syllabus, a very detrimental way towards the understanding of Science, especially if a new apprehensive of the natural phenomena is introduced. This may explain the absence from the school syllabus of the (very) new scientific achievements.

b. Teachers in schools and the influencing other educators having lost their contact with recent developments in the field either they are not aware or they do not understand achievements they had not been taught during their studies. This is a very serious problem and it may explain the absence from the school syllabus of themes like the theory of relativity or quantum mechanics. This cause together with the artificial add-on nature of the syllabus build-up referred to in **a.** above, may provide an alternative explanation to the general belief that "children think in an Aristotelian way", quite often supported with field data [3].

c. Children are not able to understand new concepts which scientists have to spend a lot of time to understand. This seems to be a "self-evident" statement but it bears no factual support. On the contrary there are field data indicating that what is perceived as a difficult subject for the students it really reflects difficulties of understanding on the part of the teachers.

In this work we test this last cause (or excuse). To this end we have chosen the concept of systems. This choice was made on the following reasoning:

d. The concept was more familiar to the teacher and consequently any possible effect of **b.** above was minimized.

e. The word system is a commonly used word in many expressions of everyday life; consequently we expect many preconceptions from the students. As a result, a successful teaching intervention will show clearly, even with a relatively small sample.

f. Characteristics of systems, e.g. relations between different parts of a system are included as factual knowledge in the school syllabus, for example (some) relations between constituents of an ecosystem. Consequently the students, who, in a Piagetian context, have not as yet reached the stage of formal logic, are not faced with a concept totally abstract to them.

2. Methodology

Students of the 5th grade (11 years of age) of the 2nd primary school of Souda bay at the prefecture of Chania were used. All field activities were effected during school year 2004-05 by N. Kountourakis from the authors of this work, who was also the teacher of the students. Souda with a population of 8.000 is located about 6km from the city of Chania; in the area operate 3 primary schools, one middle school, one high school and a higher vocational school for merchant marine. Souda is a major naval and merchant port. In its area there are also flour and cattle feed industry. Near the school of study a small lake ecosystem with herons and other aquatic birds is located.

The whole work was organized in the following steps:

Step 1: A questionnaire with 4 parts (A, B, C and D) was created:

A. Questions related to their profile (sex, overall mark during the previous year, education and occupation of the father and of the mother),

B. Questions related to their ideas on the concept of a System. The specific questions and their type were chosen so as to trace different levels of understanding and include:

- Have you heard the word system (closed question with choices yes, no, do not know)
- Could you write some expressions you have hard including this word (open question)
- Give some examples of systems (open question)
- What do you think a System is (open question)

C. Which of the following words do you relate with the notion of system? Words used: clock, stereo sound system, refrigerator, water, reading, lemon tree, human being, soccer team, state (country), PROPO (a game of chance to predict the results of soccer games), wood (of trees). Choices for each word: it relates, it does not relate (to the notion of system). Each of these questions was chosen either because it is used in everyday expressions together with the word system or because they may be considered as systems according to the school syllabus (see **f.** above). This question is considered useful to the interpretation of the findings on the previous questions.

D. To trace their understanding on the interrelations between parts of a system, the students were presented with an island as a closed (eco)system with cultivations, wood of different trees, and a variety of flora and fauna. Then they were presented with different scenarios and asked what the influence of each scenario would be on soil, on flora, on mice, on wolves, on humans (choices for each system constituent: a/influenced, b/not influenced). Again, related references may be found dispersed in the school syllabus. The scenarios used are:

- The soil is polluted with chemicals,
- A fire destroys the cultivations and the wood,
- A disease eliminates almost all the deer.
- The Humans eliminate all wolves.
- The Humans abandon the island.

Step 2: A test run with 4 students of the 6^{th} grade (age 12) followed by interviews was effected in order to check the validity of the questionnaire and get some insight from its application especially on matters of clarity of the specific phrasing used.

Step 3: Twenty two questionnaires were filled by (all the) students of the 5^{th} grade (age 11) of the school (13 girls, 9 boys). An open discussion followed to get some insight on the reasoning behind the specific answers given.

Step 4: Based on the filled questionnaires and the discussion followed, a teaching intervention on the concept of Systems was organized along two axes:

- The concept of a 'System', as a complex with interrelated parts.
- The 'systemic thinking' as the (extent of) interrelations between the different parts of a system. The aim was to advance further from the simple direct interrelations with reasoning of the form: constituent x influences constituent y, constituent y influences constituent z, consequently constituent x influences also constituent z (indirect influence).

Note. We must stress that in a Piagetian context, the students in this age are mostly in the concrete (and towards the formal) operational stage able (mostly) to one parameter (direct, one to one) relations. Consequently, the expectations here should be limited.

The teaching, based on constructivism, was done one month after the collection of the questionnaires in two parts one week apart. It was followed by homework during the Christmas – New Year recess.

Step 5: One month after the teaching, a new questionnaire was given to the same students. Its structure was similar to the first one with the following differentiations (compare with **C** and **D** referred to previously):

Part C: For every one of the following words explain if it may denote a system or not. Words included were: clock, water, reading, human being, soccer team, state (country), TV set, Car, nettle (a plant in abundance in the area), brick, lake, cat, a pack of wolves, and a village.

Part D: Students were presented with two systems and different scenarios and asked to tell what will happen on different scenarios and why. The two systems were:

- A lake with aquatic flora and fauna, turtles, herons, fishermen and hunters. Scenarios were: toxic chemicals are discharged into the lake, a large hunter fish is introduced into the lake by the fishermen, the authorities ban fishing and hunting in the lake.
- In our small city Souda (see the first paragraph of this section) what would be the effect on the grocers, the 'rent a room' owners, the school-students, the police force, and the school-teachers in the following scenarios: a/ the two industries are shut down, b/ a (new) University is established in the city.

The first case corresponds to the 'island' system of the pre-test. The second case is a more complex system on a concept (our city) which is scarcely considered in common life, even less in school teaching, as a system. It was put to test if the teaching intervention was successful on the understanding of systems and interrelations between their parts. In both cases, this time students were asked also to explain their answers, a step which in the pre-test it was replaced with the open discussion of the answers given.

3. Results

The data collected are still analyzed; however prominent conclusions are already emerging and we present them in brief.

General comments.

- The profile of the sample is representative of the Greek school students.
- Although the questionnaire was very careful phrased, some questions were not clearly apprehended by some of the students. For example, influence was mostly understood as diminishing (in numbers) or as a negative (on values) notion despite the oral explanations.
- Similarly a result that was considered as a wishful result it was not conceived as an interrelation. For example in the second system of Part D above, although many students recognize that the income of the grocers or the 'rent a room' owners will probably be increased, they do not consider it as an 'influence' because this is a desirable (positive) outcome.
- These problems restate a fact known also in other specific on this issue studies that in this age many of the students do not master the written language in full. Consequently, although the difficulties on the correct understanding were not to a significant extent, the interviews (and/or the open explanations) seem a necessary compliment to the questionnaire.

On the concept of System.

From the pre-test it seems that the majority of the school students perceive the notion of system as something repetitive or something planned or at least involving human action. For example:

- 'Reading' was considered as a system by 17 of the 22 students because 'it has to be planned systematically'.
- 'Water' was quoted as system by 14 out of the 22 because it was related to the

house water supply or to the irrigation system or because of its repetitive cycle of evaporation-clouds-rain-sea, rivers and lakes (a subject they already have been taught in the previous years). None quoted it because it is composed by hydrogen and oxygen, a subject they already have been taught

This inference is enhanced by the examination of the response to other questions. So, although the lemon tree and the human person have both been taught as complexes with different interrelated parts, only 6 out of the 22 perceive the lemon tree as system, in comparison with the 18 out of the 22 quoting the human body as a system. Even more, only 4 out of the 22 related the wood tree as a system despite the obvious multitude of trees and their teaching of the wood as a specific ecosystem.

However only 4 of the 18 related their answer to the different parts of the human body, the rest justifying their answers along the lines '… humans act, plan their actions'. The lemon tree was related as a system not because it is a complex but because its repetitive cycle of flowers-lemons. Those who did not related the wood tree and/or the lemon tree as a system justified there choice because '… the lemon tree and the wood tree do not act on purpose …'. The students who related as a system the lemon tree but not the wood explained: '… lemon tree yes because every year it produces lemons we eat while the wood no because we only cut wood…' and '… the wood no because it is trees sprang out by chance …'.

The results of **Step 5** (the post-test) show a remarkable improvement. More than one month after the teaching intervention 16 out of the 21 (one student was absent) not only are able to state a correct (working) definition of 'system' but they also explain their associations to the notion of a 'System' as a complex of interrelated parts. On the other hand, only 11 out of the 21quote (on question 1) also at least one of the examples they gave in the pre-test as a 'system', a remarkable improvement although it still indicates 'resisting ideas'. Also, 20 out of the 21 consider the human body as a 'system' because it has constituent parts. This result may not be due to the memory of the specific on this discussion because the 21st refused the human body as a system '… because it is a whole not composed of parts'. Similarly the cat was considered as a system by 16 out of the 21. Of the rest 5 remarkable is one contempting explanation '…when the cat suffers who is affected?'

On the systemic thinking

The data from the pre-test indicate the validity of Note referred in **Step 4.** earlier. Students' thinking is limited to direct, one parameter relations. For example, on the scenario of chemical pollution of the soil, of the 22 students, 21, 10, 11 stated an influence on the plants, the mice and the wolves correspondingly. Some explanations on the non influence: '… mice are used to polluted environment e.g. the drainage system', '..wolves do not lay on the soil..', '… mice and wolves do not eat plants …', etc.

Similarly, to the scenario of fire, the corresponding quoted relations were 22, 11 and 16. Some explanations on the non influence: '… mice and wolves can move away' and other similar to the previous ones.

To the scenario of deer elimination, the corresponding numbers were 5, 4 and 17. Explanations for the non-influence include: '… plants are different from deer and they will not catch the disease..' (limitation to one – the more prominent - factor), '… wolves can smell the sick deer and they will not eat them…'.

To the scenario of the elimination of wolves the corresponding answers were 3, 2, and 20. Some explanations: '… wolves do not eat plants (so the plants will not be affected)', '… plants may increase a little because the wolves will no more step on them'.

It is evident the one parameter and the direct only relations thinking of the students. This conclusion is enhanced by the observation that during the discussion, on commenting the question what will happen to the deer if the wolves are eliminated the students stated that they will increase so they will eat more plants which will start diminishing, however they had not related this in the test.

Interesting is also the explanations to the scenario 'the Humans abandon the island'. There will be influence to the plants, the mice and the wolves quoted 18, 9 and 10 (out of the 22) students. Some explanations: '.. the plants will diminish because the area will remain uncultivated… the plants will not be watered so they will run dry and die..', mice will be affected because they are fed on the food remnants of Humans', mice and wolves will not be affected because they will feed on other means'. It is remarkable that mostly the (one parameter – one way) thinking is around human activities only and focused on food. May be because the most extensively taught relation (and almost all of the examples given) on the ecosystems is focused on food. Also, in the previous 4 years, within the context of the course 'Study of the Environment', they are taught repeatedly and almost exclusively the Environment in relation to human activities and needs only.

The data on the post-test are still being analysed, especially in comparison with the pre-test data. The analysis is complicated more because of:

- The reason stated as a Note in **Step 4** previously,
- The small sample and the limited teaching intervention for an, otherwise, complex subject.

Preliminary results show that, in general, there is an improvement towards systemic thinking but it is not clear if this is consistent and systematic or circumstantial. However, at least 5 students (>20%) show a clear evidence of advance to a two step indirect relation similar to the example given earlier as objective of this teaching intervention. This rather high figure indicates that a more thoroughly planned teaching intervention may have still better results.

Conclusions

Our small scale study shows that:

- The concept of 'system' is well within the abilities of the 5^{th} grade school students.
- The situation with the development of systemic thinking is not so clear. Based on the fact that the 5^{th} grade school students, in a Piagetian context, are advancing from the concrete to the formal operational stage, we hypothesize, that systemic thinking is also within their abilities and that a more thoroughly planned teaching intervention may provide more evidence to this. The fact that of the 5 students who showed a clear evidence of advance towards a systemic thinking the 4 were girls (who mature earlier) combined with Vygotsky's [4] context of the Zone of Proximal Development reinforces our choice.

In any case our basic objective that we should put under the test of empirical evidence the general belief that 'children are not able to understand new concepts which scientists have spent a lot of time to understand' has been validated, at least partially.

4. Notes and References

[1] See a review in P. G. Michaelides, "State of the Art of Science Teaching" invited lecture, 1st International Conference on Hands on Science: Teaching and Learning Science in the XXI Century, 5-9 July 2004, Ljubljana, Slovenia, proceedings, pp. XX-XX

[2] George Kalkanis 'Which (and How) Science and Technology Education for Future Citizens?', pp. 199-214 of Vol. II of the proceedings of the University of Cyprus, '1st IOSTE Symposium in Southern Europe – Science and Technology Education: Preparing Future Citizens', Paralimni-Cyprus 29/4-2/5 2001.

[3] Similarly, it was found that Greek school students in Greece, German, Greek and other nationalities school students in Germany share the same ideas on Heat, inconsistent with their teaching, despite their different social origin. These were the ideas based on the concept of the 'caloric fluid' very prominent some centuries ago and considered as an example of Aristotelian thinking. A closer investigation showed that these conceptions were most probably originated from the non rigorous and simplistic phrasing of the textbooks (G. Vlachos, Investigations of the Ideas of Greek and German school students about Heat and Effect of Teaching, PhD Dissertation, Rethimno, Crete 2002- in Greek).

[4] Lev Semyonovich Vygotsky (November 17(5), 1896—June 11, 1934). Born in Orsha, Belarus now. Studied Law and Medicine in the Moscow University. He died of tuberculosis. His first works were on Literature and Poetry. An essay he wrote at the age of 18 on Shakespeare's Hamlet was used later to his writings on Psychology. In contrast with Piaget his work's context was that intellectual development is not a process of the individual but a function of the interaction with the society. His works were banned for long time and rediscovered by the so called West at the 60's.

Applying Concept Map to develop a new Technical Writing technique for enhancing Reading Comprehension performance

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(ISX and method for improving reading process)

Abstract. *In today dynamic information technology era, technical documents are becoming bigger and are updated frequently more than ever. As a result, people have to spend a huge mount of time and efforts to digest these technical documents.*

Although the traditional technical writing technique helps to produce cohesive and easy-to-be-understood technical documents, it does still suffer the essence problems of the prose text such as language ambiguity and ineffective key concept manipulation.

Nevertheless, interestingly, these problems can be solved effectively by concept map technique. Because of its 2-dimension spatial concept representation, concept map can help to limit the language ambiguity problem, to manipulate the concepts effectively, and to enhance reading comprehension performance.

The research described in this paper aimed to propose a new more effective technical writing technique by applying concept map. The research used some basic experiments in psychology and many examples to demonstrate this proposal.

Keywords. Concept map, technical writing, spatial text technical writing, reading comprehension, language ambiguity.

1. Introduction

Technical documents especially computer technical documents are developing dramatically in information technology era nowadays. As a result, people have to spend a huge mount of time and efforts to digest these ever-increasing technical documents. This research is about how to represent effectively the text in the technical document so that readers can perceive easily and efficiently that technical document.

The research first investigated the essence of reading comprehension process. Then, the research discussed the technical writing technique which is currently a method for producing the good usable technical documents in disciplines such as science, engineering, business, industry, etc. Technical writing forces writers to use simple accurate words and good format layouts to create the good technical documents.

However, because of its word-after-word prose text representation, technical writing still got some problems of the traditional prose text such as language ambiguity and inefficient concept manipulation. Concept map, which has the 2-dimension spatial text representation of a network of concepts, can help to solve these problems. Thus, it can be seen that concept map has a potential to replace the technical writing technique in producing efficient technical documents.

Unfortunately, concept map technique is used to map only key important concepts and is not used to map every word in a whole document. It means concept map diagram is only used to support the prose documents; it is not used to replace the prose document. The main reason is that the graphical representation of every word in a document is impossible because of concept map limitations such as diagrammatic messiness, time and effort consuming, etc.

Hence, this research proposed a new type of technical writing that applies the spatial representation characteristics of concept map. This new technical writing technique is called “spatial text technical writing” (STTW). STTW inherits some logical symbols in knowledge representation in Artificial Intelligence and can resolve the limitations of concept map. STTW can have ability to map the whole technical document. STTW takes the advantages of the usefulness of concept map and technical writing. STTW relies on the STTW grammar which is the formula for representing spatially the English sentences based on the grammar structure and parts of speech.

The research used a variety of reasonable examples to demonstrate the ability of concept map as well as STTW in reducing the language ambiguity problem and facilitating concept manipulation. Besides, the research also used some very basic experiments in psychology to demonstrate the ability of concept map in helping human to perceive the information quicker.

2. Reading Comprehension

[1] emphasizes that Reading is a complex multilevel interactive process between readers and the material. Firstly, to be able for a reader to understand a sentence, the reader has to understand the word, the syntax and the semantics of that sentence.

Secondly, their previous knowledge is very important in reading. Many students feel it difficult to digest the new knowledge because of their lack of prior knowledge [2].

Thirdly, the context is very important in reading comprehension. If the text is taken out of context, the incomplete understanding will happen. The meaning of language is insufficient to convey the knowledge of the world. Language, thus, is only a vehicle to take us to understand the world. Language is not the world knowledge itself [3].

Next, another important aspect of reading comprehension is the concept manipulation. Reading is dominated by a cognitive manipulation of the concepts. For example, when you are reading a book, you often turn the pages back and forward many times to see how the concepts or ideas in the book interrelated to each other. However, many students are not supported by a good strategy for manipulating the concepts in the text that they are reading [2].

Finally, if the text has an implication, readers have to deduce or draw inferences, form a hypothesis to understand what the text is going to talk about in a bigger context [1].

3. Language Ambiguity

Ambiguity is a common feature of linguistic expressions. Something is ambiguous when it can be understood in two or more possible senses or ways. If the ambiguity is in a single word, it is called lexical ambiguity. If the ambiguity is in a sentence or clause, it is called structural ambiguity [4].

For example, the word “Overlook” got the lexical ambiguity. “Overlook” can be signified as “inspect” (look carefully), or “miss” (look carelessly).

The reference lexical words such as “the”, “this” and “that” can be very ambiguous. For example, “Tom rushes into the room. He grabbed a cake. He should not do that”. We don’t know whether “that” refers to “Tom rushes into the room” or “He grabbed a cake”.

These are examples of structural ambiguity:

-Liz attacked the man with a knife (“Liz attacked the man who had a knife, or Liz used a knife in her attack on the man”), “with a knife” has a direct structural relationship with “attacked” or with “the man”. Other words, “with a knife” modify “attacked” or modify “the man” [5].

-They talked about the disaster on the train (“on the train” modifies “the disaster” or modifies “talked”).

4. Technical Writing

“Technical writing is writing, apart from advertising and public affair writing, that effectively communicates all aspects of technological work in applied science, engineering, business, and industry” [6].

. Technical writing helps to create good documents. Good documents save time and energy for readers. Poor documents can cause confusing, more information that readers need, irrelevant information, & too much jargon [7].

Limitations of technical writing

Although technical writing attempts to create the good prose documents with good syntaxes and simple vocabulary, it still suffers the limitations of the word-after-word prose documents. Technical writing forces the writers to produce the good technical prose documents which have a rigid word control mechanism. Good technical documents are less ambiguous than the prose documents which do not use technical writing method at all. Good technical documents use simple rigorous structure and thus can somehow help readers to reference and manipulate the key ideas. But it does not mean that we can solve thoroughly the language ambiguity and inefficient concept manipulation problem in good technical documents. Language ambiguity and inefficient concept manipulation still do exist in the good technical documents.

5. Concept Map

What is concept map? "A concept map is a graphical representation of knowledge of a domain. A concept map consists of nodes representing concepts, objects, or actions, connected by directional links defining the relationships between nodes. A node is represented by a simple geometric object, such as an oval, containing a textual concept name. Inter-node relationship links are represented by textually labeled lines with an arrowhead at one or both ends. Together, nodes and links define propositions, assertions about the domain" [8].

Concept Map was first developed by Joseph Novak and his research students in 1970s at Cornell University [9]. In 1984, [10] published a book "Learning how to learn" in which they presented a full discussion of this technique.

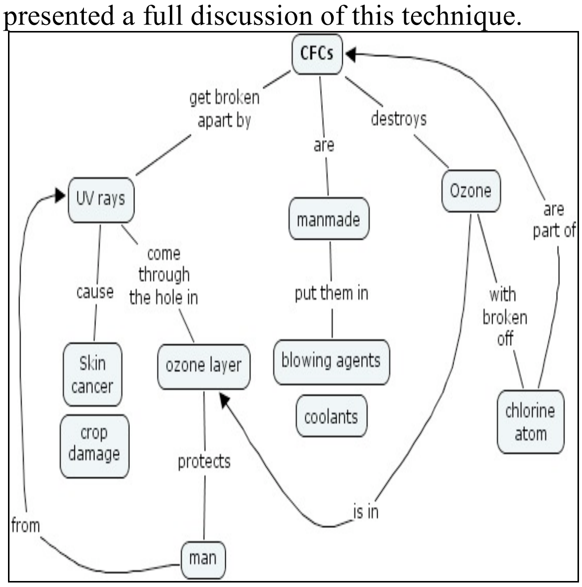


Fig. 1. A concept map is done by eighth-grade student [11].

Currently, concept map is used for checking understanding, planning the instructional curriculum, encouraging critical thinking and creative thinking, facilitating brainstorming, etc. For example, students are required to convert a paragraph to a concept map for checking their understanding. Concept map can help to limit the language ambiguity, facilitate the concept manipulation, and perceive the information quickly. Concept map is often applied for the structured documents in science, chemistry, nursing, etc areas which require representing the relationships among concepts consistently, logically and firmly [12]. Technical documents also require a rigorous structure and thus it can be utilized using the concept map technique.

However, up to now, concept map is only used to support the understanding of the prose structured documents. It means people haven't used concept map to replace completely the prose structured documents. To replace the prose structured documents, concept map has to do an enormous work that is "mapping every key concept and word in every sentence in the whole structured documents". This can be feasible if mapping a few-page document. However, this will be impossible if the documents have a hundred of pages even with the support of concept map software.

There are 6 reasons to explain why concept map is not used to map the whole document. These reasons are the diagrammatic messiness, time/effort consuming and the slowness of concept map software, lack of concept map standard, loss of the goodness of linear sentence-after-sentence document, and inability of representing all English grammar structures:

First, mapping the whole document can be impossible because it can create a huge messy concept map. A very messy concept map is not usable in practice [13].

A messy concept map can be a danger for readers because readers can forget reading some links that are not seen easily. On the contrary, if you have already read all the sentences in a prose document, you will be sure that at least you already read all of them whether you understood them or not.

Second, mapping the whole document (even with the support of Concept Map software) can consume a lot of time and effort because the mappers have to create a lot of links to connect logically all concepts together [14].

Thirdly, because the current concept map software use the drag-and-drop graphical components, a very big concept map can make the Concept map software run very slowly and heavily.

Next, there is no standard for drawing concept map at this moment. The formula for drawing a concept map is rather arbitrary and relies on the creativities of the mappers. For example, the linking word sometimes is a noun, sometimes is a verb, sometimes is a whole sentence, etc. This can make many people feel it hard to understand a particular concept map [10].

Besides, although the linear sentence-after-sentence representation of the prose documents can make it hard for readers to read due to the little spaces among words of the text, the linear prose documents got a goodness that concept map does not have. That is the sentences in the prose document can be organized in a logical sequential order. For example, in an instructional document, the sentences that represent the most basic and easiest knowledge are often discussed first before the difficult ones. However, we can not get that goodness of prose text in the concept map. When we read a concept map, we can not see clearly a logical sequential order of propositions (a proposition in concept map is equivalent to a sentence in the prose text). This is because the spatial text representation of concept map makes readers to capture the meaning as a whole rather than as a logical sequence order. Concept map is often used to represent the propositions which have a highly independence.

Finally, concept map only represent the propositions of the regularity of the facts, events and objects [15]. However, concept map is seldom used to represent the conditional sentences (IF), comparison, relative clause sentences, and other English grammar structures. This is the main reason why concept map is not used to map all sentences in the prose documents.

Hence, to be able to map the whole document, we need a new type of concept map (a new type of technical writing applying concept map) as well as a software that underlines that new concept map. These are the requirements to solve the 6 problems mentioned above.

First, the new type of technical writing has to:

- still inherit the traditional concept map's goodness which includes both minimizing the language-ambiguity and facilitating the effective concept manipulation at the highest level. These benefits are the central points of concept map because they can help readers to speed up their reading comprehension process.
- be un-messy no matter what size the concept map is.
- be easy to be drawn with a lowest effort and in a shortest time.
- adhere a single rigorous standard.
- still keep the goodness of linear sentence-after-sentence documents. That is the propositions should be arranged in a logical sequential order if necessary.
- be able to represent all English grammar structures.

Second, the software that underlines this new technical writing technique should be simple, flexible and easy to be used. Developing a technical document using the new technical writing technique on that software should be as easy as typing a prose text on a word processor. This special software should limit the drag-and-drop graphical components as much as possible in order to be run gently.

6. Applying Concept Map to develop a new technical writing technique

[14] asked an important question for concept map researchers "If maps or other spatial representation can be used for review or can capture the key concepts and relationships in discourse, why should not students learn directly from the map rather than the text?"

The hypothesis of my research is that we can apply the Concept Map to develop a new technical writing technique which is much more effective than the traditional technical writing technique.

The prose documents and even technical documents often got the language ambiguity and inefficient concept manipulation which can slow down the reading performance of readers. Traditional technical writing tries to somehow limit these two problems in technical documents, but it is not as effective as concept map. Concept map can limit the language ambiguity, and facilitate the effective concept manipulation ([16] & [2]) at highest level.

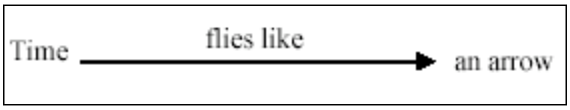
Because the essence of concept map is to link key concepts together, the ability of concept map for facilitating the effective concept manipulation is already clear [2]. We will, now, focus on the ability of concept map for limiting the language ambiguity. However, surprisingly, few researches discuss in details about this ability of Concept Map.

6.1. The ability of Concept Map for limiting the structural language ambiguity

As mentioned in section3, a sentence can have structural language ambiguity.

For example, "Time flies like an arrow" can be understood as "Time(S) flies(V) like an arrow" or "Time flies(S) like(V) an arrow". S stands for subject and V stands for verb.

By applying concept map, we can represent the above sentence as:

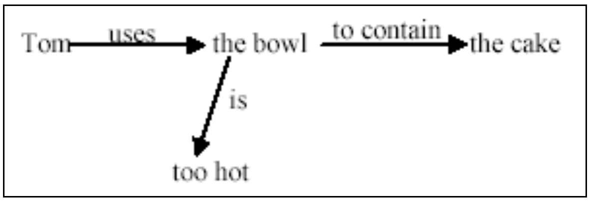


Or

By represent a sentence spatially like this, it will limit the structural language ambiguity because the readers can quickly figure out which word is subject and which is the verb.

Concept map also limits the structural ambiguity across many sentences.

Example: "Tom uses the bowl to contain the cake. It is too hot." (What 'it' refers?). This sentence can be displayed in Concept Map as following:



6.2. Spatial text technical writing (STTW) as a new technical writing type

To response to the 6 problems that prohibit a concept map to map the whole document in the section4, I attempted to propose a new technical writing type which I temporarily call it "spatial text technical writing".

STTW grammar

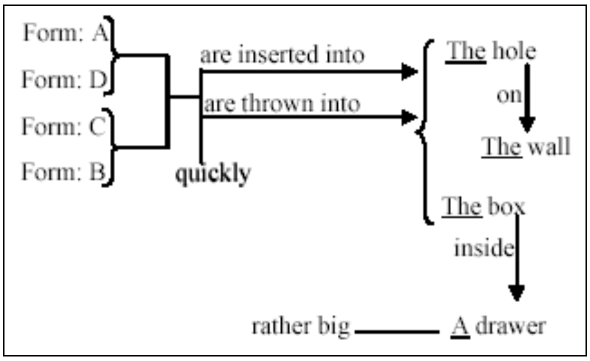
STTW grammar explains how to represent spatially English sentences subject to the English grammar syntax. In STTW:

The verb is represented by sitting on a single arrow just like we did in the concept map. The arrow direction goes from subject to the object in a sentence. If the preposition stands between the verb and the noun, the preposition and the verb should sit on the same arrow. However, if the preposition stands between 2 nouns, that preposition will sit on the arrow linking the 2 nouns.

The adjective is represented by a straight line that connects the adjective to the noun which that adjective modifies. Adverb is also represented by a straight line that connects the adverb to the verb which that adverb modifies. This helps to limit structural ambiguity.

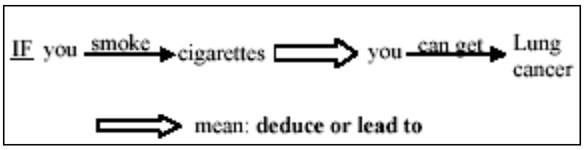
For the Coordinator "AND" and "OR", I adopted to use symbols { and [of logical language. It is because these logical symbols are must more effective in representing the meaning correctly.

Example, "form A and form D or form C and form B are inserted or thrown quickly into the hole on the wall and the box inside a rather big drawer" is displayed as following.



Besides, we can use big arrow to present the deduction for the conditional clauses (IF) and causative clause (Because). This big arrow idea is came from the symbol → of logical language, but its shape was changed to avoid miss using with other arrow symbol which is used to represent the action verb in a sentence in my STTW technique. The symbol → of logical language means "IF…Then". Thus, "a → b" means "if a existed, then b will happened" [17].

For example, the sentence "If you smoke cigarettes, you can get lung cancer" should be represented as following:



7. Conclusion

The major thrust of this research has been to examine the potential of applying concept map technique to develop a new technical writing technique. Concept map is actually a useful method for people to accelerate the reading process. Concept map helps readers to overcome the language ambiguity problems and to manipulate effectively the concepts in the prose text. People can capture the knowledge in the concept map quickly because concept map is very intuitive and attractive. However, the current concept map technique has many limitations that can prohibit this potential happened. These limitations are diagrammatic messiness, time and effort consuming, the slowness of concept map software, lack of concept map standard, loss of the goodness of linear sentence-after-sentence document, and inability of representing all English grammar structures.

The research suggested a spatial text technical writing (STTW) technique which applied concept map and adopted some logical symbols in KR. The research used many useful examples to demonstrate that STTW can be used to represent the text, particular technical document, effectively and unambiguously.

However, STTW should not be seen as a final solution. This research's main point is to stimulate other researches to think about applying concept map for writing spatially the whole documents.

Besides, the research also pointed out the limitations of the current concept map software such as inflexibility and slowness because the software used heavily the drag-and-drop graphical components. So, a new effective software underlining STTW should be developed in the future. This new software for designing technical documents should be easy-used and run gently.

Finally, if we can develop a technique and software that can help us to enhance the reading comprehension performance of technical documents, we will solve a big problem of human nowadays that is how to digest the technical knowledge in a shortest time and with a lowest effort.

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Interdisciplinariness in the Curriculum of the nursery school: An example of thematic approach of the key concepts 'evolution'

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Abstract. *Unified Cross Curricular Syllabus Framework and Programs for the planning and developing activities for nursery school, taking into consideration the current scientific perceptions about the nature of Sciences, aims at the unification of these with the Technology, the Society and the Environment.*

The Cross thematic approach the development of key-concepts and the projects are the methodological approaches which are proposed for this goal. The validity of the approach of a specific key-concept of the Sciences, depends on the possibility of the small child to feel by himself the examined theme, in cooperation with peers. It also depends on the relationship and the meaning that this theme has for the personal development of the child and for the prosperity of the society as well.

The purpose of the present speech introduction is to study the approach of a such key-concept in the nursery-school. Specifically it presents an example of approaching the key-concept "evolution". This example was organized in a nursery school in Athens and functioned as a link for the horizontal interrelation of different subjects, such as

Math, Language, Environmental Studies, etc., achieving by this way the Cross thematic approach.

Keywords. Evolution, cross thematic approach interdisciplinariness, pre-school curriculum.

1. Introduction

The Curricula constitute formulated proposals which refer to the content and form of school learning, to the way in which the learning should be organized and to the procedures by which the learning should be gained and exploited by the students. Their role is important in the educational process since they constitute the "tool" which the educator employs daily in activity and guides the education to the development of the type of person which every society desires.

The aim of the Kindergarten – according to the Unified Cross Curricular Syllabus Framework and Programs (ΔΕΠΠΣ) [6]– is the fully fledged development of the child's personality. This can be achieved when in the learning process emphasis is given not only to the acquisition of Knowledge, but also to the acquisition of skills, the development of feelings and the cultivation of positive attitudes and predispositions. The pre-school program includes "contents" from different cognitive fields, such as information, concepts, facts, accounts, formats, etc. This Knowledge can be obtained through the formulation of an environment which creates incentives towards active participation of the child in the process of learning, towards the revelation, experimentation, and preservation of his/her interest and systematic teaching and correct guidance of the nursery teacher.

Further prescribed is the cultivation of various techniques (cognitive, kinetic, ect), the development of feelings, which are favored in an environment where continual interaction is observed and the cultivation of predispositions and attitudes, which can be formulated and empowered through activities suitable to infancy.

The aim of the new curriculum for the pre-school is the creation of citizens who are equipped with self-awareness, social sensitivity and the necessary social skills. These aims relate directly to the way in which infants employ scientific knowledge so that they can take the appropriate decisions and the way in which they confront and resolve problems they encounter in the course of their lives.

The new pre-school curriculum aims at the integration of the Physical Sciences, Technology, Society and Environment. The validity of teaching of a particular concept depends on the abilities of the infant to act out the same and to live out in cooperation with peers the phenomenon under study, and the relationship and the meaning which this phenomenon or meaning has for personal development and for the broader social well-being.

An important constructive parameter-tool for the discussion of natural concepts is the involvement of language. As Sutton also claims, experimental procedure can never "speak by itself", but the words which use are the necessary cultural interpretative tools which contribute to the production of social meanings [5].

The adoption by the educator of ways and methods which presuppose the active participation of the child in the entire learning process and the planning and realization of activities which aim at the fully fledged development of the children, present the characteristics of a development program which helps the children to start their school lives successfully, a fact which can decisively influence their subsequent lives.

The thematic approach, the implementation of fundamental or interdisciplinary concepts and the work schemes constitute the proposed methodological approaches in the Unified Cross Curricular Syllabus Framework and Programs (ΔΕΠΠΣ) [6] for the kindergarten.

The thematic approach (which we will adopt for the present) constitutes an organized programmed experience of learning which gives the children the ability to approach an intergraded view of knowledge linked with a particular topic[3].

The organization of activities which is linked to different cognitive and development sectors around one topic gives the children the ability to be aware of the global dimension of knowledge to link together different experiences and to be trained in a way of working which is peculiar to scientific working. [2]

2. Interdisciplinary and the fundamental concepts

Concepts constitute intellectual constructs with which the individual categories and names entities, processes, situations and phenomena based on their essential features [4].

Every totality of concepts constructs the content of a scientific field. Each science carries its own knowledge, concepts, generalizations, methodological approaches and skills which are exercised in the particular science and which people employ in their attempts to comprehend and manage matters.

Nevertheless there is also a very broad category of concepts, like for example the concepts *system, interaction*, which can be employed in every scientific field or cognitive area, in a great variety of topics. It is a question of so-called fundamental concepts or Macro-concepts [4].

These concepts can constitute a theme of study in order that their basic definitions be displayed and the modifications which exist as they transfer from branch to branch. They could even be employed as a context of investigation of interdisciplinary or domestic concepts of the separate branches.

In the interdisciplinary approach learning is organized in a way which leads to an interrelation between different cognitive objects or cognitive fields. In this way an integration of the content of teaching is a achieved, which is realized in specific methodological approaches. Interdisciplinary knowledge does not come to supersede or to abolish the intradisciplinary knowledge, but to consolidate, extent, and deepen it and to make known the linking elements of the different cognitive fields.

It is necessary therefore for us to search out the main intradisciplinary elements, the concepts of the cognitive fields and to see the way in which they can transcend their own framework and compose the holistic authentication of matters. The role of concepts is essential in the way in which this transcendence takes place. When we elaborate a topic we initially locate the intradisciplinary or domestic concepts of the specific scientific field to which the topic under investigation belongs. Subsequently we speculate on ways in which we can extend them to the other cognitive fields. These extensions must not be fortuitous or fragmentary. The intradisciplinary concepts can be correlated with the fundamental ones. With the fundamental concepts as vehicle we pursue the horizontal interweaving of different fields, attaining in this way the interdisciplinary approach.

Through the exploitation of concepts the child can penetrate with thought the level of simple information and understand more deeply what we want to "teach". With the systematic development of concepts in the framework of the content of teaching and learning and the cultivation of the faculties of systematization of knowledge and its acquisition, the students can incorporate the new information in an integrated construct of knowledge and deepen it. [1]

3. Model of thematic approach to the study of the key-concept 'evolution'

3.1. Learning field of opportunity: Study of environment: Natural environment and interaction
3.2 Topic: In the age of the dinosaurs
3.3. Organization of class: All the children in the class.
3.4 Comment: Dinosaurs are a favorite subject for all children. Often children bring to their class little plastic toy dinosaurs which are on the market and which they love to play with. Moreover occupation with the topic serves also the goals of the Curriculum.
The educators encourages the children to express thoughts, knowledge and motions about dinosaurs, which are taken into consideration in the planning of the activities.
3.5 Occasion: The occasion could be a film relating to dinosaurs/a book/ a visit to a museum/games on the market, etc. The occasion influences the method of approach to the topic and the formulation of questions directed towards the children.
_What was the film or the book;
_What were the dinosaurs like;
_How did you feel when you saw the dinosaurs;
_What were their names;
_How big were they;
_What colors were their skins;
3.6 Previous experiences of the children: Encouraging the children to speak the educator poses questions:
_What can you tell me about dinosaurs;
_What animals are similar to dinosaurs;
_ In what environment did the dinosaurs live;
_Tell me some characteristics of dinosaurs.
_What do dinosaurs eat;
_In what age did the dinosaurs live;
_Why did the disappear;
_In what museums can we see dinosaurs;
3.7 Learning targets:
■To broader their knowledge about dinosaurs.
■To get to know and to reveal similarities and differences between dinosaurs and other animals as regards:
_Their habitat
_Their external characteristics
_Their food
_Their way of reproducing
■To recognize the need for food and air for survival.
■To begin to become aware of food relations between different organisms.
■To discuss and understand that there were categories of animals which lived in older periods and do not exist nowadays.
■To understand the interaction between the environment and the activities of Man, to locate problems and to seek reasons.
■To compare the present with the past and distinguish changes.
■To understand the chronological sequence of events
■To make use of technology
■To express themselves in art forms.
■To familiarize themselves with seeking information form sources.
■To familiarize themselves with the recording and organization of information.
3.8. Interdisciplinary concept: evolution
The concept of biological evolution and particularly its integrating role in nature, provides answers to fundamental questions which relate to the world around us: Similarities between organisms, biodiversity, etc. The concept of "evolution" in the specific unit about dinosaurs refers to the evolution of life on our planet. The concept of evolution which embraces continuity and change-elements which investigate the process of evolution of living organisms, and also of cities, villages-constitutes a major concept for the Study of the Environment and relates to the broader, fundamental concept of "change". This concept transcends the limits of the study and can function as a link for the horizontal interweaving of different learning fields, achieving in this way the interdisciplinary approach.
Interdisciplinariness: Language, Mathematics, Study of Environments, Technology, Speculation, Dramatic Art.
Proposal units: The diagram with the units serves to restrict the topic to easy approach units which are linked to the planning and development of activities, and also as a guide for the valuation of the thematic development after valuation.
Duration: One month. The children's interest is taken into consideration.

Topic presentation packet: Printed material, books, objects related to the topic, addresses of related web pages, ideas for linking home with kindergarten.
Kindergarten information file: Concerns information from reliable sources, statistical data and other useful knowledge about the topic.

3.8.1 Group and individual creative activities

The activities which follow are characteristic and have an interdisciplinary nature. They aim to assist the kindergarten in understanding the manner in which it approaches a topic linking different cognitive fields. Each pre-school teacher with a view to the knowledge, imagination and interest of the children could extent it to various other activities.
Investigations in corners organized suitably for this purpose:
a) Dramatization Corner: The educator leaves at the disposal of the children material related to paleontologists: shirts, trousers and skirts, research pockets, cameras, straw hats with wide brims, research brush, plastic toy dinosaurs, plastic bones, plastic dinosaurs eggs, magnifying glasses, torches, binoculars, geographical charts, pictures of dinosaurs skeletons, and books with archeological findings. The educator can also create a tent for sheltering the findings about dinosaurs.
b) Construction corner: The educator enriches the specific corner with plastic toy dinosaurs in different designs, sizes, forms, etc. He/she can also furnish it with materials (sand and small plants, paper, cardboard, glue, etc.), which will serve the children for the creation of a model.
c) Plastic arts corner: There must be clay and moulds in the shape of the dinosaur.
d) Mathematics corner: The educator leaves at the disposal of the children pictures of dinosaurs for classification by size, height, etc., puzzle with dinosaurs, tombolas. Also small toy dinosaurs and dino eggs for matching and measuring, wooden dino-skeleton, etc.
Preplanned research in the broader environment (organized visit to the Goulandris Museum).
Preplanned activities about concepts which are going to be clarified: Characteristics of dinosaurs (carnivores, herbivores), dinosaurs fossils, in the footprints of dinosaurs (relation of size-evolution).
Activities which have not been foreseen: Activities which have not been foreseen can result in the course of topic development. The pre-school teacher listens and records carefully the ideas and thoughts of the children and the development of the topic is adjusted to their interests and needs.
Emerging activities which can be development in the work schemes: The reading of books related to the topic of dinosaurs, the film Jurassic Park, anything a child said or brought and the interest shown by the others provide the occasion for development of additional activities, of shorter or longer duration, related to the topic.
Closing activities: Writing up of individual files, writing up of collective file, exhibition of individual and group work.

3.9. Evaluation: Observation, recording, study of children's work, readjustment of aims, revision of activities and general appraisal of targets which were attained as regards knowledge, abilities and skills.

4. Ideas for the planning of activities on the theme of dinosaurs

4.1. Carnivorous dinosaurs - herbivorous dinosaurs

Thematic fields: Language, Study of Environment, Mathematics.
Learning targets: To describe and compare the characteristics of dinosaurs. To broaden their knowledge of living organisms. To develop and employ the appropriate terminology with reference to describing and comparing dinosaurs. To interpret general elements of the world which surrounds them through processes of observation and description, comparison and classification.
Materials: Photographs of dinosaurs of different kinds.

Description of activity: The educator starts the activity by discussing with the children the differences between carnivorous and herbivorous animals. He/she questions and guides the children with the aid of photographic material to track down the characteristics of each species. With its aid the children record the different characteristics on a board. Subsequently the educator asks the children to decide which characteristics correspond with carnivores and which with herbivorous requesting them simultaneously to justify their views. After the discussion on the dinosaurs diet the educator gives the children photos of different foodstuffs in supermarket adverts to cut out. He/she prepares two cards on one of which the children are asked to place the carnivorous dinosaurs and the corresponding foodstuffs which they eat and on the other the herbivorous dinosaurs and the corresponding foodstuffs.

4.2 Fossils: witness of the past

Paleontologists do excavations and dig rocks from caves to find fossils.
Interdisciplinary fields: Language, Study of Environment, Mathematics.
Learning targets:
To understand the way in which information is revealed to us from the past.
To realize the chronological sequence of events.
To broaden knowledge about the natural environment.
To reveal the significance of fossils for the interpretation of life in the past and of the changes in nature.
To employ the appropriate vocabulary to describe fossils.
To take measurements using arbitrary or standard units of measurement.

Description of the activity

After discussion and observation of related books the educator encourages the children to discuss how animal and plant fossils are shaped, e.g. dinosaurs inhabited the Earth Died/With the passage of time their bones were covered with earth and fossilized/paleontologists found fossilized bones and assembled them piece by piece so that we could see a complete dinosaurs/How do paleontologists find fossils?/What precisely do paleontologists do with fossils? Why are fossils so important?
The educator shows the children with the aid of pictures and books the tools which paleontologists use for finding fossils. Subsequently they themselves become paleontologists and try to uncover bones from a wooden skeleton of a dinosaurs which the educator has hidden in the school sand pit. He/she explains to the children that they must dig to find dinosaur bones. He/she gives the children the necessary time to do their excavations. Afterwards they discuss the method adopted by the paleontologists, e.g. they accurately record the area of rock where they found the bones, sketching and measuring the distance between them with a view to reassembling the dinosaurs skeletons afterwards. The entire work is done slowly and carefully uncovering the sand with a brush.
When the children find the bones the educator tries to draw their attention to the outline which the fossils leave on the rock. As soon as the children's excavation finishes he/she asks the children to share their observations and discoveries.

4.3 In the footprints of the dinosaurs

Interdisciplinary fields: Language, Mathematics, Speculations.
Learning targets:
■To interpret general elements of the world which surrounds them through processes of observation and description, comparison and classification.
■To take measurement employing arbitrary or standard units of measurement.
■To enrich their language with words connected with mathematics.
■To sketch different kinds of lines and outlines and to compose different figures and shapes.
Material: Books with pictures of the footprints of large dinosaurs, large sheets of paper, scissors and ruler.

Description of the activity

With the help of the educator the children sketch the footprints of the dinosaurs on card (in real dimensions) and fix them up in the school area. They take cave that the distance from one footprints to another represents the actual dimensions of the stride of a large dinosaurs. Next, the educator asks the children to reproduce the outline which their footstep leaves on a piece of paper and to measure and compare the size of their footstep with the size of a dinosaurs footstep. The educator urges and guides the children to employ the appropriate vocabulary (larger, smaller, equal, twice the size of Dimitra's footstep, tree times the size of Anna's footstep etc.). He/she ask them to measure and compare the distance between the dinosaurs steps and the distance between their own. Next, he/she asks the children to measure how many steps they themselves need to take to get from one dinosaurs step to another.
When they finish measurement and experiments they shave the results of the measurements amongst themselves and discuss their conclusions. The educator can proceed to the development of the activity also including his/her own footstep in the problem of measurement (in this activity it would be better if possible for older children also to participate) so that the children realize that the size of our footstep changes as we get other.

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Landscapes for Learning – Rediscovering the Mediterranean Landscapes – the Case of University of Crete's woodland in Rethymnon.

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Abstract. *During the last decades, Mediterranean landscapes have been thoroughly transformed as a result of the changing socioeconomic and cultural conditions and policies. Nowadays, the design and planning of the use of land is often unsuccessful. Ecological knowledge is a prerequisite for the proper management of the landscape. Landscape Ecology education enables us to cultivate the awareness of nature and the appreciation of the landscape and encourages holistic thinking. Promoting holistic understanding and avoiding fragmentation of knowledge, Landscape Ecology can also provide a bridge between the Humanities and the Sciences.*

This paper reports an on-going research at the woodland of the University of Crete. It focuses on the restoration and management of a (previously rural) landscape, which resulted from the abandonment of the land about 40 years ago. Apart from the restoration of the landscape, the aim is to develop landscape education initiatives to promote the use of landscapes as an educational resource. In this way, young people will be helped to identify with their local environment and will be inspired to act for a sustainable future.

Keywords. Landscape, Landscape Ecology, education, Mediterranean, multifunctional landscapes, vegetation,

1. Introduction

The elaboration of a holistic view towards the environment requires our acquaintance not only with the natural but also with the historical and cultural environment as well. To develop a holistic perception, we need to make comparisons between the present and the past, but also to view the interrelations between elements of the present state.

People's awareness of the state of their immediate environment allows them to develop the ability to recognize changes and to assess their consequences. As a result, this perception leads to the development of interest and commitment for preservation and improvement of the local environment.

2. Mediterranean landscapes, Landscapes for Learning & Landscape Ecology

The shaping of land in the Mediterranean region is the outcome of the interaction of man with his surroundings. During the long human history in the Mediterranean, land was under continuous and constant pressure. Nevertheless, man's understanding of his surrounding and of the scarcity and limitations of the environment's natural resources, resulted in his using the land wisely. The high heterogeneity and complexity of the Mediterranean region allowed the development of different traditional uses of land in different places. Thus, dynamic processes shaped the different spaces, an outcome of the interactions between human, other biotic and also abiotic factors.

During the last decades, many traditional Mediterranean landscapes have been thoroughly transformed as a result of the changing socioeconomic and cultural conditions and policies of decision -makers.

Regarding the conception of planners that land is wasted if it is not converted into more profitable purposes' Naveh states: 'They ignore the fact that we live in the higher, super system of our total human ecosystem in which humans and all other living organisms are integrated with their total physical, natural and socio-economic and cultural environment'[7].

Landscape has been seen as 'the total character of a region' [6] or as a 'dynamic process developing on the visible earth surface, resulting from the interaction between abiotic, biotic and human factors which vary according to site and time' [8]. Carl Troll introduced the synthesised term *landscape ecology* as 'he was aware that ecosystems are intangible, conceptual systems diffuse in space', so that 'they cannot be regarded as a key set for larger-scale land-scapes'[6].

Naveh, too, proposed the broadening of conservation efforts from species and ecosystem levels to landscape levels and from biological diversity to ecological landscape heterogeneity and diversity [6].

'Landscape ecology is the study of spatial variation in landscapes at a variety of scales. It includes the biophysical and societal causes and consequences of landscape heterogeneity. Above all it is broadly interdisciplinary' [14]. Principles of Landscape ecology focus on: Distribution patterns of landscape elements or ecosystems, Landscape functioning and processes, Ecological changes in the landscape mosaic over time, Understanding the whole, Maintaining quality of landscapes [14].

Landscape ecology, is defined by Naveh and Lieberman, as 'an interdisciplinary science dealing with the interrelation between human society and its living space'. In order 'to account for the full value of our natural and semi-natural landscapes as life-supporting systems we have to include the following three major domains in all land-use decisions': the bio-ecological, the socio-cultural and the socio-economic domain [7].

The stimulus to conservation must come through education [10]; ecological knowledge and understanding is a prerequisite for proper management of the land. Landscapes can serve as excellent education environments (their structure and functions, especially those characters of the vegetation, which are adaptations, responsible for the resilience of the landscape).

As landscapes exist in space and time, they are also records of the past and of a cultural heritage. Moreover, as landscapes are tangible and not abstract, young people and people of all ages, can learn to observe and interpret them.

Vegetation is an important component of the landscapes and the "language" of vegetation can reveal the past landscape uses.

Today, older people recognize the value of their landscape, but not always pass the knowledge to the younger generation.

It is stressed that 'there is an urgent need to invest in ecological landscape research and education'.

Landscape ecology education enables us to cultivate awareness of nature and appreciation of the landscape and encourages holistic thinking by emphasising the interrelatedness of all components (soil, hydrology, geology, climate, topography, flora, fauna) [6].

It is also believed that Landscape Ecology education will allow a bridging of the Humanities and Science, promoting holistic understanding and avoiding fragmentation of knowledge. It can also introduce the concept of sustainable development in an understandable way [6]

Landscape Education initiatives should be developed to promote the use of landscapes as an educational resource and to develop links with schools. In this way, young people identify with their local environment, and are thus inspired to act for a sustainable future. This is especially significant in view of the accelerated urbanisation and the minimisation of contact with the natural and traditional rural Mediterranean landscape.

Landscapes provide a meaningful context for learning: In order to investigate the ecological history of Mediterranean Europe, and more specifically to give some answers to the question of desertification, Grove and Rackham adopt a holistic approach which includes all the different factors: climate, weather, geology, geomorphology, aspects of human history, vegetation, traditional multifunctional landscapes, erosion [3]. Rackham & Moody dedicate their book 'The Making of the Cretan Landscape: 'To the tectonic forces that shaped the topography; The Pleistocene fauna that shaped the vegetation; the Cretan people who shaped the landscape. Each without the others would have resulted in a dramatically different Crete'[10].

Nevertheless, there are questions to be answered about viewing Landscape ecology as a unifying discipline: 'how – going beyond general statements – can it be realized; how to implement the specialists' knowledge into holistic approaches and how to introduce this in practical land management / landscape planning?'[1].

Moreover, 'all relevant information, even if not expressible in marketable commodity values or dollars in cost–benefit analyses, must be presented in a clear and illustrative way that can be comprehended by the public …' [7].

Jala Makhzoumi and Gloria Pungetti, in their book 'Ecological Lanscape Design and Planning - The Mediterranean Context' offer a holistic methodological approach to landscape design and planning. The principles of their approach can be used in practice, for creative ecological design and sustainable planning in the Mediterranean[6].

3. From the regional to the local landscape: University of Crete's woodland on Rethymnon an on-going research

The University of Crete's (UOC) campus in Rethumnon is located within a woodland, which is the result of the abandonment of fields about 40 years ago, when the local people sold their properties to the University. After the construction of the UOC campus, the remaining vegetated land is about 1600 stremata (160 hectares).

3.1. About the history of the present landscape

The present landscape witnesses a variety of land forming processes and past human activities, which help consider what happens to areas of abandoned cultivation.

Local people had created a beautiful and harmonious landscape. People were using the different trees, in combination with grazing and the use of coppice for fuel they also were cultivating wheat and barley in the more open and free of stone places, among the trees. Lime – kilns were near the sources of fuel.

Fields were enclosed by thick dry stone walls. Making stone piles was a practice for using up stones to free their fields. Shaping of paths between two drystone - walls allowed the movements of man and animals

Dry stone building, required huge labor and persistence. The space which has been shaped and formed by dry stone walls, becomes a place inside of which special relations develop between the communities and the natural environment. The coexistence of the drystone building with the vegetation, created a complicated space formed by man [15].

Controlled grazing of domestic sheep and goats assured the existence of a low grass cover with many flowering geophytes. Cultivation of oaks was very profitable as farmers sold not only the acorn cups (to the dying leather industy) but also the acorns (to be used as forage). Most species of vegetation were used; and were used wisely. Aware of the high flammability of *Calycotome villosa*, the hot fire that produces when burned, local people used these bushes as a fuel for their oven or lime kilns. Nevertheless, they did not cut down the *Calycotome* near the base of the stem, as they knew that it would not manage to resprout, something which *Pistacia lentiscus* and *Quercus coccifera* manage to do very well. Prickly oak, before abandonment, was a major source of fire wood, and food for goats. *Sarcopoterium* was also widely used as fuel for ovens and lime kilns. Carob trees, wild or cultivated, were used for feeding the animals.

In its early stages, the complete abandonment and cessation of cultivation, woodcutting, and grazing should have led to a recovery in height and density of the herbaceous and woody plant cover. The vigorous vegetative regeneration of sclerophylls from stunted shoots and almost imperceptible rootstocks followed. Thus, gradual enclosure of the canopy should have suppressed the herbaceous understory vegetation almost totally.

'After the initial high photosynthetic rates of the regenerating shrubs has slowed down, the dense 3-6m high shrub thicket gradually becomes stagnant and even senescent and very fire prone, because of the accumulation of dry and dead branches and undecomposed litter'[7].

Thus, in the last 50 years, the abandonment of land, was followed by the reencroachment maquis vegetation which persisted and regenerated considerably. Today, large quantities of dry and dead wood are accumulated without barriers to the spread of fires.

The present situation of the landscape, is an example - in small scale - of a traditional multifunctional Mediterranean landscape with the typical complexes of agro-,silvo-and pastoral components that has changed thoroughly.

3.2. The present landscape

This is a landscape in the Mediterranean vegetation zone, near the northern coast of Rethymnon town. The elevation slightly increases as we follow the low hills southwards.

Different plant species, vegetation types and land-use forms, give rise to complex mosaics of patches.

Today the land is covered by impenetrable high evergreen sclerophyllous shrubs (maquis) and even woodland, with low phrygana on shallow soils and in exposed sites. Maquis and phrygana are intermingled in mosaics together with big deciduous oak trees, while here and there carob trees are seen, as well as the native Cypress (*Cupressus sempervirens)*. Cultivations of olive trees which covered whole tracts of land are now impermeable by the growth of the understory vegetation. Wild olives are also seen here and there. Climbers embrace shrub and tall trees creating a jungle-like landscape.

Much of the character of the local landscape is identified with large deciduous oaks with the big acorns and acorn cups (their understory being also impermeable). Oaks reproduce very well, as there were observed many seedlings of different ages in the more open places, where light can reach.

Vine cultivations were noticed within dry-stone enclosure walls which are in their turn, found within larger fields of oaks, carob trees, almonds, olives, also enclosured by dry-stone walls.

The evergreen oak, *Quercus coccifera,* has assumed a treelike habit. Many shoots arise from just one stump as they have regenerated vigorously from root suckers and shoots. Young sprouts and leaves of this dominant component of the maquis vegetation are noticed near the edges of newly opened path by heavy machinery, and they are devoured by goats which sometimes trespass. *Pistacia lentiscus* is the most abundant evergreen sclerophyll shrub and has attained its full size. *Sarcopoterium* can be observed now to dominate in many sites. Even today, cyclamens carpet under the oaks. Some annual herbaceous plants are found in the more open places.

We were surprised to find the wonderful blue spikes of the endemic *Petromarula pinnata*, which come out in May, in three different locations of the landscape: *Petromarula* being very palatable is known to be 'adapted to an inaccessible life on cliffs of the reach of goats' [10]. This finding brings to mind the similar behaviour of the endemic *Ebenus cretica* described by Rackham in areas of Eastern Crete, where grazing pressures diminished [10].

The immediate dangers to the landscape are:

a) fuel accumulation: large quantities of dry and dead wood are accumulated without barriers to the spread of fires.

b) uncontrolled circulation of sheep and goats which sometimes seem to trespass; in the past, people used to tie the sheep's feet to control their movement. Now, this constitutes a danger to the dry-stone structures. In addition to that, the palatable *Petromarula* will disappear again, along with the few remaining flowering herbaceous plants.

c) a number of exotic pines and eucalyptus species, were planted densely in the area; not only are they not suited to the landscape, but, most important, but they also represent a potential fire hazard.

3.3. Management

The management of the above described area which is a property of the University of Crete, is a huge task and one that requires sound scientific involvement.

Absolute priority should be given to the development of a master plan to determine the protection and preservation of ecological values and processes. This has to focus on the attributes of the area that should be protected from the impacts of modern technological society. This is not an easy task, given that the area is not sufficiently large and remote enough, to make the long term protection of its biodiversity and natural systems practical.

The policy developed should concern all relevant issues as restoration, fire management, access, transport. We would like to stress that the use of heavy machinery in management operations can be very detrimental to soil stability and to wildlife.

Fire Management should be given a priority as the University campus is surrounded by masses of fuel. This is a difficult task and short term solutions should be avoided. Fire hazards should be reduced by management regulation functions (i.e., through and fuel and vegetation management). Fire hazards will also be increased if recreational uses are introduced.

Generaly, management should focus on the manipulation and controlled utilization of the existing plant cover, such as cutting, thinning, pruning, chopping, copping. Grazing, if allowed as a management practice, should be controlled, should follow a special grazing system, and should not be given priority before the manipulation of vegetation described above.

3.4. Paying back the effort - Soft values

Because the area of about 150 hectares is neither large enough nor remote enough from the campus it cannot be preserved from external disturbance without real commitment.

The efforts should be oriented to the 'optimization of natural landscape values which may be of a purely bioecological nature, or they may constitute a complex and closely interwoven mixture of bioecological, gemorphological, and human-perceptual processes of scenic diversity, attractiveness, and accessibility, which can be enhanced by ecological management' [7].

About the human-perceptual processes of scenic diversity, attractiveness, 'these functions cannot be fully expressed in monetary terms, although they can prevent severe longer – term financial losses and repercussions' [7]. This can be only achieved 'if … the more farsighted and broad-minded elements in professional leadership struggle courageously and tenaciously' [7].

3.5. Education

After the proper management practises are realized, this landscape will become stimulating one which could help us guide young people through the complexities of Cretan vegetation and landscape.

Educational practises should be permitted within the area only providing they are consistent with the maintenance of the qualities of the area and operate according to the institution's policy. Thus, it could serve as an important outdoor classroom and living laboratory for ecological education, as it provides interesting information.

Education Programs could be developed with schools. Young people and people of all ages will thus be encouraged for a proper land use planning in their local community

School visits are considered an appropriate method of environmental education, when they take place in landscapes which are in the transition process from the rural to the urban phase and when they involve children's active investigation of issues like what the remaining trees witness for the possible past land uses, what kinds of plants were there initially and which are now [12].

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Review the changing role of intellectual property in the microelectronics sector

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Abstract. *The microelectronics industry has been a driving force behind significant economic and structural changes in the world markets over the last 30 years. The pace of technological change within the sector and its broad impact on most, if not all, other industries make it an extremely rich area to study. This paper will examine how intellectual property rights (IPR) have played a role in the development of the microelectronics industry as a whole and also how IPR has influenced the activities of firms and has, in many respects, forced them to take a 'core competencies' approach prior to the mainstream popularity of the notion. We will argue that IPR, and patents in particular, have played an increasingly important role in the industry, particularly with regards to their financial impact on firm strategies.*

Keywords. Changing role, IPR, Microelectronics industry, Patents.

1. Introduction

This paper assumes of the reader a basic working knowledge of IPR concepts. IPR regimes are diverse and complex, and this complexity increases dramatically as global interactions are taken into account. For the purposes of this paper we will be focusing primarily on patents and to a lesser extent trade secrets as these are the methods by which most microelectronics inventions can be protected.

2. The Microelectronics industry

2.1 Overview

Microelectronics (ME) is the design, manufacture and use of microchips and integrated circuits. Much of the production occurs at the micron scale creating massively complex sub-systems and systems which can easily contain many millions of transistors in a few square centimeters of dope semiconductor on silicon substrate.

Kick-started by the discovery of the transistor at AT&T's Bell Labs in 1947 (Lucent 2002), today the industry is filled with a wide variety of firms ranging from 'captive manufacturers' such as International Business Machines Corporation (IBM) who produce most of their chips for themselves, to 'diversified merchant producers' including Motorola who straddle many fields and produce for their own consumption as well as for clients. Also present are 'specialized single technology or niche' firms, such as Transmeta, who may well outsource their production to larger third parties or focus on producing a very specific chip which larger fabricators find un-economical to make (Podolny and Stuart 1995).

2.2 The Market

There are several key factors are important to the analysis of the ME industry in relation to IPR. Firstly the market has been experiencing technological forces commonly known as 'convergence'; this refers to the fusion of a wide variety of technologies and markets such as telecommunications, film and fashion into integrated technological products[7]. Convergence has forced firms, either through their own growth, licensing or a wide variety of partnering activities to become competent, or at least current, in an ever growing number of technical fields. In many respects ME itself has been the force behind this trend, indeed academic consensus seems to agree that ME is a pervasive technology (van Tunzelmann 1995; Freeman and Soete 1997) which has broader implications such as the technology's likely utility in many fields. The argument is that not only does the pervasive technology get embedded in a broad range of products but that also products, as a trend, contain greater numbers of technologies (Figure 1). This has had significant implications for individual firms' abilities to develop and market new product offerings, and many firms, such as Philips struggled to keep up with the breadth of change (von Tunzelmann 1995).

Apart from the technological forces, the ME market also has undergone some dramatic structural changes in its competitive nature. Citing Dosi, Freeman and Soete argue that while the ME industry was a mature international oligopoly in the 1970s the resurgence of several US firms and South Korea and Taiwan's explosive growth has re-invigorated the market (Freeman and Soete 1997). Most observers would agree with this argument; however in specific sectors of ME market suppliers still hold extremely powerful positions. The best example is, of course, Intel's hold over the X86 CPU product categories. Such is their hold, partially through 'creative' licensing policies[8], that the US Federal Trade Commission has instituted anti-trust actions several times against Intel (Savage 1999). This clearly has a distorting impact on the market making it harder for new entrants in some segments; however the continuing pace of technological development allows new niches to emerge where existing players are not suitably aligned to take best advantage of the opportunities presented (von Tunzelmann 1995).

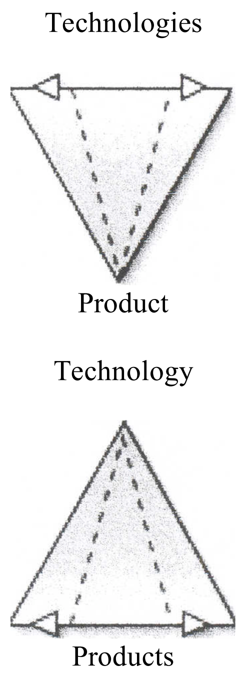

Figure 1. Products have more technologies embedded in them due to pervasive technologies. At the same time, due to its nature, a pervasive technology appears in a large range of products. pp279 (von Tunzelmann 1995)

[7] Take for example a modern laptop which may well integrate a DVD player, wireless Internet connectivity and a fashionable slim metallic exterior with a powerful computer.

[8] Savage describes one US Federal Trade Commission (FTC) case against Intel that focussed on their refusal to give customers access to key technologies and information unless the clients surrendered certain patents rights to Intel. The case was settled but the terms of the deal confirmed Intel's guilt as it "prohibited [Intel] from withholding or threatening to withhold advanced technical information or products from customers as a means of obtaining intellectual property licenses". An excellent example of patent law being used 'strategically'.

3. ME Research and Development

It is useful to briefly examine how new products are developed within ME firms, in other words the R&D process. Generally US technology firms have a high reliance on public science, 80% of citations on their patents are externally authored, with the overwhelming source being universities (Narin, Hamilton et al. 1997). Analysis of the Yale survey data (Klevorick, Levin et al. 1995) indicates the high importance of physics and computer science to the ME industry and that proximity between the businesses and the fields of science is particularly strong for the ME trade. While this survey data is questionable, particularly due to its reliance on the views of R&D managers themselves, it does align relatively well with evidence from other sources. For example Pavitt addresses this issue by quoting Mowery who argued that existing large science-based companies could develop competencies in ME due to their abilities to establish internal and external R&D projects or linkages as 'insurance' against future trends (Pavitt 1986). In other words, We would argue, the closer a firm is to the relevant fields of science, the better its chances of riding out the tumultuous sea of technical change that characterizes the ME industry.

4. ME Production

Freeman and Soete identify the huge importance of process innovation to the ME industry. A successfully designed product based on strong science and built with leading-edge technologies can fail spectacularly when wafer yields (the proportion of usable silicon wafers produced) can initially be as low as 5-10% and a single production line can cost $200m and entire 'fabs' (chip manufacturing plants) cost as much as $2billion, with the price rising rapidly as the etching scale shrinks (Rapoport 1986; Housego 1988; Freeman and Soete 1997; Becker 2001). Consequently the role of the tacit knowledge (or 'technical expertise' as Taylor and Silberston describe it) is vital and many firms valued it above patentable technical innovations when surveyed in 1968 (Taylor and Silberston 1973), though we will argue the emphasis has shifted somewhat. Nevertheless the huge size of investments in chip fabs and the potentially ruinous yields creates a massive impetus for process innovation and due to the nature of most patent regimes; this is where trade secret protection plays a more significant role (Kehoe 1986). Samsung described their efforts to make their first large scale wafer fab plant commercially viable as "working the skins off" their engineers (Housego 1988). The duality between the R&D and production roles of the ME industry fits well into the distinction, described by von Tunzelmann, citing Hicks as well as Patel and Pavitt (von Tunzelmann 1995), between technology as an artefact and as a body of knowledge. This distinction should not be taken too literally as clearly there are significant technical, artefact based, aspects to the production process; however the main gains for the firm at this stage are procedural and not technical. In many respects technical improvements dramatically raise the risks in production, as highlighted by the enormous cost of creating ever more advanced fabs. Thus in many ways firms regard a successful production process as an art, often the factors contributing to the success are not entirely clear, as typified by Intel who make each fab identical to the others to ensure that whatever aspect it is that works can be carried over to the new lines (Freeman and Soete 1997)[9].

5. The evolving use of IPR in me

5.1 The Propensity to Patent

Scherer's 1977 econometric survey of the propensity of several industries to patent identifies the relatively low propensity of the electronics industry when compared to other 'modern' fields of commerce (Scherer 1981).

The usual arguments questioning survey results can certainly be rehearsed on this somewhat dated study, and clearly the industry groupings, based on Federal Trade Commission industry classifications are questionable-specifically how were Electrical and Electronic separated? While it may be a small stretch to use the Electronic industry data for ME it is interesting to note that the reasons Scherer gives for the lower propensity to patent in that field matches those given in other work. Specifically he notes the ease of inventing around electronic inventions (i.e. the low exclusivity of many ME patents) when compared to the fields such as organic

[9] It must be noted that this is not Intel's only reasoning for identical fabs (an approach they call "copy EXACTLY!"), there are also human resources and disaster recovery issues, the uniformity allows staff to move facilities and production relatively painlessly (Intel 1998; Ristelhueber 1999).

chemistry (which regularly has highly exclusive patents). Also noted are the difficulties in patenting systems of the complexity seen in electronics. He argues that the costs per patented invention in the electronics industry, where inventions often may well have ubiquitous implications, are significantly higher than in other industries which results in a lower patenting rate. However the linkage between the scope of the invention and the cost of inventing and patenting the discovery is not firmly identified. These views are supported in the 1968 survey by Taylor and Silberston which Scherer in fact references (Taylor and Silberston 1973).

Taylor and Silberston argue (based on their survey data) that even slight innovations in electronics have a high cost and that the very high support given by governments (as high as 40% of total budgets in 1968) to electronics R&D has been the key factor in maintaining the pace of innovation of that period *(ibid.* pp285-286). They also point out the differential in patenting between the component and system levels with components dominating their results even though such patents have a higher likelihood of being invented around *(ibid.* pp290. 295). If we examine this duality through the two key dimensions of appropriability suggested by Teece, *legal instruments* and *nature of the technology* (Teece 1986) we can see that despite relatively effective legal instruments protecting components (through patenting) competitors can avoid infringements because the nature of the technology allows multiple paths to the same outcome.

The importance of patenting has historically been further reduced by the short product life-cycle that typifies the ME industry[10]. The argument is that with the short life of many technical innovations, and due to their cumulative nature, they will be rendered obsolete before a patent has been granted, particularly if it has been applied for internationally through the PCT system. Several sources identify this as a factor recognized by industry practitioners (Taylor and Silberston 1973; Knight 2001). Furthermore, partly due to this high level of technical change which makes it difficult for patent examiners to remain current, there has been historically a high level of doubt on the validity of many patents. In fact Taylor and Silberston's survey identifies a common level of doubt as being that around 90% of ME patents are probably invalid, which they argue is much higher than for any other science-based industry (Taylor and Silberston 1973). This doubt has continued with many firms pre-emptively challenging patents they regard as invalid while releasing infringing products (Kehoe 1994; Agencies 1996; Dickie 2000). We would argue that these factors are fundamental to a historically low appropriability regime in the ME industry, which partly accounts for the relatively low propensity to patent previously explored.

Not only does the cumulative nature of ME technology raise questions about the benefits of patenting inventions due to its impacts on appropriability, it also creates huge product design problems for those technologies which have been patented. Patents tend to cluster around certain technologies and as products are built up 'royalty stacking' occurs whereby individually reasonable license royalty rates build up to create an aggregate royalty which threatens the financial viability of a product. Due to the fast-moving nature of the technologies it can be hard to keep track of these royalty liabilities during the R&D process, thus to prevent nasty surprises various licensing techniques have been used by firms to preempt such problems, which will be discussed later (Teece and Grindley 1997; Teece 1998).

In their survey Taylor and Silberston's respondents claimed that the size and direction of their R&D activity was not affected in any significant way by patents, nor did patents have any important impact on the competitive landscape of the market, especially for the larger firms (Taylor and Silberston 1973). However we argue that the licensing data to be discussed subsequently indicates that that 1968 response is no longer representative of the ME industry, patenting has taken a much larger role.

5.2 The Role of Disclosure

An argument often rehearsed against the use of patents is the forced disclosure of innovations that results from the patent registration process which divulges some technical advantage the firm may have. However Knight argues that skilled patent agents can ensure that no additional tacit knowledge is codified into the

[10] The ME life-cycle is certainly short when compared to industries such as the automotive sector, however I am not arguing that product life-cycles are necessarily getting any shorter.

application and that only the fundamental technology is described, reducing the perceived disclosure risks to firms (Knight 2001). The 1968 survey has a surprising result which confirms this view: The firms responded, when asked about disclosure, that they were far more concerned by disclosure in technical journals and product documentation (which had to be detailed to keep customers satisfied) than in patent applications where the registration write-up was a closely controlled process (Taylor and Silberston 1973). While we have been unable to find more recent qualitative research on this topic one most note the high rate of patenting by ME firms and the fact that the patenting process continues to be a highly structured activity, due to its legalistic nature may indicate continued relative indifference to the issue of disclosure.

6. Patent Portfolios & Licensing

6.1 How Portfolios focus strategy

As the ME industry has developed and matured many larger firms have built large portfolios of patents which, in aggregate, have significant value. This creates a situation whereby there is competitive advantage in not duplicating the R&D activities of competitors but focusing on core competencies and thus creating a valuable portfolio which other companies need access to (as they to have focused on differing technologies). This creates a situation whereby there are strong inducements to license from each other so that product development is not blocked and those technologies which the company does not have the resources to develop can still be accessed (Teece and Grindley 1997). This could be seen as a market solution to the problem previously mentioned that products in the ME industry require knowledge in an ever widening range of technologies. Thus in many respects the size and nature of ME patent portfolios has inherently encouraged a *core competencies* approach to creating sustainable competitive advantage as described by Hamel and Prahalad, cited in Tidd, Bessant et al. (Tidd, Bessant et al. 2001).

6.2 The Changing Nature of Licensing in ME

While one could attempt to argue our position on the basis of the increasing numbers of patents filed each year by ME firms, we regard this as a trite approach as most if not all of the growth could be accounted for by the expansion of the ME market itself. Thus we have chosen to base the core of our argument that patents have become increasingly important to ME firms on the historical evidence relating to the changing licensing strategies the ME industry has seen and what their evolutions tells us.

For the ME industry the story begins with patent pools, which emerged out of several major firms who had created fundamental inventions that would play a vital role in the formation of the ME industry. The pools, which collected the vital patents for a specific field into an easily licensed collection allowed the field to develop without the cumulative nature of the technology (and the resultant patent problems) blocking progress. This approach emerged, Taylor and Silberston argue, due to the lessons learned from the classic patent blocking problems that delayed the radio and other innovations from becoming mainstream industries (Taylor and Silberston 1973; Teece and Grindley 1997).

However by the late 1960s the patent pool was all but defunct due to a variety of reasons including the expiry of the key patents which justified the pools, the reduced number of large firms in the market (thus making other types of licensing more viable) and the lack of simple clusters of patents (from sources such as Marconi or a productive government department) which could be easily defined and pooled (Taylor and Silberston 1973). We would argue there was one additional factor working on patent pools-the political and legal pressures of anti-trust activity by governments who had, by this time, already forced the hand of IBM and AT&T with regards to patent licensing.

The consent decree induced licensing by IBM and AT&T created an industry attitude to IPR which Taylor and Silberston characterize as 'liberal', certainly many of the key firms were keen to avoid the mistakes, which blocked the industry and prompted the creation of RCA (Taylor and Silberston 1973). At this point Teece describes patents as being seen as a 'weak' market tool, firms were relying on time to market and the production experience curve to maintain competitive advantage (Teece and Grindley 1997) as licenses were usually cheap and easy to obtain.

The licensing regime evolved quite rapidly from this point, but with a common factor remaining throughout, exclusivity was generally avoided-partly to avoid blocking and anti-trust issue but also due to the nature of licensing strategies adopted. From pools bi-lateral agreements became common as did 'armed neutrality' which can be best described as mutual acknowledged infringement. Most bi-lateral agreements were purely to avoid infringement however some included a broader knowledge transfer including process and manufacturing expertise, this choice has remained in ME licensing, though the majority of licensing does not include knowledge transfer (Taylor and Silberston 1973).

As the number of patents companies held in their portfolios increased it became ever more impractical to license patents individually or even in small clusters. In the 1960s Texas Instruments and IBM used the power of their portfolios to muscle their way into Japan, refusing to license local production. Having seen the power of portfolios other firms began to be more strategic with their own portfolios. Furthermore as the decade came to an end the policy used by many US government departments forcing 'second sourcing' came to an end, which increased the value of patents held on ME inventions. Thus by the 1970s entire portfolios or portfolio sections were being licensed bi-laterally. Occasionally a 'sniper shot' license would be given for a single patent, but the transaction costs prevented this being done on more than the key, high exclusivity, patents. New entrants, from the Asian Tigers[11] in particular, created a significantly more competitive ME market-they had paid nominal licensing fees to gain access to technologies but had offered no balancing portfolios to the licensors. Led by Texas Instruments the established firms began to re-evaluate how they licensed, specifically in these unbalanced situations and created processes for accurately putting financial values on specific patents and portfolios. As ME technologies became more complex the risks of launching new products increased (as typified by the cost of Intel's fabs) so intellectual property became more actively used to protect these investments, often by using patents to force joint ventures[12] Or cooperative R&D ventures with infringers. (Kehoe 1986; Rapoport 1986; Housego 1988; Butler and Thomson 1991; Thomson 1991; Anon 1996; Teece and Grindley 1997).

To indicate the massively transformed scale of licensing in the ME industry it is useful to note that from 1952 to 1963, as Taylor and Silberston quote Freeman, AT&T's Western Electric subsidiary recorded only a £3 million licensing income for their transistor patents when by 1965 over £20 million has been spent on R&D whereas, in contrast, Texas Instruments (TI) earned $85 million when they settled a single DRAM infringement suit with Samsung in 1988. By 1992 TI had, by one estimate, cumulatively earned $1 billion from infringement lawsuits and Teece quotes cumulative royalty earnings of over $1.8 billion between 1986 and 1993; this income was so significant TI used it to offset a sales slump during an industry downturn.

As previously described the breadth of technologies required in new ME products forced companies to increase their licensing activity, Teece even quotes a manager from IBM as saying "[we have] less time to invent everything we need". All the surveys and reviews we have examined highlight access to technologies (and thus infringement avoidance) as being significantly more important to ME firms than the potential revenue earned from licensing. In spite of this Teece identifies a trend whereby licensing has moved from a liberal 'capture' model to the more flexible and financially astute (for the licensor at least) 'fixed period' model which gives limited survivorship rights and more opportunity to renegotiate payments (Taylor and Silberston 1973; Housego 1988; Podolny and Stuart 1995; Teece and Grindley 1997).

7. New IPR concepts

Current IPR legislation has not covered significant portions of innovation created by the ME industry and, thanks to the economic importance of ME firms in many economies, the industry has been able to lobby for extensions of IPR concepts in the legal regime to cover their requirements. Examples include the 1989 Chip Protection and 1994 Integrated Circuit Layout Protection Laws in Taiwan (Chang and Tsai

[11] The Asian Tigers are : Taiwan, Hong Kong, South Korea and Singapore

[12] Counter examples certainly exist for at least the role of patents in joint ventures e.g. After a flurry of joint venture activity between Hitachi and Texas Instruments, IBM and Siemens as well as NEC and AT&T Microelectronics a Financial Times article noted that the primary motivations has been political and financial, intellectual property issues had been of low importance in this raft of activity. See (Butler and Thomson 1991).

2002) as well as the 1984 Semiconductor Chip Protection Act which gave mask[13] works 10 year copyright protection from first registration or first commercial exploitation (Podolny and Stuart 1995). This leads one to conclude that in spite of increasing use of patent and trade secret protection, ME firms have not seen these tools as sufficient to protect competitive advantage. Industry observers may well offer different interpretations of this increased IPR control!

8. Conclusions

Due to the resource constraints we have used a literature and news publication review of admittedly limited scope to argue our case citing some historical and more current sources. From these we have attempted to show that as the ME industry has matured into a field with short product-life cycles and increasingly capital intensive production IPR and specifically patents have become increasingly more important to the industry and especially the large firms, in spite of a relatively low appropriability regime.

We have also argued that due to their growing portfolios and the cumulative nature of the pervasive technology on which ME firms are based, their strategic hands have been forced into a core competencies approach for, at least, their R&D activities.

These tentative conclusions raise further research questions: What are the industry's views on this topic today versus Taylor and Silberston's 1968 results? Can we create and measure some useful indexes to track this trend quantitatively over time? The analysis provided also does not give us much guidance for future change, especially considering recent comment that the trend to open standards committees with compulsory licensing terms is threatening the value of patents (Festa 2002). The dynamic nature of the ME industry's use of IPR will continue to provide fertile ground for further research.

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The Experimental Approach of Physics in Secondary School

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Abstract. *The first meeting with Physics is very important, especially because this subject matter is perceived like a very difficult one by most people and parents too.*
The theoretical approach of any science is abstract and difficult. An experimental approach is more interesting and attractive.
Our college is an associated member of the "Hands on Science" network from 2004. Here are some pictures with experimental devices and experiments made by my students. They are 12 and 13 years old and they are to the beginning. Details are also given about the experimental scientific method and the steps involved.

Keywords. Experiment, Physics, Science, Scientific method.

1. Introduction.

In Romania, students begin the study of Physics on 12 years old and they study two hours by week in secondary school. Curriculum included all the chapters of Physics: Mechanics, Thermodynamics, Electricity and Magnetism, Optics, Atomic and Nuclear Physics. In high school all these chapters are studied again, but at a higher level. The number of hours for Physics' study in high school is 3 hours by week for classes with scientific profile and 2 hours weekly, first two years only, for classes with other profiles.

Education reforms are under way in Romania like in other European countries during the last 15 years. Despite the fact that Science Education becomes a major constituent of school curriculum, comparable to language, in all Europe, in Romania things took the opposite direction. The number of hours allocated for Science's study dropped and many changes, some favorable and many mistaken, have been performed.

2. Experimental approach of Physics

The first meeting with Physics is very important, especially because this subject matter is perceived like a very difficult one by most pupils and parents too.

The modern society demand not only theoretical knowledge, but also practical skills. Our students must solve interdisciplinary problems. They must participate in an active way to the teaching/learning process.

The theoretical approach of any science is abstract and difficult. An experimental approach is more interesting and attractive. I found this thing to more generations educated by myself.

Physics is a science which explains the world, the Universe.

For the first time, was the question. Any science starts like this.

Of what are things made?
What is time meaning?
Can we build a Sun?
Why things are fall down?
What is the light?

From answers was born Physics.

If you put the student find the answers by him, instead of give them directly, you made him curious.

When he found the first answer, he thinks he discovered the world. This is the first step. Then he starts by himself to ask questions and to search for answers. As a teacher, you can teach him how to search for answers. How can you do that?

To find out how works the Universe, we must recreate it. How? By experiment. Experimental science is actually the search for cause and effect relationships in nature. A hypothesis is our best guess at what this cause and effect relationship is. Our conclusions will allow us to predict the result of future cause and effect relationships.

3. Steps in doing an experiment

An experiment must not be made at random. Here intervenes the role of the teacher. He must teach students a scientific method to make an experiment. Such a method must have next steps:

1) Define the purpose of the experiment. You must define what you want to find out.
2) Make a hypothesis. A hypothesis is a supposition made on the basis of known facts or of an impression.
3) Plan the experiment (choice of the title, state of what we must observe, the successions of operations, what measurements we must make etc.)
4) Choose of materials necessaries;
5) Experiment; Experiments are often done many times to guarantee that what you observe is reproducible, or to obtain an average result. Reproducibility is a crucial requirement. Without it you cannot trust your results. Reproducible experiments reduce the chance that you have made an experimental error, or observed a random effect during one particular experimental run.
6) The examination of data, calculations and errors;
7) Conclusions.

Some students work alone, some works in team. The team spirit must be encouraged. Also, the teacher may give like homework, experimental projects for students and parents together because the involving of parents in the school life is very important.

Here are some pictures with experimental devices and experiments made by my students, presented in Fig.1, Fig. 2 and Fig. 3.

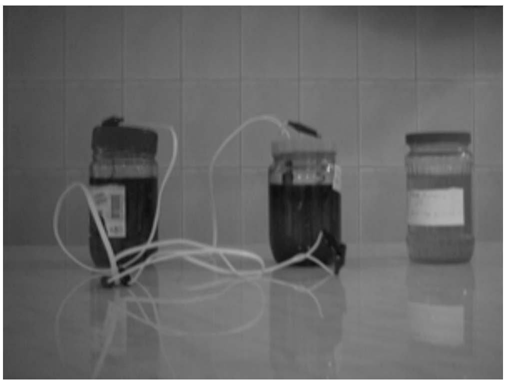

Figure 1. Experimental devices: copping devices

Figure 2. Experimental devices: hydraulic pumps

Figure 3. Experimental devices: cars by land and by water

They are 12 and 13 years old and they are to the beginning. All devices were presented by their authors in front of all students during a special class. Students had right to ask questions, to discuss and critic the devices. They manufactured an electrical rotating lamp, phone network, water mills, copping devices, electrical circuits, a steam machine, vehicles with air suspension, hydraulic pumps, batiscafs, boats, cars by land and by water, electromagnetic devices, little robots and others like these.

Like teacher, I evaluated the projects. First, I told to my students the evaluation criteria: the manufacturing effort, the originality and the utility of the project, the explanation for the phenomena that are to the basis of their device. After that, each student has received a grade.

The interest of students was major. Parents and students came to me and told me that they damaged toys, electrical apparatus, battery for manufacture their devices.

Also, I organized an exhibition-contest “How can I study Physics by experiments?” in the frame of Comenius 3, “Hands on Science” network.

Here all devices were presented to all school, teachers and students, and a jury evaluated and awarded prizes. The success was enormous (Fig. 4).

Figure 4. Exhibition-contest "How can I study Physics by experiments?"

Our competition provided the pupils with an opportunity to compare their own achievements with these of their colleagues. I think that exhibition-contest must become an annual one.

This year, the winners were invited to participate to a similar activity with students from all the country to "Grigore Moisil" High School, Bucharest, where they were awarded with some prizes.

Also, I encouraged my students to participate to "Science Fair" contest organized by "Hands on Science" network.

3. Conclusions

I will use the devices manufactured by my students like didactic material for classes of Physics, so they be more attracted and interested to understand physics phenomena. Self-made devices and simple materials are more appropriate for students in smaller ages. Teacher must guide pupils and teach them scientific method.

I think this approach combined with theoretical one is very advantageous and leads to a better understanding and interest for Science. Physics teaching and Science teaching in general, must develop creative spirit, imagination, logic reasoning, team spirit and practical skills. The "Hands on Science" network provides a frame to promote experimental teaching of Science as a way of improving in-school scientific education.

4. Acknowledgements

I would like to thank the "Hands on Science" coordinator Manuel Felipe Costa for his support and encouragements.

I would also thank the national coordinator Dr. Dan Sporea who gave me the opportunity to work in this school network.

Data acquisition and analyzis of real signals experiments

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Abstract. *We are trying to develop our studies on gathering, organizing, representing and analyzing the experimental data extracted from the real world from under the frame of the Socrates-Comenius "Hand's on Science" (110157-CP-1-2003-1-PT). We are still using our data acquisition board NIDAQ 6013 which explores the real word: the uniform rectilinear motion of a racing car, the intersection of two cars, the impacts study using the Force sensor (bought by the HSCI Network), the oscillatory motion using the force sensor, the simulation of the alternating current circuits, the coil in AC, the capacitor in AC, the sonic interference, the magnetic field using the Magnetic Field sensor (bought by the HSCI Network), the boiling of water, etc,. This paper shows a short presentation of these experiments, of the way of gathering and analyze the real signals and the fantastic impact they have on our lessons.*

Keywords. LabVIEW, DAQ-data acquisition, DAQ-software, VI-virtual instrument.

1. The study of the frictional force

The shortest way for demonstrating the variation of the frictional force during the traction of the sheet of paper under the wooden cube is shown in Figure 1.1. The force sensor coupled with the data acquisition board is used as a dynamometer.

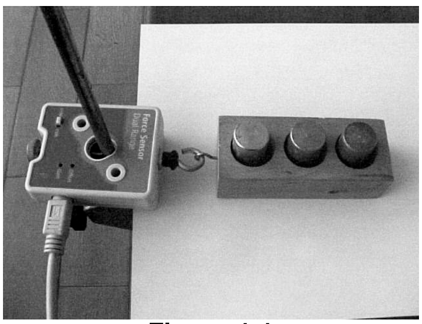

Figure 1.1

The registered signal can be observed in the Figure 1.2

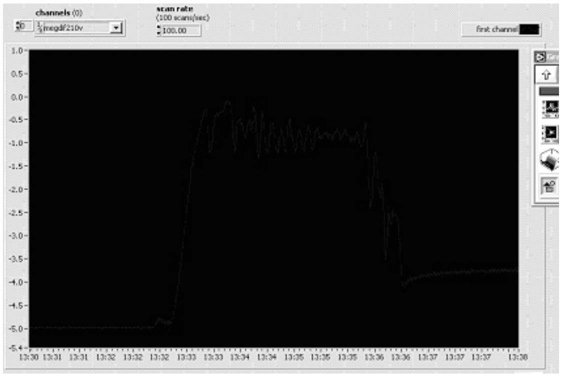

Figure 1.2

2. The oscillatory moving

By using the force sensor we can see how the amplitude of spring pendulum oscillations depends on the resistance of the medium, on the friction. It's an illustration of the oscillating regimes. The experimental set up is shown in the Figure 2.1, and the amplitude of the pendulum in air and water is shown in the Figures 2.2 and 2.3.

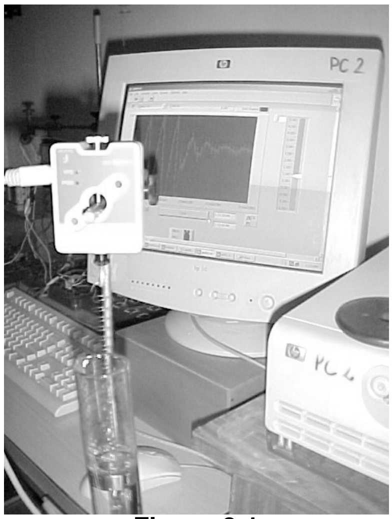

Figure 2.1

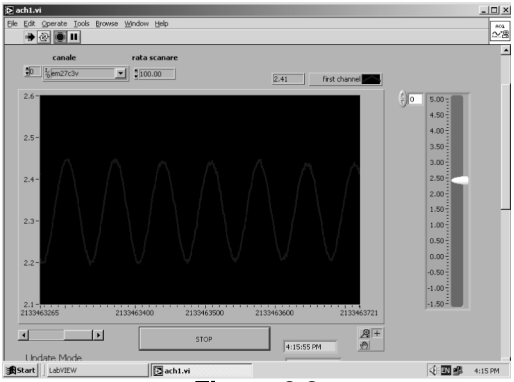

Figure 2.2

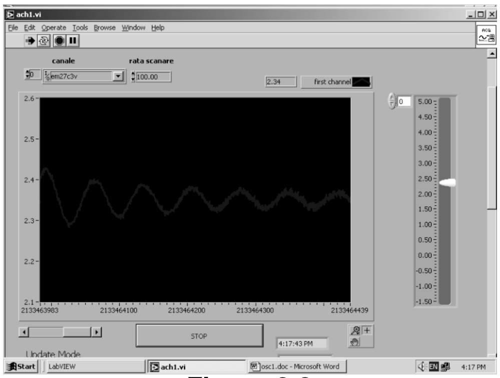

Figure 2.3

3. The study of the collisions

Method 1

Figure3.1

The Force Sensor helps us to register the dependence force versus time during the collision of a metallic ball that free falls over the sensor, (Figure 3.2). The experimental set up is shown in the figure 3.1. By analyzing the registered signal we can calculate the variations of the momentum and kinetic energy.

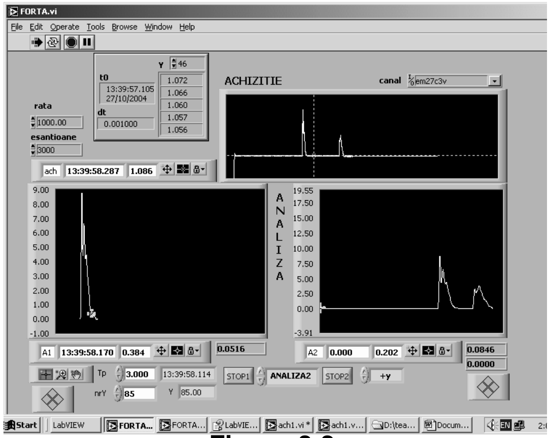

Figure 3.2

Method 2- The experimental set up is shown in the Figure 3.3. The car collides the force sensor which is fixed on the table. For the determination of the speed of the car we have used a photodiode and a led

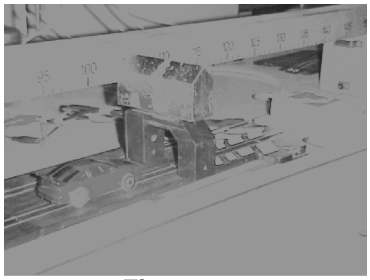

Figure 3.3

Figure 3.4

4. Hooke's Law

The experimental set up is shown in the figure 4.1. The force sensor will work as a dynamometer and will measure the stretching force from the spring and from the elastic band. The values of the stretch are measured using a simple line. The dependences of the stretch versus the stretching force are represented in the Figure 4.2

Figure 4.1

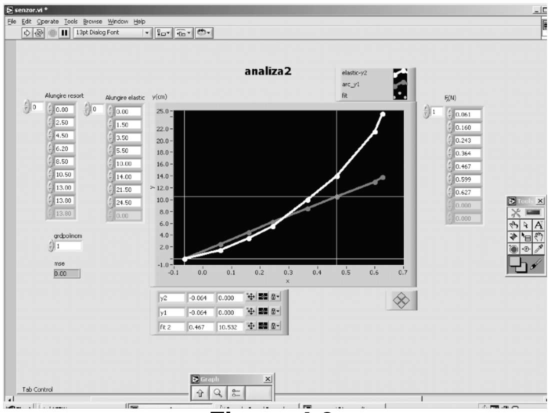

Figure 4.2

5. Magnetic Fields

The magnetic field sensor shown in the Figure 5.1 could be calibrate for measuring the magnetic induction in different fields (figure .5.2).

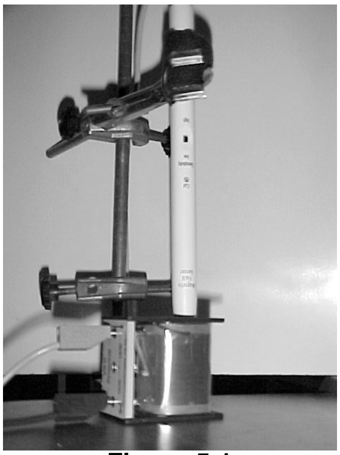

Figure 5.1

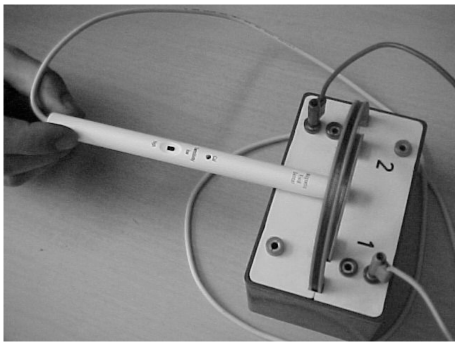

fig.5.2

The Scale of this teslameter looks like the figure 5.3.

Figure 5.3

6. AC circuits

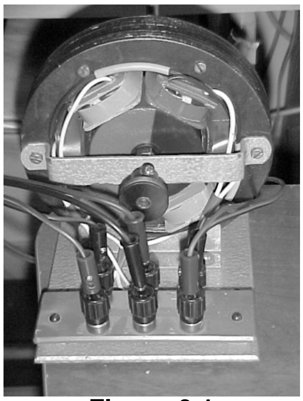

Figure 6.1

The experimental set-up for producing alternating current is shown in the figure 6.1. The basic principle is the electromagnetic induction. The triphase current is shown in the figure 6.2. If only one pair of terminals is connected , than we are speaking of monophase current, figure 6.3.

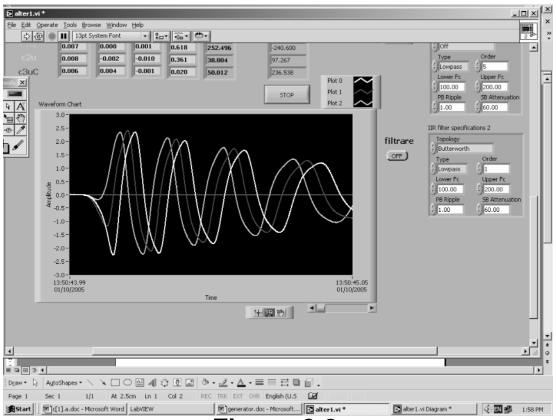

Figure 6.2

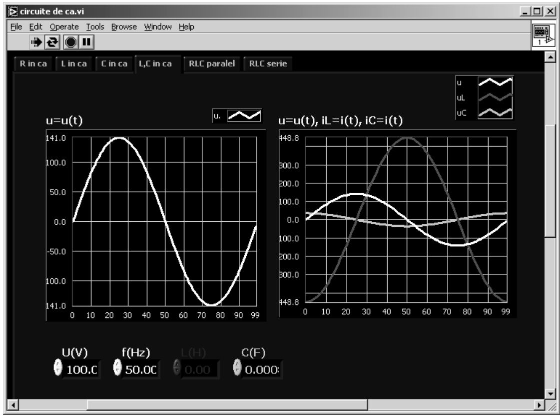

Figure 6.5

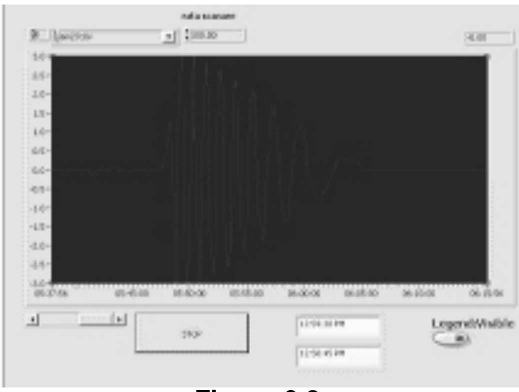
Figure 6.3

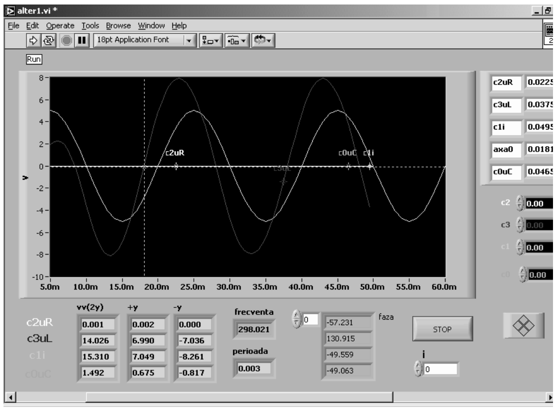

Figure 6.6

Instead of a double spot oscilloscope we can use a virtual circuit (Fig 6.4 şi 6.5) or the data acquisition board NIDAQ-6013 connected in a real one to demonstrate the behavior of the coil and of the capacitor in AC (Fig. 6.6)

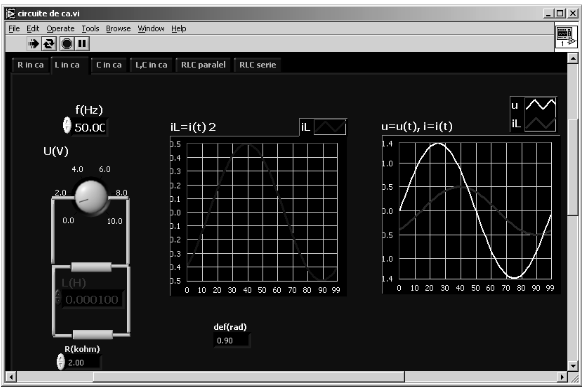

Figure 6.4

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Data aquisition experiments for Science Lessons

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Abstract. *We are trying to develop our studies on exploring and analizing the real world from the Science teacher's point of view, under the frame of the Socrates-Comenius "Hand's on Science" (110157-CP-1-2003-1-PT). We are still using our data acquisition board NIDAQ 6013 which explores the real word (experimental devices, electric circuits, aqueous solutions, plants, human beings) by transforming the computer in a chronometer, a voltmeter, an ammeter, a dynamometer, a teslameter, a Ph-meter, a microphone, a thermometer, a pletysmograf, etc,. Our contribution consists of the choosing and the coupling of the sensors with the data acquisition board and of the analyze of the signals we get. By using the classical set of a magnet (placed on the car) and a coil (with a fixed position), we can register the position of a race car in the circuit, by using a sonic explorer (a toy), we have registered the sonic interference, for the simulation of an acid rain we have used a pH electrode, for measuring the temperature we have used a thermistor, for the muscle fatigue we have used a Force Sensor (bought by the HSCI Network), for the study of the transpiration of a plant we have used a humidity sensor, for the study of the magnetic field we have used a Magnetic Field (bought by the HSCI Network).*

This paper shows a short presentation of these experiments, of the way of gathering and analyze the real signals and the fantastic impact they have on our lessons.

Keywords. LabVIEW, DAQ-data acquisition, DAQ-software, VI-virtual instrument.

1. Phase Transitions

For monitoring a phase transition such as the boiling of the water (fig 1.1), we have used a thermistor as a temperature sensor, by measuring his voltage and the established current. If we can calculate his resistance we can calibrate it as a thermometer. The dependence of the temperature during the heating and the boiling of water, versus time is shown in the fig.1.1.

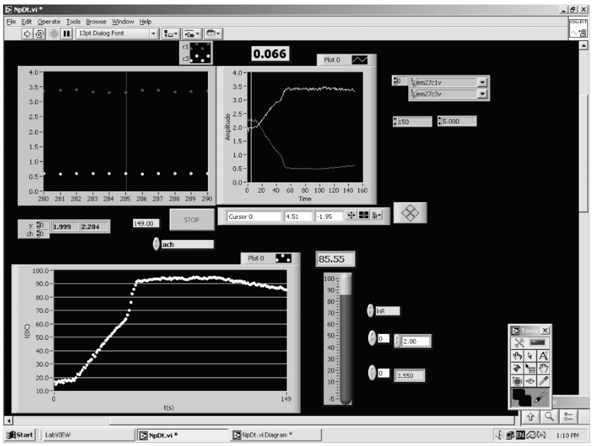

Figure 1.1

2. The Transpiration of the plants

For monitoring the transpiration of a plant we have used a thermistor as a temperature sensor and a sensor for humidity (fig.2.1). The result is shown in the fig. 2.2


Figure 2.1

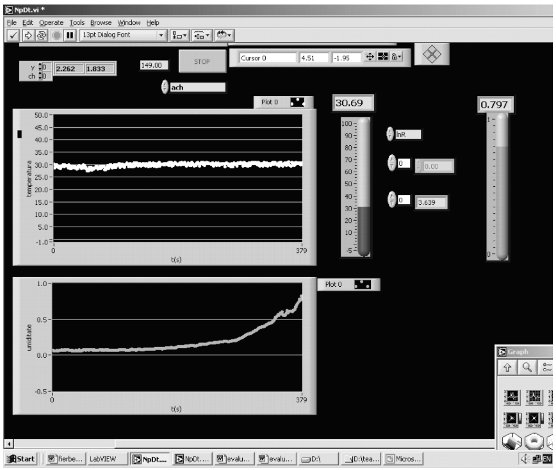

Figure 2.2

3. The monitoring of the cardiac rithm

A simple pletysmograph contain a IR emitter and a phototransistor .(fig. 3.1). It is able to work both on the ear lobe and on the little finger. You can see the results in the fig. 3.2. The acquisition software can show the value of the cardiac rhythm.

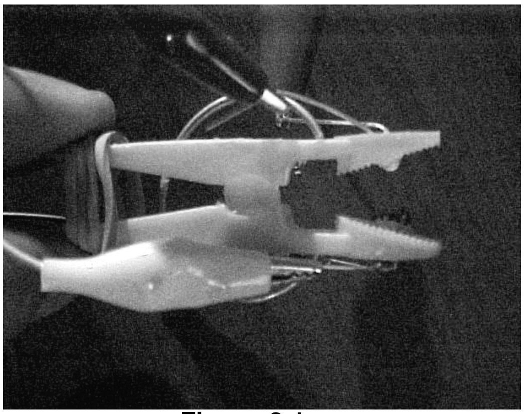

Figure 3.1

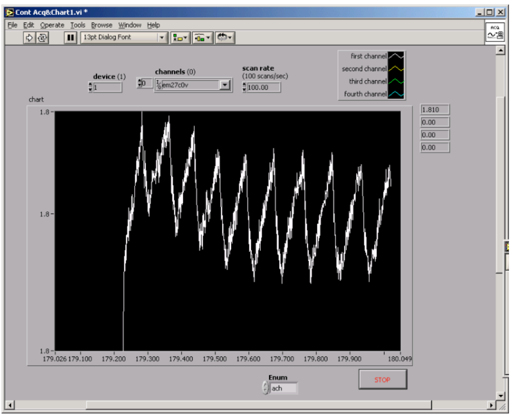

Figure 3.2

4. Acoustic registration

We have used a sonic explorer from the toy shop for acoustic registrations (fig 4.1) In the fig. 4.2 you can “see” a musical LA, emitted by a diapason.

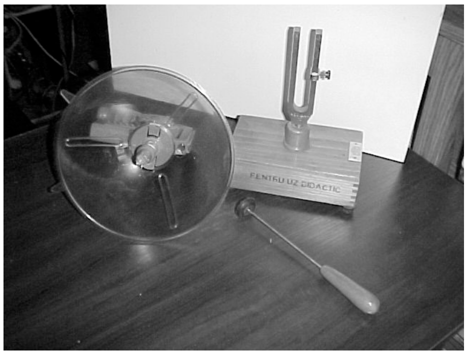

Figure 4.1

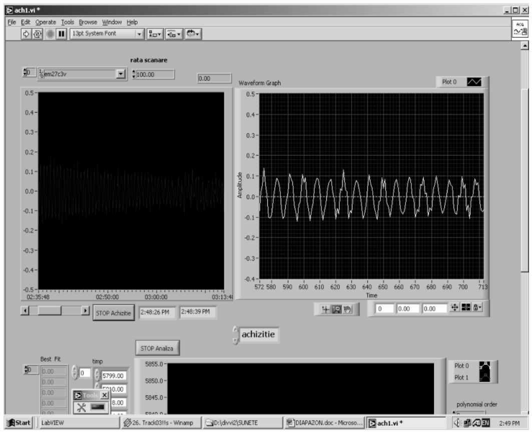

Figure 4.2

The same LA emitted by the organ from the fig. 4.3 looks like fig. 4.4.

Figure 4.3

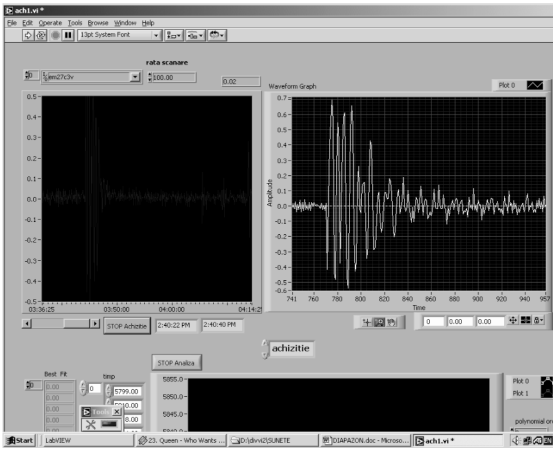

Figure 4.4

The experimental set-up from fig. 4.5, helps us to observe the apparition of the oscillation beats. (fig.4.6)

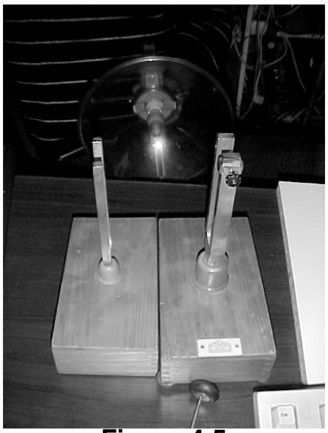

Figure 4.5

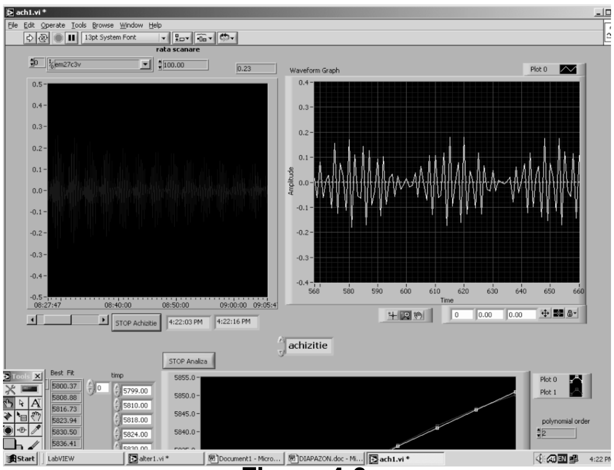

Figure 4.6

And a real sound: Mia, the turtle from our laboratory, during she was arguing us (fig. 4.7.)

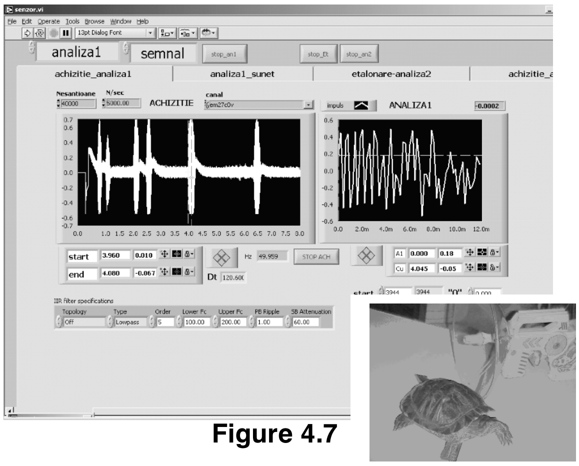

Figure 4.7

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A LabVIEW Simulation of the Ideal Gas Transformations

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Abstract. *In this paper, a software program concerning the ideal gas transformations is presented. The isotherm, the isocore and the isobar transformations are simulated using LabVIEW as a programming medium. The LabVIEW windows contain a vessel filled with a gas, a thermometer and a manometer indicated the temperature and the pressure respectively.*
The three parameters (V, T and P) are connected between them depending on the type of transformation, which is also shown in the window. The time variations of these parameters are recorded on three diagrams (P-V, P-T and V-T) during approx. 60 s.

Keywords. LabVIEW program, simulation, simple gas transformations

1. Introduction

In the 11th grade of the Romanian high schools, the ideal gas, as a physical model for the real gas, is studied from two points of view.

For the microscopic and macroscopic levels the kinetic molecular theory and the thermodynamic method are respectively used.

This paper presents a new approach of teaching the lesson "Simple transformations of the ideal gas" using the LabVIEW program. LabVIEW can be found in Romanian schools due to an agreement between National Instruments and the Romanian Ministry of Education.

2. Simple transformations of the ideal gas

According to the Romanian Syllabus the isotherm, isocore and isobar transformations are studied. Consequently, the simulations have been done for these three processes only.

2.1. Isotherm transformation

An ideal gas with a constant mass undergoes an isothermal transformation when the temperature remains constant during the thermodynamic process and only the pressure P and volume V change. Under these conditions the P – V dependence is governed by the Boyle-Mariotte law (PV = const.). In Fig. 1 the simulation panel for the isotherm transformation is shown. It contains a vessel with a moving piston, a thermometer and a manometer indicating the volume, the temperature and the pressure of the gas during transformation. All the gas parameters, including the number of mols, the temperature, the pressure and the volume are clearly displayed. The amount of gas, representented by the number of mols, must be initially set. The initial and the final volum, together with three different temperature can be also set. When the "RUN" button is pressed, the gas is slowly compressed or expanded from the initial to final volum. Its pressure changes according to the Boyle-Mariotte law. The transformation is shown on three different diagrams in coordinates P-V, P-T and V-T. According to the three temperatures initially set, three different curves appear on each diagram. In P-T and V-T coordinates these curves are streight lines, whereas in P-V coordinates the curves are hyperbolas. The simulation takes about 1 minute. Then it can be re-started with the same or different parameters.

2.2. Isobar transformation

An isobar transformation of a certain amount of gas occurs when the pressure is kept constant. The gas is heated up or cooled down and the correlation between its temperature and volume is given by Gay-Lussac law (V/T = const.). The simulation panel for isobar transformation is shown in Fig.2. It is similar to that described at the isotherm transformation except that a heating source has been introduced below the vessel. This time, three different values of pressure can be chosen. The time variations of the process parameters are recorded on the three diagrams for the three set values of pressure. The simulation takes about 1 minute. The curves are streight lines on all diagrams.

2.3. Isocore transformation

During an isocore transformation for a certain amount of the ideal gas, the gas volume is kept constant, whereas the temperature and the pressure change according to the Charles law (P/T = const.). The simulation panel, which is very similar to that corresponding to the isobar transformation, is shown in Fig.3. Since the transformation occurs at a constant volume, three different values of this parameter can be chosen. The simulation takes also about 1 minute and the curves are streight lines on all diagrams.

During the teaching lessons, the values of the three parameters (P, V and T) can be modified and the student understands much better their interdependence according to the corresponding laws of the thermodynamic processes.

3. Simulation program

The LabVIEW application for simulating the simple transformations of the ideal gas contains a main program and three subprograms. Each subprogram calculates and displays the corresponding data for the isotherm, isobar and isocore transformations. The control panels for the three subprograms are those shown in Figs. 1, 2 and 3. Depending on the type of transformation, one parameter (T, P or V) is set and the other two change according to the corresponding law. The number of mols must be always set.

For each panel the following instruments have been used:

- digital thermometer for the temperature display
- digital manometer for pressure display
- a vessel with piston which is used to simulate the compression or expanding of the gas.
- numerical display for the calculated temperature, pressure or volume.
- graphics in P-V, P-T and V-T coordinates.

As an example, the code of the isotherm subprogram is shown in Fig.4. As it can be seen, it contains a main loop, which is executed as long as the "STOP" button is not pressed. In the loop there is a "case" type structure, which imposes that the data calculation to be made at established moments. In this respect the "get date/time in seconds" function is used [1, 2]. For each subprogram there is a similar code.

4. Conclusions

The presentation of this lesson in front of the students was a real success as the simulation of the simple transformation enabled each student to see directly the modification of process parameters depending on the type of thermodynamic process which was studied.

5. Acknowledgements

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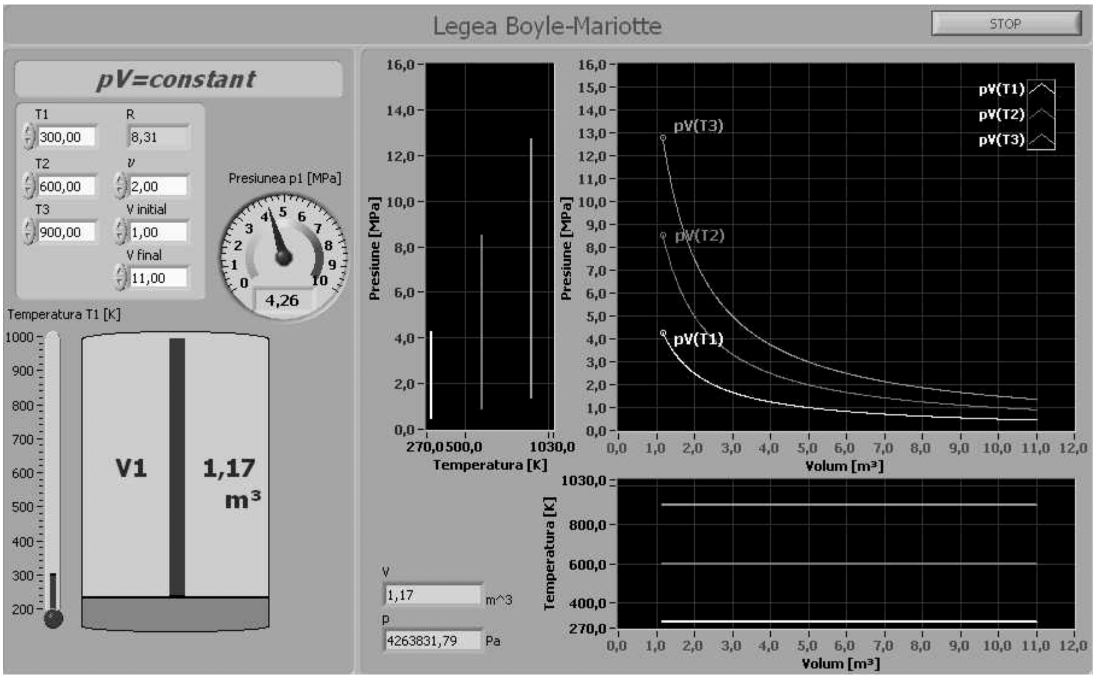

Figure 1. The isotherm simulation panel

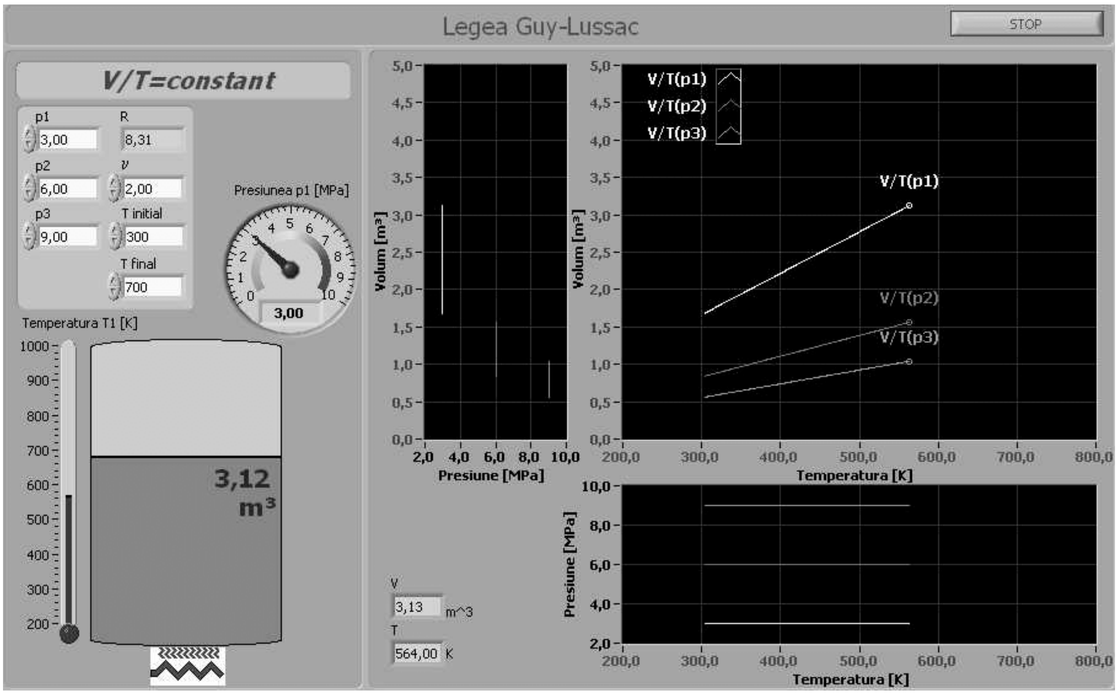

Figure 2. The isobar simulation panel

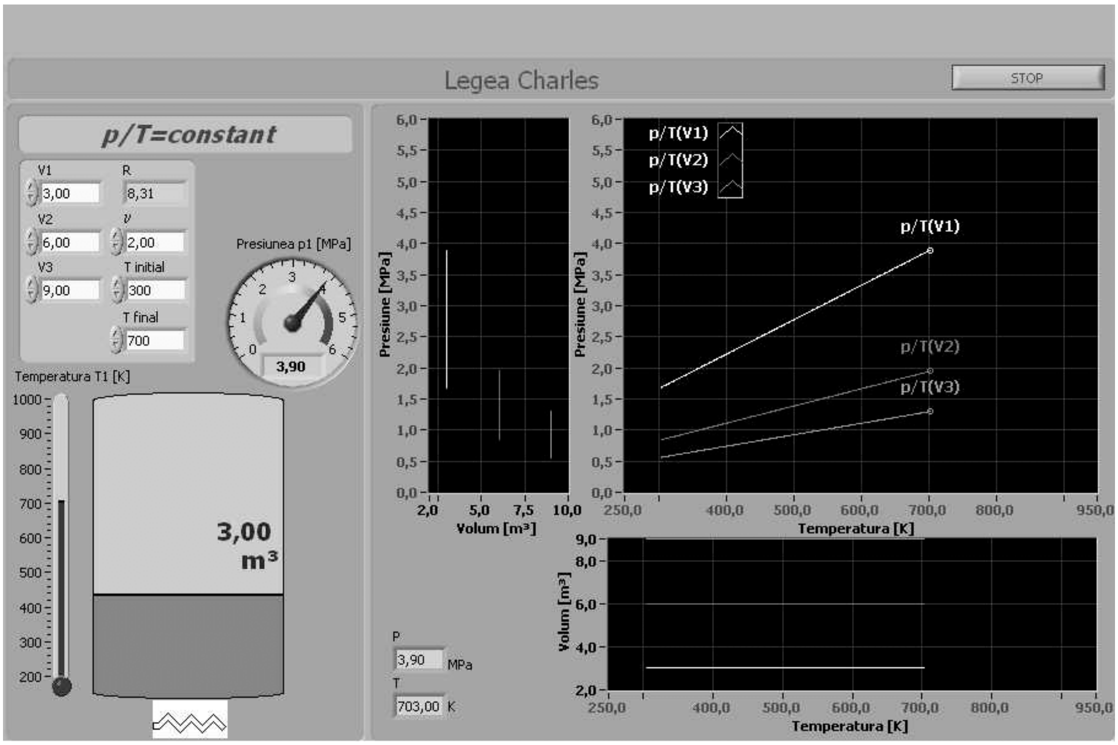

Figure 3. The isocore simulation panel

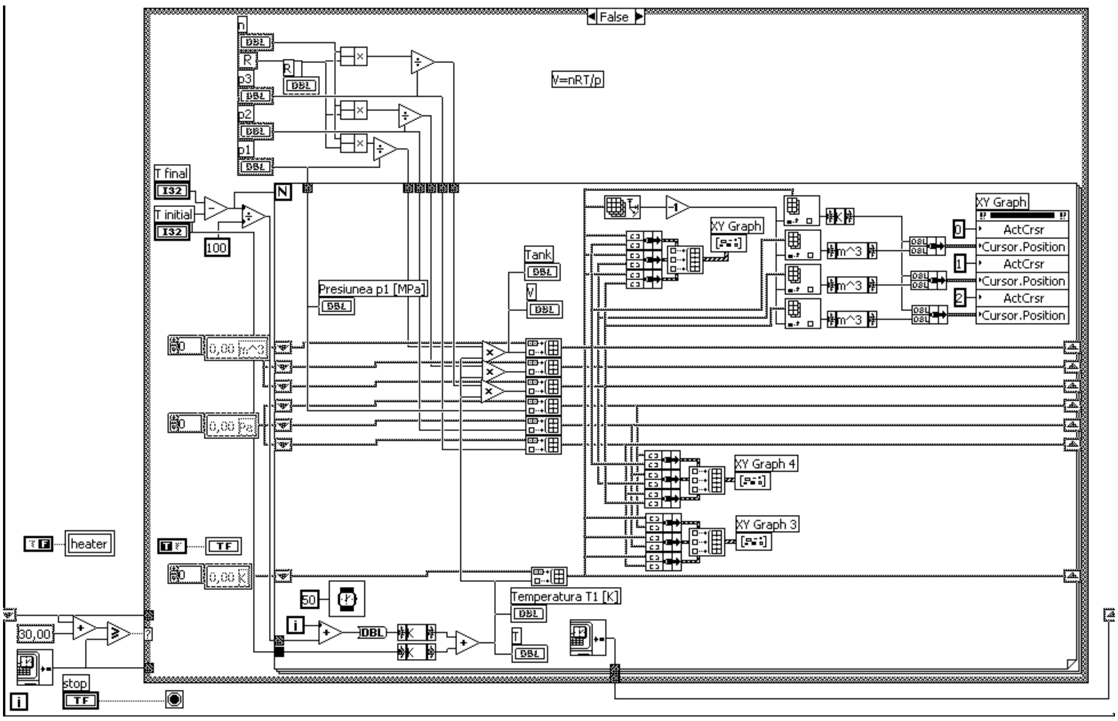

Figure 4. The subprogram code for isotherm transformation

The Technology Fair as means for enhancing problem solving skills and interest in Science and Technology

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Abstract. *This paper presents the idea of using the Technology Fair as a means for promoting students' problem solving skills. The purpose of the study was to investigate the influence of a procedure of working with primary school children to complete and present a Technology Fair project, on the problem solving skills of undergraduate students. Pre-tests and post-tests were administered to undergraduate students before and after the preparation of the Technology Fair, respectively. A number of students were selected and interviewed after the completion of the technology fair. Data were also collected from reflective diaries kept by the students during the preparation of the technology fair. The analysis of the results indicates that the Technology Fair contributes to the development of positive values and attitudes in science and technology education and has a significant influence on improving students' understanding and application of problem solving and decision making strategies within the domain of technology.*

Keywords. Decision Making, Design and Technology, Problem-Solving, Technology Fair.

1. Introduction

Science Fair projects have long been used as a mechanism for promoting scientific skills with an emphasis on learning through "doing". Identifying problems, formulating questions, making observations, proposing solutions, and interpreting data are necessary skills for students in school and throughout their lives. The type of education that places emphasis on these skills through hands-on science activities can simultaneously promote understanding of fundamental principles in science [3] [5].

The Technology Fair is a new idea derived from Science Fair projects that have been taking place for many years by the Learning in Science Group, University of Cyprus. Technology Fair initiatives encourage students to explore their technical environment in a systematic manner. The underlying principle is that participation in a Technology Fair stimulates students' interest in science and technology while simultaneously promoting the development of technological problem solving and decision making as important life skills. In this paper we present a preliminary study of an initiative to integrate the Technology Fair in the context of an elementary teacher preparation program.

2. Theoretical Background

Science and technology education share a commitment to teaching process, scientific method in science, design in technology and problem solving in both areas. Teaching students how to solve problems is an important goal of education.

Problem solving strategies hold a special importance in education. Many tasks performed in professional and daily life require such strategies, which we define as planned sequences of activities leading to a goal which is the solution to the problem. Examples of such tasks are: writing an informative text, designing a product, solving a management problem or a technical or scientific problem. Much research has been carried out into problem solving, analyzing and describing strategies for solving different types of problems, designing instruction and/or training for chosen strategies, and measuring the result of teaching interventions [1].

Problem based learning is an instructional approach that has already been at least implemented on a trial basis in elementary and secondary education [4]. The problem acts as the stimulus and focus for student activity and learning [1]. Learning in this way is purposeful and self-sustaining as the student learns while searching for solutions to the problems they have formulated themselves. Students are actively involved and learn in the context in which knowledge is to be used.

First versions of teaching approaches in relation to problem solving sometimes rely heavily on practicing problem solving on a large number of problems. Instruction and feedback are usually focused on the sequence of problem solving steps to be performed and less emphasis is placed on the knowledge and the cognitive strategies necessary to perform these steps. In the 1980s, researchers introduced new methods of instruction composed of a wider variety of learning tasks. Some of these were based on new insights into cognitive processes. Many of these approaches are inspired by theories on the role of schemata in domain knowledge [6] or by theories on mental models [2]. Recently, more emphasis has been placed on the use of computers and modern information and communication technology (ICT) in the teaching of problem solving and on peer collaboration [7], whereas cognitive psychology has produced new perspectives such as multiple-code theories and connectionist models [10].

Thus, a wide variety of promising instructional approaches is available to teachers, instructional designers, and researchers. However, a more systematic overview of the merits of
the various approaches in terms of learning outcomes achieved in experimental settings is needed as a basis for the application of new methods of instruction [11].

Problem solving and technological developments have much in common. Technologies have historically given solutions to many of the problems people encounter. Problem solving activities provide students with opportunities to create and evaluate designs and to experience knowledge seeking, processing, and applications.

Problem solving activities implemented in technology education expand the opportunities for students. They teach students how to think, make decisions, and apply knowledge learned from experiences in and out of school. It is important for prospective primary teachers to develop this important instructional component.

To develop problem solving skills, students, through practice, must apply problem solving and thinking techniques to solve real problems. Students must merge the content of problem solving and the content of technology and integrate technical skills and problem solving skills. Technology Fair projects provide an opportunity for interaction between undergraduate student teachers and elementary school students so that they can work as a team with shared but different goals: The child aims to solve a problem and present both the problem and the solution during the Technology Fair. The student – teacher aims to use the interaction as a medium for helping the child develop problem-solving skills through a systematic approach.

In the context of Design and Technology problem solving is generally achieved through a sequence of steps called the design process. Based on the work of various researchers [12][9]. Figure 1 presents is an overview of a Design Process that can be followed in almost any technological problem solving activity. While the process has been divided into a number of discrete steps or phases for purposes of clarity, in reality one tends to "jump" between steps as the ideas take shape and one develops the solution to the chosen problem.

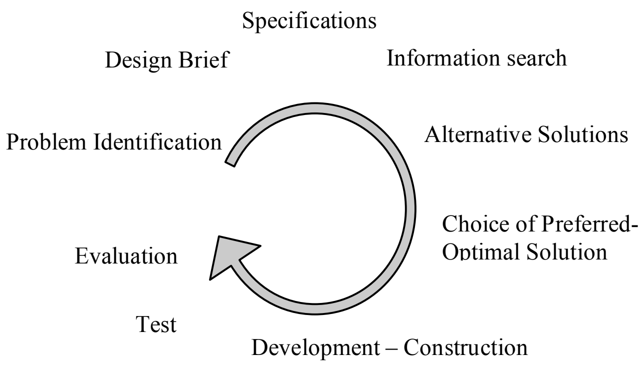

Figure 1. Design process

3. Purpose of the Research

The purpose of the study was to investigate the effectiveness of the Technology Fair in developing undergraduate students' problem solving skills. More specifically, the purpose of the study was:

A. To examine whether the Technology Fair influences undergraduate students' involvement and interests in technology

B. To improve our understanding of the processes used in developing technological problem solving and decision-making strategies and how the Technology Fair could contribute in this direction.

4. Research Design, Methods and Sample

The design of the research was based on the preparation and assessment of a technology fair. Primary school students with the assistance of university primary education students were responsible for identifying a human need, formulating a technological problem collecting information and developing an appropriate solution. Each university student was responsible for collaborating with one primary school student on a single technological project.

In this context, Technology Fair projects provide an opportunity for interaction between undergraduate student teachers and elementary school students so that they can work as a team with shared but different goals: the child aims to solve a problem and present both the problem and the solution during the Technology Fair; the student – teacher aims to use the interaction as a process for helping the child develop problem-solving and decision making skills through a systematic approach.

The Technology Fair was held with the cooperation of a local primary school in November 2004. During the fair, each student teacher displayed a poster describing the design process and the artifact they constructed. Additionally, the children engage the public in a specific aspect of their work through a specially design interactive exhibit. In order to assess their understanding about the design process, a number of tasks were selected and organized into pre-test, mid-test and post-tests. Tests were administered to students before and after the preparation of the technology fair, respectively (25/10/2004, 8/11/2004 and 29/11/2004). All tests included the same tasks.

In addition, each student teacher was asked to keep a detailed reflective diary after every meeting with the child. These diaries formed an additional source of data. In the diary each student teacher recorded all the information about difficulties they encountered and how they were able to overcome them. Additionally, teaching methods, emotions and ideas were reported after each meeting with the primary school student.

Following the completion of the technology fair 12 students were selected and interviewed about their experiences, problems and difficulties faced as well as their interest while working for the fair. Figure 2 shows graphically the design of the research.

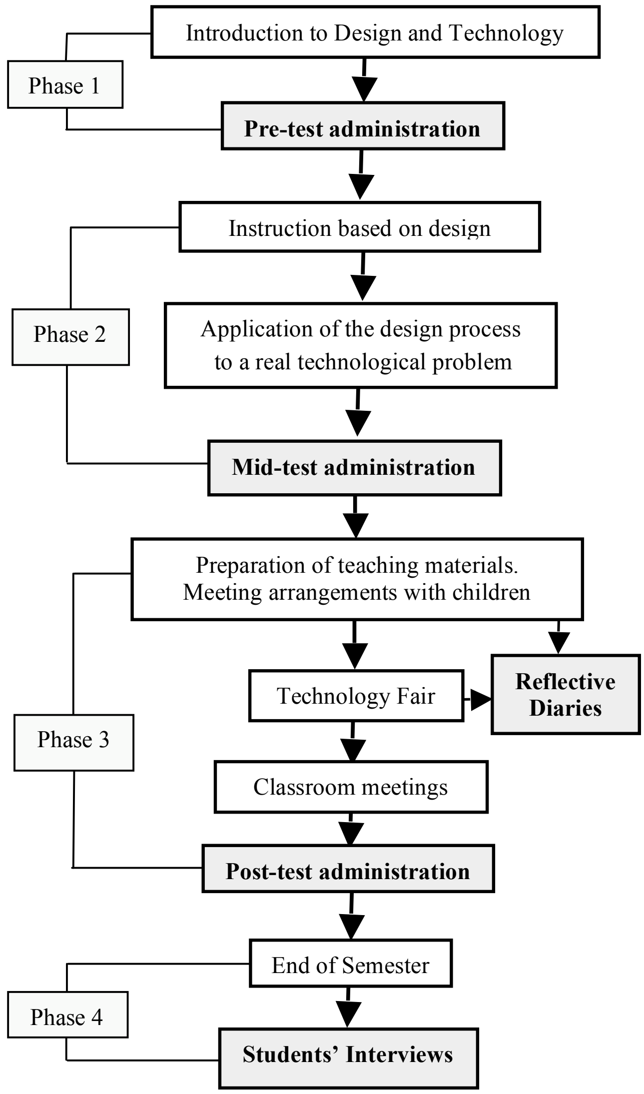

Figure 2. The research design

The sample of the research consists of 82 pre-service teachers at the Department of Educational Sciences, University of Cyprus. All pre-service teachers enrolled in a compulsory course on Design and Technology Education

5. Purpose of each Task in the Test

Eight tasks were designed to assess the understanding of pre-service teachers of the technological problem solving process

Task 1: Requires students to identify a need from the area of Transportation

Task 2: Requires students to formulate the Design Brief for a given problem

Task 3: Requires students to write the specifications and limitations for a given product (Bridge)

Task 4: Requires students to list a number of issues on which they need to seek information in order to be in a position to develop an appropriate solution

Task 5: Requires students to Draw/Sketch possible ideas/solutions for a given problem

Task 6: Requires students to choose a solution from a given table through an optimization process

Task 7: Requires students to Test and Evaluate a finished construction (bridge model)

Task 8: Case study - Requires pre-service teachers to prepare learning activities that take into account the technological problem solving process

6. Results

Responses to pre-tests, mid test and post-tests were analysed using the phenomenographic approach developed by [8].

The test consisted of 8 tasks that required understanding and implementation of the problem solving process in order to solve a new technological problem. The student responses to five of the tasks (task 2, 3, 4, 7, 8) are on an Interval Scale and will be analysed using the paired sample t-test. Three tasks (task 1, 5, 6) have responses on an Ordinal Scale and will be analysed using the Wilcoxon test. Tables 1-2-3 shos the results of the paired t-test for task 2, task 3, task 4, task 7 and task 8. Table 1 shows the comparison between pre-test and mid-test, i.e. the period from the introduction to the topic until the teaching and the implementation of the technological problem solving process. Table 2 shows the comparison between mid-test and post-test, i.e. the period before and after the Technology fair. Table 3 shows the comparison between pre-test and post-test, i.e. the effect of the overall intervention on pre-service teachers problem solving skills.

Table 1. Paired t-test comparing pre-test and mid-test

Task	Mean pre-test	Mean mid-test	t	d.f	p
Task 2	1,13	1,56	-3,84	81	,000
Task 3	3,09	3,39	-1,78	81	,078
Task 4	2,11	3,01	-5,18	81	,000
Task 7	1,21	1,39	-1,50	81	,136
Task 8	1,66	1,82	-1,01	81	,314

Table 2. Paired t-test comparing mid-test and post-test

Task	Mean mid-test	Mean post-test	t	d.f	p
Task 2	1,56	2,51	-9,55	81	,000
Task 3	3,39	6,24	-17,51	81	,000
Task 4	3,01	5,24	-12,19	81	,000
Task 7	1,39	2,54	-10,49	81	,000
Task 8	1,82	6,09	-25,63	81	,000

Table 3. Paired t-test comparing pre-test and post-test

Task	Mean pre-test	Mean post-test	t	d.f	p
Task 2	1,13	2,51	-11,88	81	,000
Task 3	3,09	6,24	-18,30	81	,000
Task 4	2,11	5,24	-19,50	81	,000
Task 7	1,21	2,54	-10,90	81	,000
Task 8	1,66	6,09	-22,81	81	,000

From table 1, we can see that pre-service teachers perform better in mid-test as compared to the pre-test, in task2 and task4. The differences are statistically significant for both task2 and task 4 with $t(81)=-3,84$, $p<0.01$ and $t(81)= -5,18$, $p<0.01$, respectively. There are no statistically significant differences between pre-test and mid-test performance for task 3, task 7 and task 8. From table 2 and table 3 it can be seen that there are statistically significant differences for all the tasks from mid-test to post-test and from pre-test to post-test.

Table 4. Wilcoxon test comparing pre-test and mid-test

	Task 1	Task 5	Task 6
	Mid– Pre	Mid– Pre	Mid– Pre
Z	-1,605(a)	-1,043(a)	-1,502(a)
Sig. (2-tailed)	,109	,297	,133

Table 5. Wilcoxon test comparing mid-test and post-test

	Task 1	Task 5	Task 6
	Post– Mid	Post– Mid	Post– Mid
Z	-5,244(a)	-5,587(a)	-4,310(a)
Sig. (2-tailed)	,000	,000	,000

Table 6. Wilcoxon test comparing pre-test and post-test

	Task 1	Task 5	Task 6
	Post– Pre	Post– Pre	Post– Pre
Z	-6,140(a)	-6,277(a)	-4,978(a)
Sig. (2-tailed)	,000	,000	,000

From the table 4 it can be seen that none of the differences between pre-test and mid-test are statistically significant for task1, task 5 and task 6. On the contrary table 5 and table 6 indicate that there are statistically significant differences for task1, task 5 and task 6 from mid-test as compared with the post-test ((Wilcoxon Z = -5,244, p<0,01, Wilcoxon Z = -5,587, p<0,01 and Wilcoxon Z = -4,310, p<0,01 respectively) and from pre-test to post-test (Wilcoxon Z = -6,140, p<0,01, Wilcoxon Z = -6,277, p<0,01 and Wilcoxon Z = -4,978, p<0,01 respectively).

7. Indications from students' Reflective Diaries and interviews

Almost every student (94%) characterized the opportunity to participate in the Technology Fair as a very important experience for their future teaching career, eg. a student stated in his reflective diary: "*my cooperation with the primary school pupil was very important for my future studies. I found myself improving my teaching skills*"

Students expressed the belief that at the end they were more confident in teaching the subject of Design and Technology in primary school, eg. a student said during his interview: *"After the Technology Fair I am feeling more confident to teach the subject of Design and Technology in primary school. It is very important to have this kind of teaching experience as part of our studies"*

A significant number of students express their positive dispositions and values gained through the Fair. They expressed the importance of hands on activities, the ability to transfer the knowledge and strategies used throughout the fair to other projects or areas of life. They also consider themselves to be more effective in identifying technological problems and to overcome possible obstacles that they might encounter in the process of teaching problem solving skills.

A great percentage (86%) of the students noted in their Reflective Diaries that primary school children worked through the design process with enthusiasm and positive attitude, eg. a student stated in his reflective diary: *"the pupil worked with enthusiasm during the design and construction of his project"*.

The overall process and the presentation of their work in the fair seem to enhance University and Primary school students' motivation and interest in the areas of Technology and Science, eg. a student said during her interview: *"The atmosphere during the Technology Fair was very stimulating for both pupils and students. My pupil showed an interest in every single project presented in the fair"*.

During the Technology Fair pre-service teachers expressed a number of emotions. Their initial emotions were characterized mainly by stress about the teaching process and about the interaction with pupils and their families. After the first meeting students showed different and substantially more positive emotions, eg. a student said during her interview: *"During my first meeting with the pupil I was very stressed. I was worried about the cooperation with the pupil. At the end of our meetings I was really happy and satisfied about our cooperation"* .

8. Discussion

The purpose of the study was to examine the influence of the Technology Fair in developing undergraduate students' problem solving skills. The analysis of the results indicates that the Technology Fair has a significant influence on improving students' understanding and application of problem solving and decision making strategies within the area of Design and Technology.

From the analysis of the reflective diaries kept by university students, and their work (before and during the Fair) it can be concluded that the Technology Fair contributes to the development of positive values and attitudes in science and technology education. Furthermore, the Technology Fair fosters cooperation among the University of Cyprus and local schools. Important factors that emerge from previous research on the Science Fair and are confirmed by this study for the Technology Fair, is the enthusiasm and the motivation that this kind of education conveys to students [3] 1996, [5].

9. Conclusions

Based on the results of the tests, the reflective diaries and the interviews, it can be concluded that the technology fair can enhance the development of technological problem solving skills by pre-service teachers. Another important factor that emerged from this study is the enthusiasm and the motivation that this kind of education offers to both children and students. The technology fair seems to be considered by pre-service teachers as an important educational activity that will help them in their future career. From reflective diaries and interviews it can be concluded that the Technology Fair developed positive values for science and technology. In addition, during the fair, students expressed positive emotions both for the cooperation with children and for the learning gains.

Further research should include the design of teaching material to support the Technology Fair activities. The way students select their solution to the problem from a number of alternatives, through optimization, should be reconsidered (even though a significant improvement was achieved from pre-test to post-test) and a better design strategy should be considered in order to achieve better results. This study also identified a number of limitations that could be improved in future designs of the Technology Fair.

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The Science Fair as a Means for Developing Children's Graphing Skills in Elementary School

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Abstract. *This article reports on an ongoing research program aiming at the pedagogical exploitation of the science fair as a mechanism for developing investigative skills in elementary school and promoting student inquiry through a sequence of formal and non-formal activities. Specifically, this paper refers to the development of data graphing skills by children aged 10-12 years old. The students, who participated in the teaching intervention, were engaged in a process of undertaking and reporting on authentic investigations in order to contribute to a school science fair. The curriculum used in the present study, was drawn from the program "The Science Fair as a means of developing investigative skills". Qualitative and quantitative data were obtained from students' responses to paper and pencil open-ended tests, their notebooks and their posters, which were used as sources of evidence in the present study. Analysis of the results demonstrate children's ability levels on data graphing, difficulties that hamper students' attempts to develop and interpret graphical representations of data, differences between students' graphing achievements between pre-test, mid-test and post-test, and correlations between constructing graphs and interpreting information from graphical representations. This work clearly demonstrates that the construction of graphs needs to be taught systematically in elementary school in combination with other science investigation skills such as interpreting data.*

Keywords. data graphing, formal and non-formal activities, investigative skills, interpreting information from graphs, science fair.

1. Introduction

The rising interest expressed by researchers in reforming science teaching proposes to the promotion of a fundamental objective: to prepare students to participate in a scientifically literate and technologically dependent society as informed and insightful citizens. Curriculum designed for this purpose must provide special emphasis on the development of scientific thinking skills in the context of learning science [18].

The ability to construct graphs is important to science and it can be considered as oe aspect of an individual's scientific literacy [27, 31, 24, 1]. When arguing in favour of a specific theory, a scientifically literate person needs to manipulate data and refer to relationships as they emerged from evidence represented on graphs or tables. Graphs can summarize very complex information or relationships very effectively. The extensive use of computers, nowadays, has made easier the use of graphs as a way of representing data [29, 1, 26]. This has led to an increas in the visibility of graphical representations in the popular press and other mass communication media.

During the last years, the effective use of graphical representations in mathematics and science education has received special attention [25]. Still, there is considerable evidence to suggest that students perform poorly in tasks related to graphing procedures [24, 1]. We take the perspective that graphing strategies need to be systematically promoted in the context of learning science in elementary school within students′ involvement in broader inquiry - oriented activities that are close to their experiences and interests [10]. Hence, there is a necessity for designing teaching interventions aiming at the development of data graphing skills in elementary school through a combination of different learning styles.

The curriculum designed for the purposes of the present research study combines formal, non-formal and informal educational activities.

Students who participated in the research, were involved in data graphing processes as part of the investigations they implemented for participating in a science fair. In this paper, we discuss the results regarding 10-12 year old children´s performance on data graphing, the difficulties that hamper their attempts to graph data and the necessity for a systematic promotion of this skill through science education.

2. Backround

2.1. Data Graphing

Investigation is a process central to science that involves both reasoning and procedural aspects [7, 5]. The ability to organize and implement an investigation can be analysed into specific investigative skills: the identification of variables, the formulation of questions, the experimental design and control of variables, data graphing, the interpretation of data from tables, graphs and combinations of independent sources and the identification of faults in experimental design are examples of such skills [16].

Graphing skills fall into the procedural part of the investigative procedure. Data the emerge from the investigation are organised represented concisely during this stage, which therefore assumes a productive role in sense making. In this context, the production of a graph is a part of a process of problem solving and not an end in itself [1].

Graphs are a flexible medium for displaying data, revealing relationships between variables and communicating the results [27, 31, 29, 24, 1, 26]. Graphs are often preferable to tables for the purpose of displaying data. Firstly, a graph allows the reader to quickly identify trends and relationships between variables and evaluate the strength of the relationships. Moreover, a graph distills a lot of information into a restricted amount of space [27, 31, 24].

The kind of graph chosen for displaying data depends on the type of the variables involved. A histogram is appropriate when the variables involved are categorical and a line graph is preferred when the variables are continuous. Constructing either histograms or line graphs requires some level of abstract reasoning ability. Construction of graphs "involves going from raw data (or abstract function) through the process of selection and labeling of axes, selection of scales, identification of units and plotting" [21]. The complexity in data graphing is identified by researchers [27] who analyzed the skill into other sub skills:

(a) drawing and scaling axes,
(b) assigning manipulated and responding variables to the correct axes,
(c) plotting points, and
(d) using a line of best fit in the case of a line graph or sketching the bars in the case of a histogram.

These subskills can be approached individually in science education as part of the development of data graphing skills [31, 9]. However, we take the approach that graphing skills are better developed in combination with other investigative skills in the context of authentic problem solving situations [19].

2.2. Interpreting information from graphs

The graphing process involves both construction and interpretation [24, 1]. Hence, graphing is sometimes defined as a unique skill that includes two aspects: construction and interpretation of graphical representations.

However, interpretation of information from graphs refers to the ability to read a graph and develop meaning from it. It relies on and requires reaction to a given set of data. This makes it different from the ability to construct graphs, which requires generating new parts that are not given [21].

As a result, the two skills (construction and interpretation of graphs) are approached separately in our educational design. The interpretation of graphs was also analyzed into subskills [27]:
(a) determining the X and Y coordinates of a point
(b) interpolating and extrapolating
(c) stating relationships between variables
(d) interrelating the results of two or more graphs.

Accurate interpretation of evidence relies on good data handling [9]. Hence, the ability to construct graphs would be expected to relate to the ability to interpret information from graphs.

The two skills would be expected to interact throughout their development.

2.3. Difficulties related to Data Graphing

Several studies, that examined graphing tasks, showed that students encounter various difficulties in their attempt to make their own graphical representations [27, 31, 24]. Approaching graphs as pictures is mentioned by researchers as one of the difficulties students come across [21]. Another difficulty refers to student's ability in drawing the best fit line [27]. The construction of a series of graphs, each representing one aspect of the data, was also identified as a difficulty [24]. Difficulties that are common in both interpreting and constructing graphs strengthen the hypothesis that there is a strong relationship between the two skills through their development.

These difficulties seem to function as obstacles to students' efforts to construct graphs and they often make them feel a general lack of competence in graphing. As a result, they prefer constructing a table than a graph and they often draw conclusions with little or no reference to their graphs [27, 9]. The research literature also declares that many teachers seem to recognize that pupils have difficulties in constructing a graph, but only few teach graphing strategies explicitly [9].

2.4. Teaching Approaches

There is comparatively little mentioned in the literature about approaches aiming to systematically promote data graphing in science education. Graphing is often considered as a domain only of Mathematics. However, research has shown that many students cannot apply what they have learned about graphs in mathematics to science or other disciplines [23]. Hence, since data graphing is a part of the investigative procedure, it can and should be systematically addressed within science education.

Several research attempts demonstrate that students can improve their graphical techniques through computer-based learning environments, especially the process of interpreting and manipulating graphs [29, 1, 26]. Yet, students firstly have to be encouraged to construct graphs within paper and pencil activities, which is probably more meaningful and understandable for them and then become involved in activities with spreadsheets.

2.5. The Science Fair

The Science Fair is a non-formal learning activity in which students implement science projects and exhibit them to the public [30]. Educators internationally use the science fair activity for two main reasons. First, students participating in a science fair are encouraged to become involved in issues related to science and hence, they develop positive attitudes towards science learning. Second, parents have the opportunity to become involved in the learning process [3, 4, 8, 6, 12, 15].

There are relatively few examples of fairs that have clearly specified educational goals and are assessed for their learning outcomes. The very loose connection with the official curriculum is one of the disadvantages of science fairs that are usually acknowledged as the reason for considering them as celebratory school events without much emphasis on the learning outcomes [2, 13, 4].

However, our literature review suggests that when a science fair is used as a learning activity, the students participating:

(a) develop critical thinking skills, problem solving skills and social skills [3, 8]
(b) enhance their opportunities to develop an understanding of the nature of the work of scientists [4, 6, 13, 22].

In our research, the science fair is used as an extended instructional activity that combines formal, non-formal and informal activities and aims at the improvement of investigative skills in elementary school. According to the approach that has been developed, the science fair is the final stage in a long process, where students undertake authentic investigations related to simple questions of their own interest. They work collaboratively to implement an investigation in which they design experiments, collect data, construct graphs and formulate answers. The whole process culminates in a specially organized school event (*the science fair*), during which children display the procedures and results of their investigations and also engage in interactive activities that they have designed in collaboration with their parents in order to teach certain aspects of their investigation to visitors.

We used this teaching context to investigate the development of children's ability to represent evidence in graphical form. Two examples from the students' efforts to graph data for the purposes of their investigations are presented in figure 1.

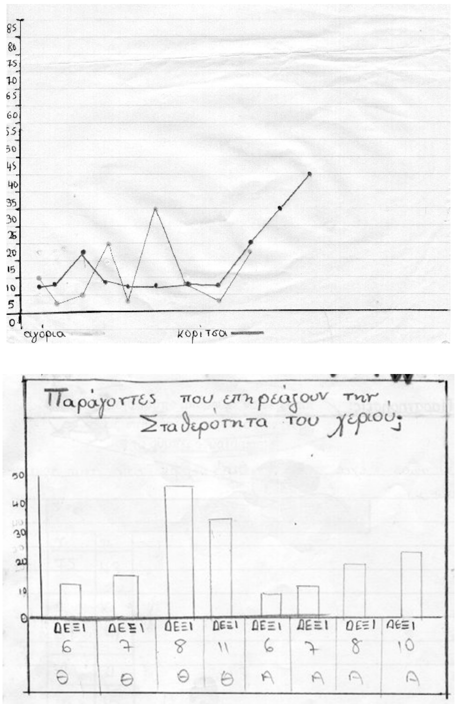

Figure 1. Examples of student's efforts on data graphing

3. Research study

3.1. Participants

Thirty-five 5-graders of a rural primary school in Cyprus participated in this study. The students were engaged in both the formal teaching intervention and the science fair.

The curriculum used in the present study, was designed for the purposes of the research program: *The Science Fair as a means of developing investigative skills, that is* implemented by The Learning in Science Group at the University of Cyprus. The program focuses on the pedagogic exploitation of the science fair as a means for developing investigative skills in elementary school and promoting student inquiry through a sequence of formal and non-formal activities. The teaching and learning materials, involve a handbook for teachers, a student workbook and an investigations' booklet [5]. Part of the material is available online for use by teachers, students and parents [17].

3.2. The Intervention Program

The study was divided into three phases, as shown in figure 2. In the first phase, the students participated in a teaching intervention, which took place in a formal classroom setting. One of the lessons was devoted to data graphing strategies. During the non-formal phase, students implemented their investigation collaboratively and interacted with other students, their teachers and their parents in preparation for their participation in the science fair. The children formulated investigative questions, designed and implemented valid experiments, described their procedure in a notebook and created a poster for displaying their methods and results. Whenever it was possible, the students constructed graphs to display their data. The actual science fair took place in the third phase of the research.

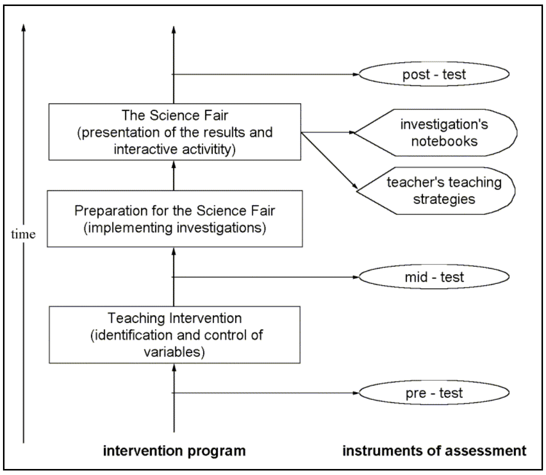

Figure 2. Organization of the research study

3.3. Method

For the purposes of the research study, paper and pencil open-ended tasks were administered to the research participants, before and immediately after the formal teaching intervention and after the Science Fair. Totally, four of the tasks aimed at evaluating students' abilities to graph data. Each instrument was administered at least twice during the study. Tasks 1 and 2 were included in the pre and post test. Tasks 3 and 4 were included in the mid and post test.

All assessment tasks presented unfamiliar situations that have not been encountered during the intervention. The context of tasks 1, 2 and 4 was associated with science experiments and the context of task 3 related to everyday situations that were not associated with science by the children. Moreover, in tasks 1 and 4 students were expected to construct histograms and in tasks 2 and 3 students were expected to construct line graphs. These were stringent criteria that helped us measure real learning as demonstrated by the ability for knowledge transfer.

Task 1.
Melina filled up 3 pots with water of different temperatures: pot A with hot water, pot B with lukewarm water and pot C with cold water. He measured the time needed to dissolve sugar in each pot and organized the data in the table below:

cup	time for sugar to dissolve
A-hot water	12 sec
B-lukewarm water	17 sec
C-cold water	30 sec

Construct a graph with the data displayed on the table.

Task 2.
Simon took two similar plants. He placed plant A in the light and plant B in the shadow. He measured the height of the plants every three days. He organized the data collected in a table as shown below:

day	1st	3rd	6th	9th	12th	15th	18th
height of plant A	5cm	6cm	8cm	10cm	12cm	13m	15cm
height of plant B	5cm	5cm	6cm	8cm	9cm	11cm	11cm

Construct a graph with the data displayed on the table.

Task 3.
Mr Manolis wrote in a table how many costumes and jackets were sold in his shop between April and August.

month	costumes	jackets
April	250	150
May	200	200
June	150	400
July	100	500
August	140	450

Construct a graph in order to compare the number of costumes and jackets sold in each month.

Task 4.
Leonidas investigated if the colour affects the extent of transparency of a surface. He used surfaces of four different colours: yellow, red, colourless and blue. He counted the number of surfaces needed to cover completely a specific drawing.

colour of the surface	number of surfaces
yellow	24
red	15
non-colour	29
blue	18

Construct a graph to display these results

Posters constructed by the students for the purposes of the Science Fair and their notebooks were used as additional evidence in the research.

4. Findings

Qualitative and quantitative data were obtained from the phenomenographic analysis of student's responses to the four tasks.
The results demonstrate:

- Ability levels on data graphing
- Difficulties that hamper students' attempts to graph data
- Significant student differences on graphing achievement on pre-test, mid-test and post-test
- A significant interaction between the skill of constructing graphs and the skill of interpreting information from graphs

Student's notebooks and posters were mostly used to identify difficulties that students come across in their attempt to construct graphs.

4.1. Description of Students' Responses

In tasks 1 and 4, most of the students constructed histograms as they were expected to. Before the intervention (as demonstrated by their responses to task 1), students had chosen the appropriate type of graph. However, most of them either scaled wrongly the axes or did not assign any variables to them. After the teaching intervention (as shown from their responses to task 4), a high percentage of students constructed the suitable type of graph (histogram), they assigned the corresponding variables and they scaled the axes correctly. At the end of the intervention program, in both tasks, almost everybody managed to assign correctly the corresponding variables and to scale the axes correctly in the histograms they created.

In tasks 2 and 3, students were expected to construct line graphs. Before the teaching intervention (as shown from their responses to task 2), most of the students assigned the variables in an inappropriate type of graph (a histogram) and they scaled wrongly the axes or did not scale them at all. The majority of the students did not assign the corresponding variables. Many of them did not offer an answer at all. In task 3, which was administered for the first time after the formal teaching intervention, many students again did not come up with an appropriate type of graph. Most of them constructed a histogram, without any or wrong scaling and assigning of the variables. In a high percentage of these responses, the axes were scaled correctly, but the variables were not assigned properly. After the science fair, the majority of the students still did not choose the appropriate type of graph to present the data in both tasks and they encountered several difficulties in scaling the axes or assigning the variables. Only a few of them constructed a line graph and assigned the variables and/or scaled the axes correctly.

The responses of the students on each task were analyzed phenomenographically. The groups that emerged were compared and organized in eight general categories, which were ordered hierarchically from the lower level to the higher. Finally, the responses in each task were classified into the levels described below.

4.2. Ability Levels on Data Graphing

The eight ability levels on data graphing, which derived from the phenomenographic analysis of student's responses, are:
Level I: S/he does not answer, or s/he does not understand the question or s/he simply reconstructs the given table
Level II: S/he does not choose an appropriate type of graph, does not assigns the corresponding variables and does not scale the axes
Level III: S/he chooses an appropriate type of graph, without assigning the corresponding variables or scaling the axes
Level IV: S/he does not choose an appropriate type of graph, but s/he

- assigns only the independent or the dependent variable, without or with wrong scaling of the axes
- assigns the independent variable with verbal reference to the dependent variable, without or with wrong scaling of the axes

Level V: S/he does not choose an appropriate type of graph, but s/he

- scales the axes correctly without assigning the corresponding variables, or
- assigns only the independent variable with correct scaling, or
- does not assign the independent variable, but s/he refers to the dependent variable verbally and scales the axes correctly, or
- assigns the independent variable with quantitative reference to the dependent variable, and correct but sometimes double scaling of the axes

*Level VI***:** S/he chooses an appropriate type of graph, but s/he

- assigns the independent variable with quantitative reference, includes only verbal or no reference to the dependent variable and s/he scales the axes wrongly
- does not name the variables, but s/he scales the axes correctly
- assigns only the independent variable and does correct but double scaling of the axes

Level VII: S/he does not choose an appropriate type of graph, but s/he assigns the corresponding variables and s/he scales the axes correctly
Level VIII: S/he chooses an appropriate type of graph. S/he assigns the corresponding variables and s/he scales the axes correctly

Typical examples from students' responses are presented below:

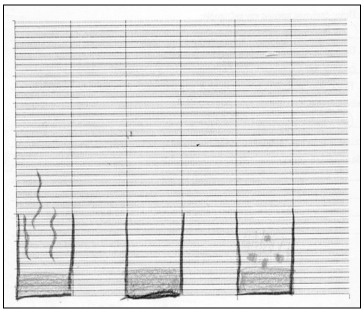

Figure 3. Example from task 1 – level 1

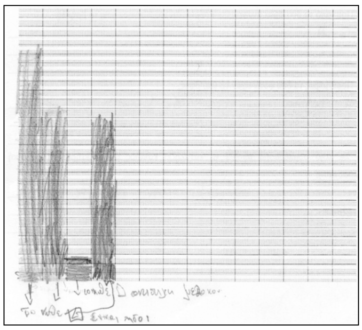

Figure 4. Example from task 4 – level 2

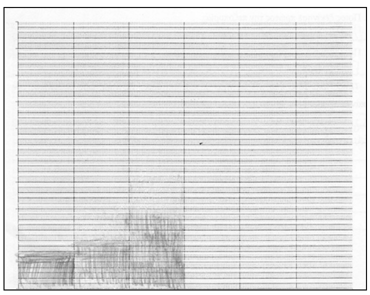

Figure 5. Example from task 1 – level 3

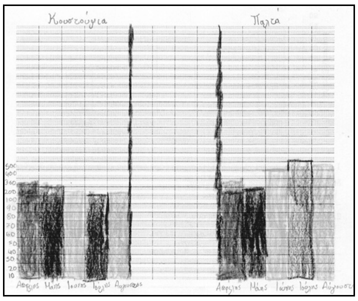

Figure 6. Example from task 3 – level 4

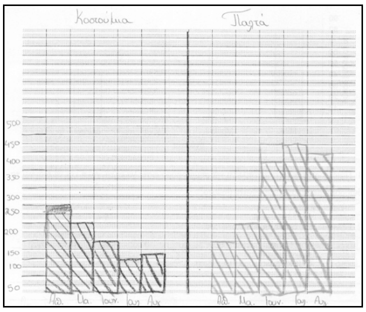

Figure 7. Example from task 3 – level 5

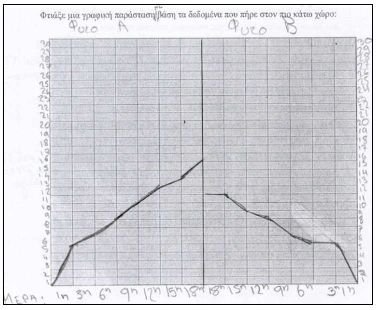

Figure 8. Example from task 2 – level 6

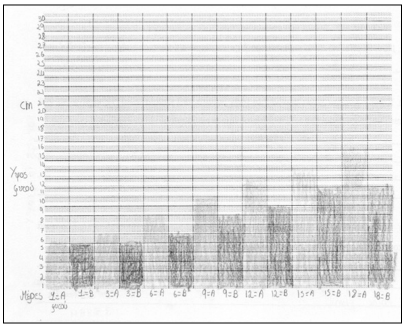

Figure 9. Example from task 2 – level 7

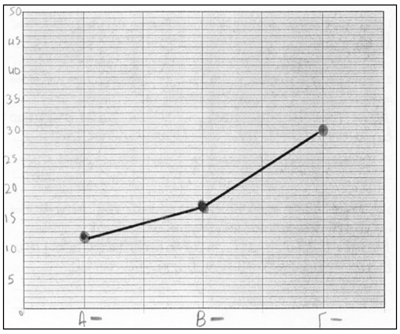

Figure 10. Example from task 1 – level 7

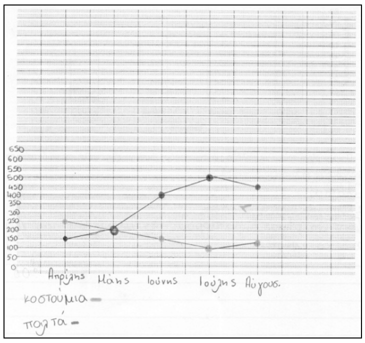

Figure 11. Example from task 3 – level 8

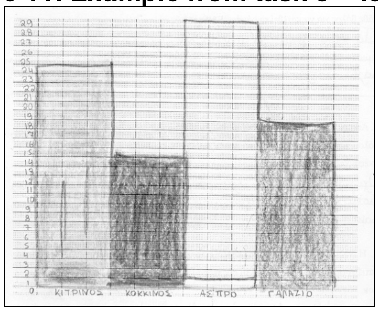

Figure 12. Example from task 4 – level 8

4.2. Student Difficulties with Data Graphing

The students seemed to encounter various difficulties with graphing. Three of them are given below with typical examples:

Difficulty 1: Students tend to construct histograms rather than line graphs, even when the dependent variable is continuous. They understand that they have to display the variation in the values of the corresponding variables, but they prefer a histogram in doing so, as shown in the example below.

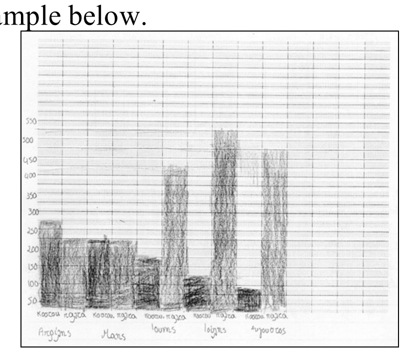

Figure 13. Example from difficulty 1

Difficulty 2: Students tend to believe that graphs can present only a small number of measurements (a couple of values). They have difficulty in realizing that it is possible to display the continuous variation of these quantities through the same graph, as shown in the example below.

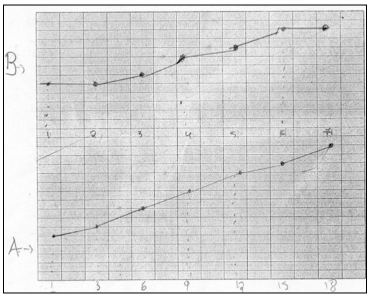

Figure 14. Example from difficulty 2

Difficulty 3: Children do not appreciate the importance of scaling the axes correctly, so as to make it possible to compare the quantities. They do not scale the axes in equal intervals, but according to the space they have to construct their graph, as shown in the example below.

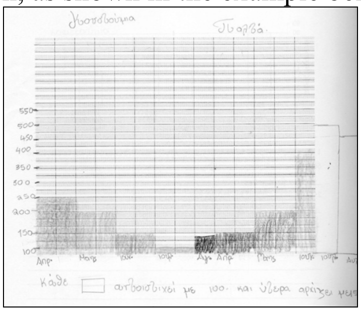

Figure 15. Example from difficulty 3

4.3. Comparing students' graphing achievement on pre-test, mid-test and post-test

Students' responses to all tasks were evaluated and categorized (false answer – score=0, correct answer – score=1). We used the Paired-Samples T-test to compare students' achievement on each task between pre-test, mid-test and post-test.

The mean score on each task and the results of the statistical analysis are presented in table 1:

Table 1. Paired-Samples T-Test

Task	pre-test (mean score)	mid-test (mean score)	post-test (mean score)	T	df	Sig
1	0,34		0,66	-2,750	34	,009*
2	0,00		0,06	-1,435	34	,160
3		0,03	0,09	-1,435	34	,160
4		0,63	0,77	-1,406	34	,169

Table 1 shows that the mean score of students' achievement in all tasks was higher after the intervention program. However, the difference in students' achievement was statistically significant with $t_{(34)}$= -2,750 and a p-value of ,009 (<,05) only in the case of task 1. Students' achievement is also higher on constructing histograms (tasks 1 and 4), as compared to constructing line graphs (tasks 2 and 3).

We also used the Paired-Samples T-test to compare students' achievement between the total mean score on each test (pre-test, mid-test and post-test). A student's achievement on each test was the mean score of the graphing tasks. The results of this analysis are presented in table 2.

Table 2. Paired-Samples T-Test

	pre-test (mean score)	mid-test (mean score)	post-test (mean score)	t	df	Sig
Data graphing	,171		,357	-3,404	34	,002*
		,328	,269	-1,871	34	,070

Table 2 shows that the difference of students' achievement between pre and post test is statistically significant, with $t_{(34)}$= -3,404 and a p-value of ,002 (<,05). There is no statistically significant difference between mid and post test, with $t_{(34)}$= -1,871 and a p-value of ,070 (>,05).

4.4. Interactions between data graphing and interpreting graphs

In order to identify any interactions between the skills of data graphing and interpreting graphs, we estimated the Pearson Correlation. Table 3 presents the correlation between the two skills on pre, mid and post test.

Table 3. Pearson Correlations and signifigance level

skill				Interpreting data from histograms	Interpreting data from line graphs	
Data graphing	Pre-test	Achievement 1	Pearson	-.150	.341*	---
			df	35	35	---
			Sig.	.390	.045	---
	Mid-test	Achievement 2	Pearson	---	---	.390*
			df	---	---	35
			Sig.	---	---	.02
			Pearson	.082	.138	.072

	df	34	35	35
	Sig.	.647	.430	.680
Achievement 4	Pearson	.195	.371*	.090
	df	34	35	35
	Sig.	.268	.028	.608

Table 3 shows that before the intervention there was a statistically significant correlation between students' achievement on data graphing and interpreting data from line graphs, with $P_{(35)}$=,345 and a p-value=,045 (<,05). This interaction remains statistically significant after the formal teaching intervention, with $P_{(35)}$=,390 and a p-value=,02 (<,05) and after the science fair, with $P_{(34)}$=,195 and a p-value=,268 (<,05). There is no statistically significant correlation between data graphing and interpreting data from histograms. This might reflect the large difference in emphasis given to these two types of graphs in the context of formal education in Cyprus at these age levels.

5. Discussion

This study refers to a research program in which the Science Fair is used as an instructional activity aiming at the development of investigative skills in elementary school and the promotion of students' inquiry skills through a sequence of formal and non-formal activities.

The results presented in this article show that active participation in a science fair can lead to constructive development of graphing skills. Particularly, in this study we identified eight achievement levels on data graphing and several difficulties that hamper students' efforts to represent data using graphs. However, quantitative results showed that the students who participated in the research scored higher in all the tasks at the end of the intervention program. Their performances were better in tasks referring to the construction of histograms as compared to line graphs. The improvement in their performance was always significant after the whole intervention program. Finally, the results also demonstrate that the skill of constructing data graphs interacts with the skill of interpreting information from line graphs. This study also demonstrates that data graphing skills need to be taught systematically in elementary school in combination with other science investigation skills such as interpreting data.

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Hands-on quantum physics — Introducing quantum principles to non-physics major's students

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Abstract. *An effort to enrich a university course of non-physics majors, with principles of quantum mechanics is mainly not widely supported because it demands strong competences in physics and mathematics. This obstacle can be surpassed by the use of ICT applications and hands-on activities. An intervention was conducted to students of the Pedagogical Department of the University of Athens.*

In order to support the intervention, educational material was developed including the subjects: mechanical waves, duality of light – with reference to duality of electrons–, line spectra, atomic models for the atom of Hydrogen

Keywords. curriculum, hands on activities, quantum mechanics, software

1. Introduction

The last two years in the Pedagogical Department of the University of Athens the curriculum of science education course is enriched with principles of quantum mechanics. The students of our Department have a low background in physics and mathematics. The effort to enrich a university course of non-physics majors, with principles of quantum mechanics is mainly not widely supported because it demands strong competences in physics and mathematics. This obstacle can be surpassed by the use of ICT applications and hands-on activities.

2. Reviewed literature

The so far reviewed literature brought out researches which introduce quantum mechanics to non-physics major's or to students of high school education. These researches aim to estimate the mental models of students of upper high school [4], [2], [3], or of students of non-major physics Departments [5], [1], concerning quantum phenomena (duality of light / electrons, non locality…) and the atom of hydrogen, while in some cases the research is followed by an intervention based on educational material which includes simulations / visualizations, animations, applets.

3. The Software

3.1 The characteristics

In order to support the intervention, educational material has been developed the previous academic year. The developed educational material has the following characteristics: a) methodology based on the educational method. The consisting steps of the method, in both options, may be described as (table 1):

Table 1

Scientific method	*Educational method*
trigger in research	trigger student's interest
making hypothesis	questioning the problem
experimentation	work in the lab or/and in situ
Developing theory	conclusions
testing of theory	problem transfer, generalization

Educational method used for the intervention

b) scientific and historical models transformed to curricular / educational models, c) simulations / visualizations of probabilistic microkosmos and quantum mechanic model of Hydrogen, based on methods of the stochastic analysis and Monte Carlo techniques, d) hands on experiments in order to study phenomena concerning the wave nature of light (diffraction, interference) or different spectra, e) web-based environment.

3.2 Description of the units

The developed software includes six units:

1. mechanic waves, 2. duality of light, 3. spectrum, 4. early models of atom, 5. the quantum –probability– model for the atom of hydrogen 6. electric current.

In the first unit we examine the characteristics of a wave, longitudinal and transverse wave, wave interference and stationary waves.

In the second one, we have included experiments with laser and hands on materials in order to show interference (figure 1), diffraction (figure 2) and a simulation program (figure 3) for the photoelectric effect.

Figure 1. Interference pattern

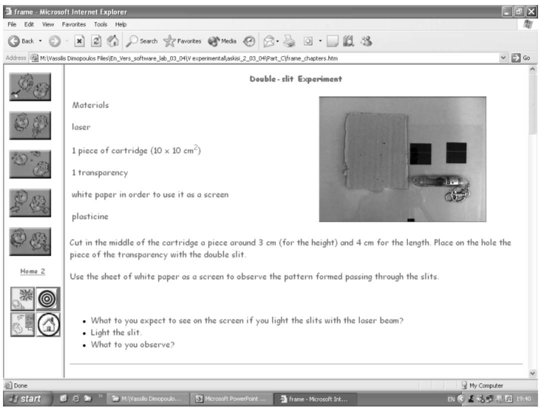

Figure 2. The page of the software for the double-slit experiment

In the simulation program both the macro and the micro-scopic view of a circuit appear, in order to present the photoelectric effect. The program aims to bring out, that when the intensity of light is changed, although the number of electrons emitted is proportional to the light intensity, the maximum kinetic energy of the electrons is independent of light intensity, a fact that cannot be explained by the concepts of classical physics and the wave nature of the light. The kinetic energy of the electrons increases when we increase light frequency.

Furthermore, in this unit, reference is made to historical experiments, concerning the nature of light / electrons such as the two slits experiment of Claus Jönsson conducted in 1961.

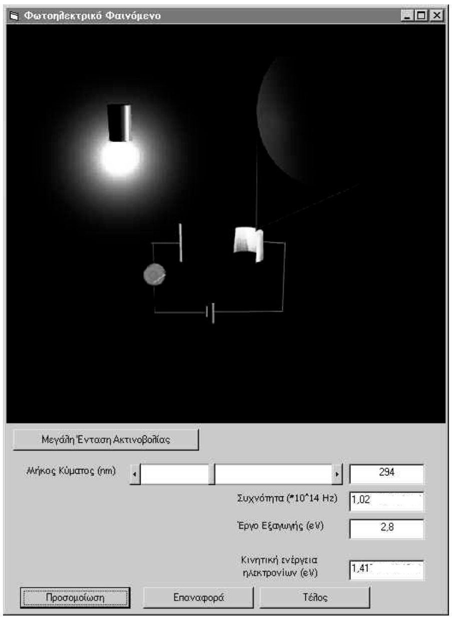

Figure 3. Visualization program for the photoelectric effect

In the third unit we have included experiments with spectroscope in order to study continuous and linear spectra (figure 4). The unit, also, includes a page with instructions for the building of a spectroscope.

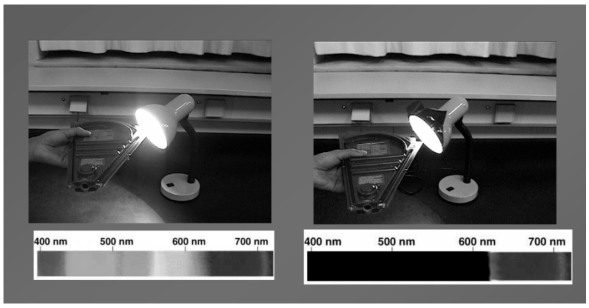

Figure 4. Observing spectra

In the next two units we study the early models of atom (including the Thomson's, the Rutherford's model and the Bohr's atom of hydrogen) and the probability quantum mechanics model. In order to present the probability model, a simulation programm has been developed which includes 2D and 3D models representing the radial probability distributions of an electron for the 1S, 2S and 2P states in hydrogen (figure 5-6). The models have been developed in 3d studio max. In this program the possible positions of an electron, around the nuclei, are represented by dots and the shape of the probablity model is created. The shape, the size and the orientation of the probability model is determined by three quantum numbers.

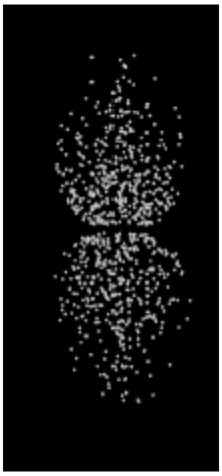

Figure 5. Probability model for the n=2, l=1, m=0 state of the atom of hydrogen

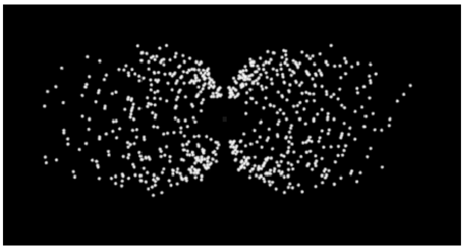

Figure 6. Probability model for the n=2, l=1, m=1state of the atom of hydrogen

In the last unit we study electric current, in order to show an application of quantum mechanics to phenomena that can be explained by both a classical and quantum mechanic model.

The software was implemented in four classes of 120 students of the Pedagogical Department of the University of Athens. The students had limited mathematics and science background and were on the third year of their studies, taking the obligatory physics lab course.

5. Conclusions

The developed material aims to present one of the most attractive thematic of Physics to a broader audience –to students with limited math / physics background. The so far research showed that this can be achieved up to a level by the educational approach we propose.

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Complete Interactive Environment for Science Training

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Abstract. *Representation of an educational environment which offers the combined use of the advantages provided by ICT and science laboratory.*

The main aspect of the proposed educational environment is the use of ICT not in the form of custom made, usually complex and difficult to use and understand tools but on the contrary with the use of common applications which are supplied and installed by the operating system on every windows-compatible computer. Expected outcome of such an action is simplicity and effectiveness.

The experimental procedure can now be included in a daily basis. Inclusion of new educational material or adaptation of the existing one relative to custom needs is possible and expected. Access to the material can be done either locally or through routed networks, even Internet.

Keywords. information technology, computer, experimentation, computer based training,

1. Introduction

The main motive for every educational approach, modification and proposal is to make the educational process more effective than is in its current state.

Usually, proposed modifications and / or adaptations are related to the content of the training process and mostly tend to the development of models and prototypes for the proceedings, the methodology and the means which will lead to the expected results.

During the last years Information Technology with its main representatives –personal computers– either with the use of software or with the use of hardware (mainly integration with environment sensors) has been introduced as one of the most important parameters with the help of which we increase students' conception.

The complete learning environment as long as the individual tools which have been developed for being used into science teaching include: multimedia applications for the representation of the educational material, tools that allow the creation of models and simulations of physical phenomenon's or the structure of the macrocosms and microcosms. Lately we have seen environments based on virtual reality. For science teaching in physics the main role of ICT during the educational process has to do with experimenting and collecting data digitally. Until today a serious amount of experimental procedures have been presented by using laboratorial provisions based on the use of personal computing which they cover almost every section of physics we teach, at least in secondary school. Having this in mind we can be assured that already exists a serious background into which we can count on in order to realize our experimental process [1[, [2]).

The possibilities that Computer Based Laboratory (CBL) offers a completely new way for students to discover the significances of science [3]. Also students are now allowed to undercover the role of a scientific researcher [4]. The use of digital technologies during experimentation provides the opportunity to ask questions, to make prognosis, or even more to propose experiment, to collect and evaluate data, to examine ideas, to create interaction, to research of new ideas, to make comparisons and come to a conclusion. Generally the use of a micro-computer can strengthen the ability of students to solve problematic situations and to create and evaluate graphic charts or graphic representations in general [5].

The current possibility of CBL to transform in almost real-time the collected data into graphical format (graphs) is an opportunity that was not offered during the past. For students is now possible -and quite important- not only to observe the actual experimental process but also to evaluate collected data, with the form of a graphical representation.

Another advantage of the use of laboratorial provisions is the so-called "Real Time Experimentation". Often, definitions that cannot be revealed by the use of Real-Time measuring systems, are inaccessible by didactical terms. With the use of CBL techniques (too little time frames, slow motion, pause, etc) such areas now become revealed to our students and in nowadays can be taught able [6].

The use of such tools by its self isn't usually enough to improve the results of our educational interventions [7], [8] and they raise the importance of the methodology under which those techniques are implemented into the educational process for the achievement of our predefined goals. Interventions that do not rely on promotion of exploratory activities are neither effective nor cause long term conceptual change.

2. Proposal

Our proposal which has been designed, developed and implemented consists of two individual parts. By starting the software application (module 1) and the material (mod-2).

For the design of our software we took under consideration the principles of discovery learning, as proposed by Brunner in combination with principles of Piaget and Vygotsky.

The discovery by learning theory emphasizes the importance of learning by doing. Such actions consists of research, experimentation, submission of questions and answers re-creation. The didactical approach focus on the evaluation of the information in order to provide a valid answer. To schema that is usually used contains:

· Problem identification
· Making hypothesis
· Data collection
· Data analysis
· Conclusion formatting

The methodology which is used consist of the inquiringly evolving educational model, which constitutes educational application of scientific method. Under this method we meet the following steps:

· trigger
· hypothesis
· experimentation
· conclusions
· general and theory testing

In spite of the fact that we have laid on the principles of discovery learning in some points of the method we follow we can distinguish elements which are proposed from other learning theories too, like those which stands for constructivism.

The software we propose provides a complete training environment. This software interacts with other add-on modules (e.g. real time measuring systems) providing a complete solution without the need of wasting extra time of our students in order to get familiar / comfortable with it. The application is installed locally on every personal computer and is used for the presentation of the actual educational material. The physical location of the material can be either locally (local store) or through routed network (internet too).The network solution is preferable in conjunction of having many individual local installations for obvious reasons. By this way we have to maintain, upgrade, etc only one "material stage'. It is important to emphasize that the network or local solution are not exclusively between. By this we mean that the selection and / or change the source of material can be done by run-time and not at install-time. By this way our teaching process overcomes network problems, slow internet connections, etc.

In case we use some add-on software which integrates with MBL systems for data collection and representation our software offers the possibility to be customized in order to work with a number of already made such systems and also includes functionality for future integration too (Figure 1). The primary add-on module we used for data collection in our experimentation is "Coachlab™".

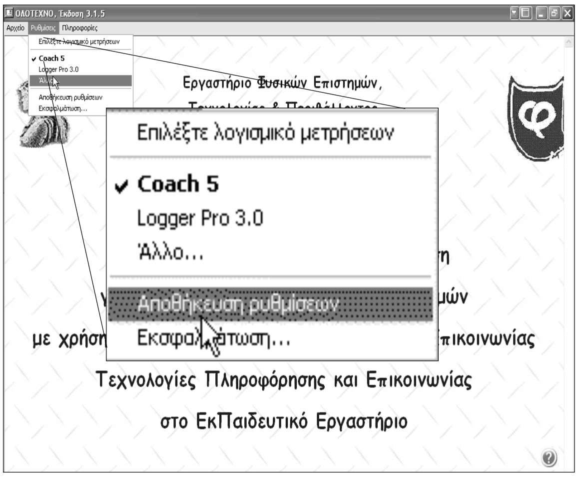

Figure 1: Selection of Real-Time MBL system

By the first time a student tries to use the software, a user registration form needs to be completed (Figure 2). By this way every single user is not anonymous but named and his/her course can be evaluated.

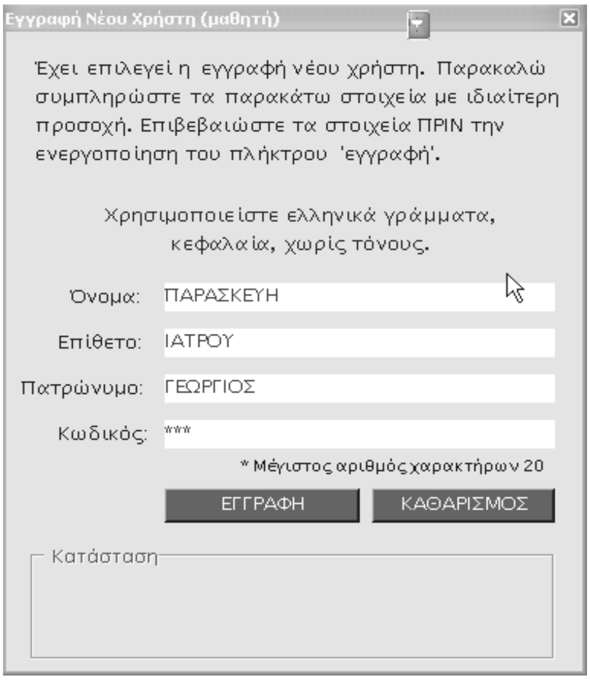

Figure 2: Student registration / single user creation

After the "user creation" access to the user is granted. The main idea of having individual users consists on the following:

- · A physical student is a single user,
- · Ideas, thoughts and answers are related to physical students,
- · Observations through student notes during time not single session evaluation,
- · Offline evaluation,

.... in general we use a e-portfolio scenario.

This e-portfolio is implemented by a user rights mechanism which allows single users to access only their specific data. Educators have the possibility of having full access to all students portfolios. For security reasons teachers have a private login password too.

By entering into the application we are able to select the specific unit of the educational material which is needed according to our scope.

The structure of the educational material we have created follows the steps of the evolving educational model. During trigger and/or hypothesis we try to draw students' attention and in parallel we ask for their hypothesis concerning the evaluation scenario. Their replies can be written by using common operating system applications which are executed by buttons stored at the bottom of the page. Depending on the form of the data which is needed to be written down can be used a text-editor, a voice-editor or other form-specific editors.

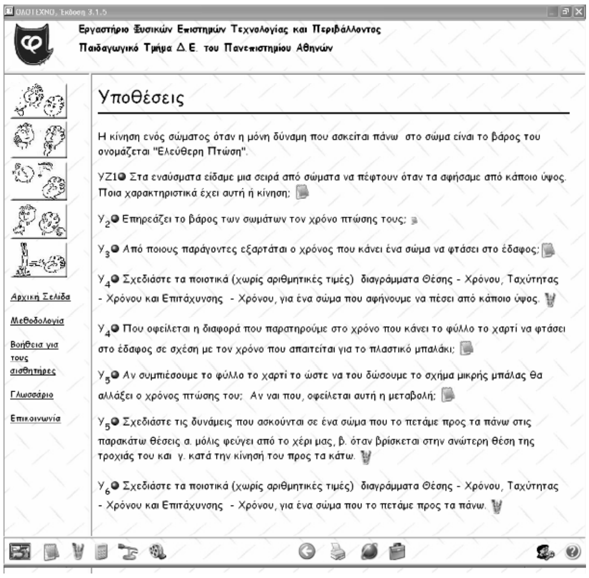

Figure 3: Main Unit Selection

During experimentation the add-on module of the MBL system is activated. During the experiment all data collection and representation is done by the add-on module. In the end that specific data can either be lost –if temporary data- or imported into our software and saved in the "e-portfolio stage". In general the different types of files that can be created, handled and stored are: text, chart, sound, video (through web-cameras).

More over we also provide the functionality to visit internet sites which are pre-defined (accepted and evaluated for their content) or visit custom web-sites provided by the educator.

Finally, we provide the possibility for every educator to add his / her own material in a specific form and add this material for viewing by his / her students. The add material procedure is documented and is error-free in all cases, when all restrictions are followed. For this purpose we developed a forum for exchanging ideas, material and trouble shooting / support services.

A lightweight version of the application is public available and can be downloaded for free from : http://www.primedu.uoa.gr/~mpatrin

4. Conclusions

The developed software has been primarily tested on students in secondary education and also with teachers-to-be. At this moment and after completing the first stage of data analysis it seems that it fulfill the specifications of its creation. From the data that been measured and analyzed, the results are quite encouraging. Specifically, we measured little or almost none time for familiarization, simplicity of use and manageability. Closing, student portfolios' assessment is under evaluation.

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Experiential phenomena as experimental activities in science laboratory based on the human body – Four cases

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Abstract. *In order to motivate the trainees participating in a science laboratory and to cultivate through this, basic skills on laboratory techniques, we developed four interdisciplinary experiential activities. In these activities students estimate, measure and/or calculate using sensors and other devices certain biological characteristics of the human body such as: heart and human respiration rate, human response time, acceleration of a human punch, body's temperature after exercise and during woman's period and factors that influence oral hygiene.*

Keywords. experential, human body based experiments, interdisciplinary.

1. Introduction

The main scope of this paper is to elevate an idea of hands on science experimental procedure: the use of the human body as a means for experiential interdisciplinary activities. These activities can easily be placed under the general umbrella of Science Technology Society (STS) teaching. STS education addresses learning of science concepts in the context of real life experiences and with application to real life problems and issues (Lutz, 1996) [1]. The human body and its functions are easy to understand and affects and interests every human being that is the main reason it can be a good vehicle of promoting students to be involved with measurements in a laboratory procedure. Thus we develop four experimental activities: a. counting heart and human respiration rate using a microphone attached to a computer. b. calculating human response time when a ruler falls and the acceleration of a human punch, using a range sensor.
c. counting body's temperature in various circumstances: after body exercise and during woman's period using thermometers and temperature probes and d. oral hygiene with the use of a PH sensor.

2. Methodology

For the whole intervention we propose the scientific /educational method which is a pedagogical approach of the historically recognized scientific research method. That method through which scientist, researcher, man, had research, is researching and will continue to research natural world [2]. In every activity we used software, which developed under the simplest form so that it can be used for any other similar procedure to support it. The software acts supplementary giving in every step of the methodology the necessary elements such as videos and pictures, which are used to activate the students and to give them the appropriate guidance through the experimental procedure. The way the software is used can be altered according to the kind of the laboratory that is chosen each time. The software provides also the necessary worksheets that the students used to follow the scientific / educational method. The worksheets were developed under simplicity and directness of executing specific acts.
The first implementation took place with students of the Pedagogical department of the University of Athens. These students are future teachers so they should acquire certain experimental skills and general knowledge about human body and health.

Generally speaking that kind of procedures can be implemented in the two last grades of primary education, to the last grade of high school according to the curriculum, mostly in the educational zone which is known as the interdisciplinary activities zone or as introductory lessons to science experimentation.

That kind of procedures could familiarize students with sensors, computer software and experimental practice.

3. Experimentation

3.1. Counting heart and human respiration rate using a microphone attached to a computer

In many researches it is clear that most of the students confuse the cardiac rate with the breath. Although both functions are interdependent the rate of the breath is not identical with the rate of heartbeat. In order to establish this kind of difference we used a simple way of measure the heartbeat and the rate of the breath (without using expensive measuring tools). Using a microphone that is attached in a certain point on the neck, we measured, through a program of processing sounds (e.g the shareware software Goldwave) the heartbeat. An image taken from this software is given below.

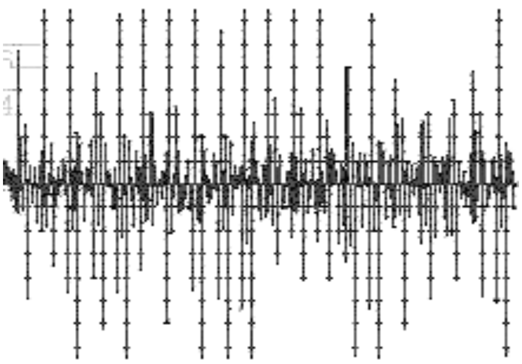

Figure 1. Heartbeat of a student

If the sound is not clear enough using the previous mentioned software (or any similar to that) it can be cleared so that the sound is heard loud and clear (experential). From this graph students can measure the cardiac rate (measurement/calculation). After that students put the microphone near the nose and an image like this will print to the screen:

Figure 2. Rate of the breath of a student

This kind of software depends on timeline so it is easy to estimate the heart and breath rate from these graphs. In addition using the microphone we can measure the rate of the breath before, during and after certain activities, in order to correlate them with the heartbeat. We can also use people who are smokers or people who don't exercise regularly in order to underline the bad affects to our health in these circumstances. The kind of the activities that finally are adopted depends on our didactic approach and the school level.

3.2. Calculating human response time when a ruler falls and acceleration of a human punch, using a range sensor

Further more an activity we suggest is that one which uses a range sensor that measure the distance of a moving body. In this activity we use a ruler that falls and we have placed the sensor in order to measure the change of the height of the lower part of the ruler. The time-height graph that the sensor's software is producing is the one of Fig. 3.

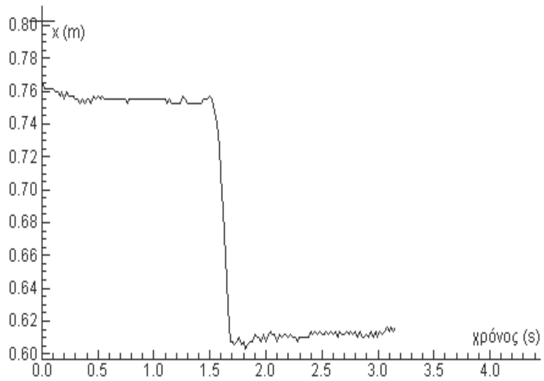

Figure 3. Catching a fallen ruler…

The experimental process is carried out by two people. The first person holds the ruler in a certain height above the sensor and the second person is ready to catch the ruler when it falls (the activation is given with a sound). In that way we measure the time one person takes to react so we can discuss a lot for the way the human brain works

To enrich the reports concerning the human brain but also to deal with experimental procedures relevant to the velocity and the acceleration, using the same sensor we propose the measurement of the velocity and the acceleration of the human punch. One graph measuring distance and time has the formulation of that in Fig. 4

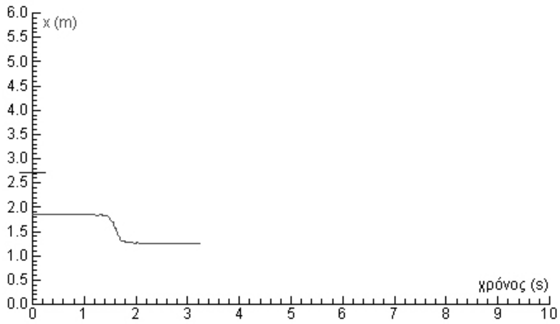

Figure 4. Graph of a human punch

Further more we can compare two graphs from two students with very different body shapes and expand the possible results in specific Biology and Physics lessons.

3.3. Counting body's temperature in various circumstances: after body exercise and during woman's period using thermometers and temperature probes.

In this activity is attempted to measure the human body's temperature in many different situations. The temperature in a laboratory can be measured using sensors or digital home thermometer. Then the measurements are recorded and appear in graphical representations like this one in Fig. 5. We can also measure the temperature of a number of people and extract specific conclusions through dialogues about the variation or not of the experimental data.

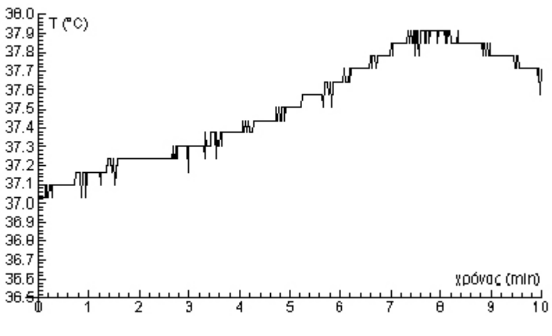

Figure 5. Body temperature

In the next experiment we propose (in latest grades) that the girls can measure their temperature during their period. This is something that apart the other (science) benefits can help the students, not only girls of course, to socially mature and to stop having taboos about human body through a scientific procedure. Furthermore the measurements, in general, outside laboratory can help students to introduce in every day life the scientific method and with particular references they could estimate the value of the measurement.

3.4. Oral hygiene with the use of a PH sensor.

Even though the PH sensor is constructed to measure the PH of chemical solutions, through specific procedures can help students to estimate how acid or basic is their slaver. Generally speaking our slaver has specific PH that remains steady and varies after drinking or eating and there are many factors that can influence the PH in our mouth. In many circumstances the reason for having problems with our teeth is what we drink or what we eat. So it is good to know what affects our oral hygiene. In addition the PH of our mouth indicates more for the whole health of a person. For that, we organize experimental procedures using a PH sensor and appropriate worksheets. Maybe the whole procedure sounds difficult to be made but finally it is less difficult than it sounds and can help the students to understand and interconnect these factors that can give them good health.

4. Conclusions

The most encouraging element of all the procedure was the huge interest that students showed from the beginning of the experimental procedures. It is also good to be mentioned that students with low expectations of themselves appeared to be more skilful in that kind of experimental practice than we expected. Most of the problems encountered concern the use of the sensor's software but this is something we were expecting as soon as the implementation was limited in time. We can overcome that kind of difficulties with the extensive use of sensors and software in introductory laboratory. Nevertheless more conclusions can be extracted if more research take place, but the first elements indicate that this kind of experimental activities can cultivate experimental skills with an easy and pleasant way and help students to become scientific literate members of our society.

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Investigating air resistance using extractor fan filters and plummet in MBL

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Abstract. *A serious motive for this work constituted the following question. Is it possible to find the air resistance dependence on the velocity in the solid movement with the processing of data which results from authentic inquiry-oriented lab activity? For this reason an experimental process was designed and the research was executed by students of the Physics Department. The activity is also proposed for the students of High school that have been taught kinematics and dynamics. For this reason we created educational software which helps the students in the inquiring methodology and the teacher in the educational evaluation of the students. This experimental issue was also given to 400 students of the first grade of High school, in the competition of Physics 2004 and the results of this activity are incorporated in this paper.*

Keywords. Educational assessment, educational software, inquiry-oriented lab, M.B.L.

1. Introduction

Can the students of the Greek High school act as independent researchers examining open type inquiring problems? Can the teacher have the role of an adviser? In what way can inquiring subjects and methodologies be imported in High school? Can we change the way of evaluation of students and move further from the example of educational measurement in the example of educational evaluation? [8], [1], [6]. With which type of problems and activities can we awake the interest of students, develop their critical thought and elevate the character, the processes, the significances and the values of science?

The use of the proposed material does not render the students as scientists and researchers, because the scientist and researcher aims the creation of models, while the students work upon the models we provide them. This role is named "the student as a researcher". There is a need of balance in the preparation of educational process, in order the students to execute the experiments but also not to blunt the peak of discovery. The students that will use the material will act as researchers and scientists in the sense that, formally they do not have the complete knowledge of scientific background on the subject they search.

The role of the teacher differs from the traditional type. The teacher plays the role of adviser which interprets the total picture, he educates the students to use the materials, he records the progress of the students, he offers indications in order the students execute the work that was assigned to them and progressively he withdraws in order the students end their research. Through this process a social act is developed between the students while they collaborate and learn one from the other but also from their schoolteacher. This process is proportional with the one that follows a professor in order to import a postgraduate student in his research. Through his socialization within the members of the inquiring team he learns the inquiring process. This social frame provides a sense of aim and genuineness for the work of the students. Through the process the student confers with the professor who presents the inquiring process either directly (techniques of calculation) or indirectly (proposing the next step). In other words, the professor imports the students into what genuinely means "scientific action". As they advance, they undertake also increased responsibilities concerning the completion of the research, and the determination of the work that should be done. The professor however continues watching the progress and he provides support by interfering indications in suitable moments. Finally when the students begin to show confidence in his opinion and his advices, his role as an adviser is lost and emerges his new role as a collaborator. This process constitutes a new role for the professor of medium education that will use this proposed material. The use of computers in interconnection with laboratorial provisions via sensors increases the possibilities for independent researches from the students for the following reasons:

a) The teams of students, that have access in computer, create a social environment similar with that of scientists and researchers.

b) A lot of measurements and handlings are executed in very rapidly evolving phenomena.

c) The computer can substitute many individual measuring tools.

d) The computer helps so that the schoolteacher is released from his supporting role. This becomes with suitable educational software that additionally gives the possibility of simulation of meditative processes of the microcosm with MONTE CARLO methods [3].

With regard to the particular subject, the dependence of air resistance from the velocity is not reported to the school books. Is it proportional to the velocity, is it proportional to the square of velocity or something else? Could this appear from the experimental data?

There have been recorded enough misapprehensions, where it is considered that the resistance of air in a big piece of paper that is moving in high speed is proportional to the velocity. In our opinion the best approach was in a school book of PSSC page. 76. As a result of the bibliographic research and the research in the internet, there were recorded enough proposals for activities on the air resistance. The most interesting was that of Professor Paul Hickman of Belmont High School of Boston. The procedure didn't contain a position sensor but only a chronometer and it wasn't executed and lead to no conclusion.

2. The experimentation

With diabetes is engraved a circle of beam R on an extractor fan filters and with scissors is cut the corresponding circular disk. With a balance of precision is measured the mass of this disk. Then seven other disks are cut. A small aperture is opened in the centre of each circular disk and a fishing line is passed through this. A weight is tied up in the end of the line and the other end is fixed in a constant point, in order the line is vertical and stretched. Under the weight a position sensor is placed.

The first circular disk is left to fall from the top of the line roughly 2 m high from the position sensor, activating simultaneously the sensor from the computer. The pairs of rates of place and time are presented in the computer screen.

The diagram of position and time that it was presented simultaneously had the form that appears in figure 1. The process is repeated by adding a disk each time.

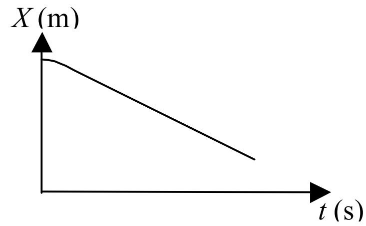

figure 1.

The computer gives the possibility to focus in any department of the diagrams. Three focuses appear in the following figure 2

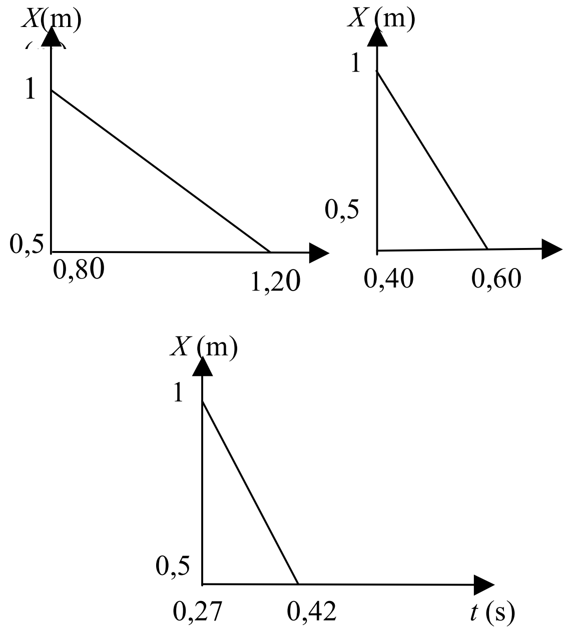

figure 2.

As it appears from the form of the diagram of position and time, the disks very quickly (almost immediately) acquire constant speed.

At terminal velocity the weight of disks equals the air resistance according the first low of motion.

The diagram and the pairs of values as they are presented in the screen by Coachlab 5 are shown in figure 3.

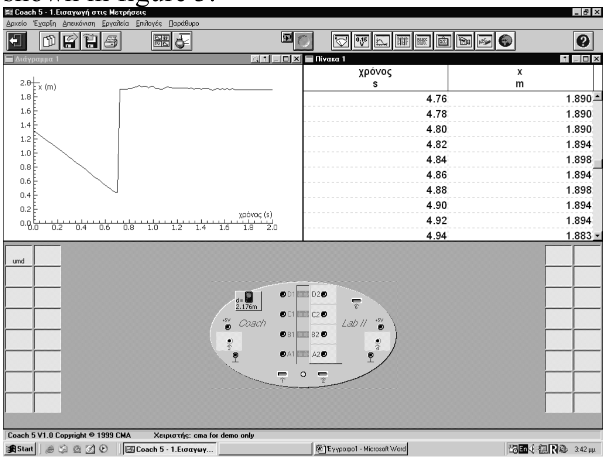

Figure 3.

The air resistance will be finally equal to the weight of disks. In every case, the terminal velocities are calculated by the slope of the three focuses in the diagrams 2,3,4.

Raising the velocity in the square and calculating the quotients of forces with the corresponding speeds as well as with their square, it is realised that the quotients of the resistances with the square of velocity do not differ a lot. Thus it results that the air resistance in this case is proportional to the square of velocity. The number Reynolds helps us to foresee when the air resistance is proportional to the velocity and when it is proportional to the square of velocity and it is fixed as follows:

$$Re = \rho\, v\, d / \mu \quad (1)$$

where: ρ=1,293 kg/m^3, the density of air

v speed of body in in air

d diameter of body

μ = 18,8? 10^{-6} Pa s, the air viscosity

In the following table 1 appears the relation of number Reynolds with the law of resistance.

Table 1.

Reynolds number	Law of resistance
0 – 10	$F = kv$ (no turbulent flow)
10 – 300	Intermediary region
300 - 300000	$F = bv^2$ (turbulent flow)

Concerning the parameters of the experiment, and which should be modified, so that we achieve those conditions in which the air resistance is proportional to the velocity, was used as a criterion the number Reynolds, which oscillates from 0 to 10 for the asked region. Since the density and the ιξωδες air remain stable and the speed will be measured experimental, the only parameter that can be altered is the diameter of the body. Thus a very small body was sought such as a spherule felizol.

The diameter of the spherule is d = 2mm and it was left to fall from h = 1m high. With the digital chronometer the time was measured, t = 1,2 s. The velocity was calculated : $v = h/t$ = 0,83m/s.

First it was found that the reduction of dimensions resulted the decrease of the marginal speed something that contributes positively in the effort of alleviation of number Reynolds.

Knowing that v=0,83 m/s, d = 2mm, r = 1,293 kg/m3, μ = 18,8H 10^{-6} Pa s the Reynolds number is : $Re = 115$.

The last result shows that we abstain a lot from the region Reynolds (0 to 10) in which the resistance is proportional to the velocity. The result of the reduction in the body dimensions was that the acquired velocity we found is in the intermediary region ($10 < Re < 300$) where the relation of air resistance and velocity does not have a certain concrete form.

In order to be in the desirable region $0 < Re < 10$, we will have to use very small objects of diameter (1,8 mms). However then is not possible the recording of the position by the sensor.

The educational software was structured based on the inquiringly evolving educational model [3], that includes the following steps:

1. Trigger of interest
2. Ypothesis expression
3. Experiments
4. Formulation of conclusions and proposals - recording
5. Generalisation - feedback - control

It contains worksheet, report about the educational evaluation of students, a sheet of common self-assessment. It gives the possibility of simulation in a molecular level.

The evaluation could take place with the sheet of report on the laboratorial exercise. This sheet has four sectors. Each sector is evaluated separately.

3. Conclusion

The general conclusion from the above activity is that with the use of filter it is possible the study only of that region where the resistance is proportional to the square of velocity. For the study of region where the resistance is proportional to the velocity there must be used very small plastic balls of diameter 1,8 mms, a microscope and a digital camera in an experimentation similar to the Millikan experiment.

The roles of the students as researchers and the professor as adviser were observed as it was reported in the introduction and had very encouraging results. It was realised a certain difficulty in the export of conclusions from the experimental data, that however the students overcame alone in a way that was described in the experimentation.

From a first recording of the results of the Physics 2004 competition, it appears a major difficulty in the resolution of problems that does not resemble to the formal problems of school books. Regarding the rest of the problems on the competition, students marked the worst record in this problem. Difficulties were recorded in the comprehension of the meaning of ratio of two sizes. A lot of students do not conceive the meaning of the ratio of two sizes. Many numerical errors were recorded in the calculation of the bent and errors about the comprehension of meanings. Also a major weakness was detected in the export of information from experimental data.

A lot of students of 14 to 17 years old, express the wish to deal with impressive and inquiring problems of an open type, while their interest for the formal problems of school handbooks appears to decrease. They ask from their professors more provocative and interesting problems that could take place in the laboratory, be accompanied by measurements and supported by suitable software. The professors do not have educational material with definite educational methodology, they do not exploit the interest of their students and they give extra problems which discourage their students.

We consider that with the proposed material we will help students to overcome this lack of interest in order to start acting as independent researchers and the professor to take the role of the adviser. Also it is suitable for the educational evaluation that takes place in the laboratory by the professor with the help of suitable tools of evaluation. It creates a new social environment using new technologies and helps in the appointment of the character, the processes, the significances and the values of Science.

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The Didactics of Science through Polymorphic Self-Made Experimental Apparatus of Quantitative Determinations. An alternative proposal for the teaching of Natural Sciences

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Abstract. *The undertaking of teachers' training in Natural Sciences is very difficult. This difficulty is related with the implementation of the two classic models "learn how you learn" and "active exploratory approach of knowledge" during the teacher training. That's because we have to use the same teaching style as we propose them to teach in their classrooms. During their basic and probably during the Academic studies, they have had the theoretical model of knowledge, as a unique model of learning Science. The disengagement from that requires a suitable model of teaching, through which the knowledge is approached experientially, within scientific – inquiring way. This model has the following advantages: a) it triggers their interest and the spontaneous attendance, b) they control the acquisition of knowledge, c) they acquire training and psychomotor skills and d) they collaborate. More generally, they are expected to behave as students with the same way as they are proposed to use as teachers in their classroom.*
Our laboratory has already a five-year experience in the application of self-made experimental apparatuses, for quantitative and semi-quantitative measurements. These two limits of precision, quantitative and semi-quantitative, coexist in most of the developed apparatuses. This co-existence constitutes an additional instructive approach through the concept of the Polymorphic Exercises in Science teaching [1].

Keywords. Polymorphic practice, Science teaching, Self/made apparatus.

1. Introduction

In our previous work (cf. reference [2]) we have analysed the concepts *"self-made construction"*, *"quantitative measurements"* and *"polymorphic exercises"*. As they constitute the main components of our proposed model the instructional and pedagogical framework, on which it is based, is explained thoroughly. During the last five years, we have acquired important experience from the implementation of our model during an in-service teachers training program, called *"Exomiosi"*. Through those teachers, we have had an experience of its application in their schools. Additionally we applied that model in our students' teaching of Science, through seminars and the teaching practice program, in which student-teachers of the Primary Education Department are participating. At the same time we extended the number of experimental apparatuses that we have developed and applied. We describe bellow the approach and the experience from their implementation, as well as their instructive evaluation.

2. Project method and stages

We apply a project method in all applications, with the following stages.

2.1 Sciences Area-Definition of the Educational Goals

Most of the natural laws, can give us ideas for an experimental apparatus, for quantitative measurements. At the same time, we can gather ideas from technological applications or from the technology of the ancient world. During the practice of a team of students, the emphasis is given on the planning of a set of applications. This set, constitutes a sample of approaches from various fields of Science. During student meetings, each one informs the team for his/her subject and his/her progress, so all students have an integrated idea of all projects. Our experience shows that, at the beginning there is a need, this team work to be supported by the teacher. In the following meetings, each student acquires a personal relation with his/her subject and spontaneously seeks to inform the team about the work, the aims and the difficulties. It is characteristic that everybody understands the complications and all are making proposals towards an effective collaboration.

The subject of each project usually concerns something already processed from the teacher, (self-constructions ..-..). A processed proposal from the teacher however should not be repeated identically in each instructive period, but the student or the teacher, must seek for changes and exploitation of proposals taught. Additionally, a new idea affects the teacher's function, in the frame of research and experimentation. Subjects for self-constructions are based also on students' proposals according to their interests (constructions .. and ..). Both ways of subject choice have advantages and disadvantages. The advantage of a teacher's proposal is the clear objectives and prerequisites in an integrated entirety. The main disadvantage is that probably the idea is faced with decreased enthusiasm, compared to a proposal from the students themselves. The proposals from students are usually challenging and when they are adopted, they work with enthusiasm, regarding the whole process as a personal affair, without necessarily having comprehended the difficulties of the undertaking. In many cases, the disadvantage is that they cannot focus on the objectives and tend to exploit everything as far as the level of difficulty permits. They are either particularly easy or particularly difficult to implement their work for a given period of time. In every case the teacher tries, with the collaboration of students, to provide further dimensions in their proposals, so that they constitute a sufficient and completed objective. An additional effort is made so, that each construction can be graded in three different levels: for the primary school, for the High school/Lyceum, and for the University level (Polymorphic exercise), with corresponding objectives and requirements each time.

2.2 Initial Planning.

Study of natural law, theoretical calculations and bibliographic search.

In this stage the students are called to study in-depth the corresponding natural law, and search the literature. They do the essential theoretical calculations. The framework of the assignment and the expected problems are determined, and they study the theoretical divergences. The student writes a brief work-proposal with an initial plan for discussion and a likely timetable on the construction. This timetable and the plan usually have the value of a review. In this stage, the student works alone, with general directions from the teacher.

2.3 Final Planning.

During this stage the final planning of the apparatus is done, with the collaboration of the teacher. Critical points of the initial plan are pointed out and the students try to foresee possible adjustments for physical quantities that they cannot estimate accurately enough with their theoretical background. The aim is not to replace the initial provision, but to make as many corrections as needed, in order to make it functional and effective. For this reason there must be an anticipation of adjustments in critical points. Although in practice, the most likely thing to happen is the need for a new construction after the initial prototype, it is an important teaching tool during the study to estimate all the crucial points. This procedure helps in the understanding of the phenomena as well as in the final review of mistakes in a self-monitoring process of students.

2.4 Aesthetic requirements, materials

Particular emphasis is given in the aesthetics of the construction. The aesthetic requirements support the creativity and the growth of interest for the construction as the student faces an opportunity for a personal expression. At the same time it supports the development of skills in the use and handling of new materials and the practice in new methods and techniques of exploitation.

The materials that are used should be common, easy to be found in the market and as cheap as possible. The required mechanical equipment should not exceed the usual equipment of a school or a house. (Manufactures … require only an electric drill).

2.5 Construction

In the stage of construction we can identify the following:

a) Combat and abandon stereotypes specific different skills between men and women. It is proved in practice that students are capable to handle the same things, despite of being male or female. It has been observed that in female students special skills emerge, which they realize for the first time and this causes an excitement to them.

b) Essential personal engagement of each student with his/her self-construction. The construction is not just an obligation for the course, but it becomes something worth to be dealing with, which is beautiful and functional. This makes the assignment a pleasant work. From now on there is no need to make plans and schedules for meetings, because students are interested in participating and they arrange things as necessary.
c) The teacher intervenes for proposing ideas and solutions. That supports the development of the construction and students improve their knowledge, on the application of theoretical data into practice and the use of materials.

2.6 Calibration, Measurements, Errors

After the completion of the construction, we have the calibration of the apparatus, following the procedure that already has been prefigured theoretically. Special interest is given in the comprehension of the concepts '*precision*' and '*resolution*' through the elements that consist the calibration procedure followed by repeated measurements, control of measurements, statistical analysis and localisation of errors. The analysis and processing of errors and the appropriate adjustments of the apparatus constitute henceforth the stage through which the students comprehend completely the natural law, in which the self-construction is based. We give a great emphasis on the error analysis. Independently of the size of the error, it is analysed in depth looking for ways to avoid or even minimize it. This search and analysis has to be done, independently if the error has a size acceptable to that apparatus. The treatment of errors will help in the complete comprehension of all parameters involved and how each one and all together influence the measurement.

2.7 Results of application

It is particularly satisfying for the students to build something that functions according to their expectations. This of course does not always happen. In the case where, despite the efforts, the apparatus does not function, they also feel satisfied with the course because of the analysis of stages and the justification of failure. Independent of the success or the failure, they feel capable of applying their knowledge, in studying, manufacturing and checking something out.

2.8 Writing of work

Students are writing up an essay of a small size, with the final construction, the problems that emerged, the way that were solved and a series of directives to someone else, how to repeat the project.

The experience of the application of the model showed, that the route followed between teacher and student, leads to an authentically active participation of students in an exploratory process during which proposals are emerged, processed, tested, rejected or are being accepted through peer collaboration. During this collaboration the teachers 'fatefully' banish their 'authority' and allow the handling of knowledge and his/her experience in an inquiring process, in which the student becomes participant straightforward. The experience of this type of research that the students acquire is useful and essential, for the activation of an inquiring interest of the students in the future.

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The Science Fair at the 2nd Primary School of Avgorou as a Means for Developing Investigative Skills

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Abstract. *This is a report of the investigative work undertaken by upper elementary students of the 2nd Primary School of Avgorou at Famagusta in Cyprus, in order to participate in a school science fair during the school year 2004 – 2005. The science fair was organized in collaboration with the Learning in Science Group at the University of Cyprus in the context of the ongoing research program: "The Science Fair as a means for developing investigative skills in elementary school". The curriculum used for the purposes of the science fair aimed to the development of investigative skills through a sequence of formal, informal and non-formal learning activities.*

Keywords. Investigative work, formal, non-formal and informal ways of learning, science fair.

1. Introduction

During the last decade, a lot of efforts aiming at the development of curriculum for preparing students participated in a scientifically literate and technologically dependent society as future citizens were made by educators and researchers, respectively [4]. The coordinated program: *"The Science Fair as a means for developing investigative skills in elementary school",* is implemented by the Learning in Science Group at the University of Cyprus, as an attempt for providing special importance on the development of investigative skills in the context of learning science [1].

The curriculum designed for this research program purposes on the promotion of student's inquiry through a sequence of formal, non-formal and informal activities. According to this approach, science fair is the final stage of a long process, where students undertake authentic investigations related to simple questions of their interest. They work collaboratively to implement an investigation in which they design experiments, collect data and formulate answers. The whole process culminate in a specially organized school event (*the science fair*), during which children display the procedures and results of their investigations and also engage in interactive activities that they have designed in collaboration with their parents in order to teach certain aspects of their investigation to visitors.

Figure 1. Which factors influence the dissolution of substances in water?

2. The Science Fair at the 2nd Primary School of Avgorou

The 2nd Primary School of Avgorou, at Famagusta in Cyprus, is located in an agriculture area. Families' livelihood is mostly related to cultivation and hence, parents most of the times are regarded as unqualified to support their children's learning. Children's interests and experiences are, thus, much different than school's expectations.

The need to engage students in activities that are close to their interests and to give parents the opportunity to get involved in the learning process has gained special importance during the school year 2004 - 2005 at the 2nd Primary School of Avgorou. For this purpose, the educators of the school regarded Science Fair as an activity, suitable for giving motives to students to get involved with investigations related to their interests and developing school and parents' partnerships.

Figure 2. Which factors influence planting?

Totally thirty-six (36) 6th-graders and fourty-one (41) 5th-graders were involved in the activity, which was organised into three parts.

The ***first part*** implemented during November 2004. Students participated in a teaching intervention, which took place in a formal classroom setting. A handbook for teachers and a student's workbook, drawn from the research program mentioned above, were used for the purposes of the formal teaching intervention [1, 3, 5].

Two months later, after the teaching intervention, students were called to participate voluntary in a school science fair. This was the ***second part*** of the intervention. In the first place, a catalogue of suggested topics was given to pupils. They had to choose a topic of their interest and work collaboratively to formulate investigative questions related to it. Pupils could also suggest a different topic, other from the given list. The number of questions they could formulate depended on the topic they have chosen, as well as group's qualification.

As soon as they formulated several investigative questions, they had to design and conduct valid experiments and describe their procedure in an investigations' booklet [2]. They, also, created posters for displaying their methods and results and designed interactive activities in order to teach certain aspects of their investigation to visitors at the science fair. During this part of the activity (informal way of learning), students interacted with other students, their teachers and their parents in preparation for their participation in the science fair. The website of the research program was useful at this phase [5].

Totally twenty two (22) groups, consisted of 2 to 4 students, were engaged in investigations of different topics. The students investigated factors that influence for example the evaporation, the friction, the growth of plants, the balance of bodies, the number of oscillations in the clock pendulum and the hydrostatic pressure. For the purposes of some of the investigations, students had to construct models using materials of daily use (e.g. telephones, music bottles). In other cases, such as the investigation of factors that influence stability of hands, they had to make a machine that could measure hand's stability with the use of electricity.

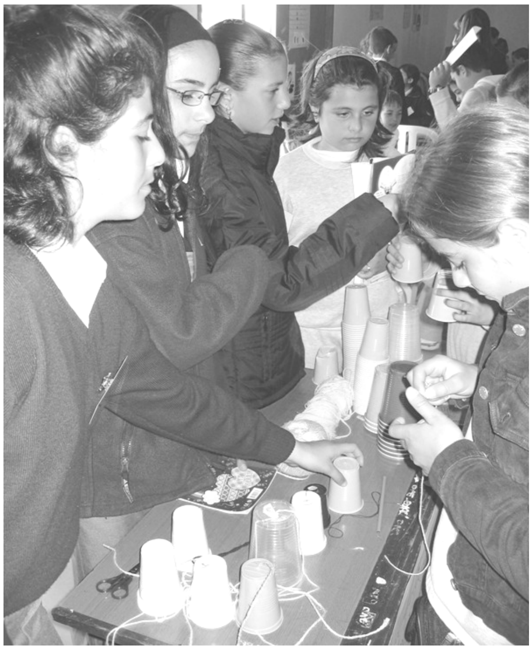

Figure 3. Which factors influence the distribution of sound in telephones made from materials of daily use?

Many of the parents expressed their interest in getting informed about science fair in order to be able to support their children's efforts. Hence, the teacher organized a meeting with them during this part of the activity.

When all the investigations were accomplished, a special day was chosen for organizing the event (17th of March 2005). The students made an invitation for that purpose. Parents, educators, students from other schools of the district and general public were invited at the Science Fair.

Figure 4. The invitation

The day of the Science Fair is the ***final part*** of the activity. Students interacted with the visitors within non-formal conversations in the context of their investigations. During this day, the students presented their experimental procedures and their results to public. They, also, engaged visitors in interactive activities they organized in order to teach to them aspects of their investigations.

A parallel contest was running during the Science Fair day, between the visitors. In every group, students were giving points to visitors, as an award for their involvement in the investigation. The visitors were trying to collect as many points as they could.

Figure 5. Which factors influence sinking of bodies in fluids?

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The Science Fair at the 1st Primary School of Sotera as a Means for Developing Investigative Skills

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Abstract. *This report refers to the investigations implemented by 5th-graders at the 1st Primary School of Sotera in Famagusta Cyprus, for the purposes of a school science fair. The activity was organized in collaboration with the Learning in Science Group at the University of Cyprus, as part of an ongoing program for exploitation of the science fair as a mechanism for promoting scientific thinking skills.*

Keywords. Formal, non-formal and informal educational activities, investigations, science fair, scientific thinking skills.

1. Introduction

The Science Fair at the 1st Primary School of Sotera was organized in collaboration with the Learning in Science Group at the University of Cyprus. The curriculum used for the purposes of this instructional activity was drawn from the ongoing research program: *"The Science Fair as a means for developing investigative skills in elementary school"* [1, 4].

According to this approach, the science fair is exploited as an activity for promoting scientific thinking skills through a combination of formal, informal and non-formal educational activities. The science fair at the 1st Primary School of Sotera was organized for two further reasons. Firstly, there was a need for encouraging students to become involved in issues related to science and hence, developing positive attitudes towards science learning. Secondly, the activity was an opportunity for parents to contribute in the learning process.

2. The Science Fair at the 1st Primary School of Sotera

Fifty-two (52) 5th-graders of the school contributed to the science fair. In total, seventeen (17) groups, consisting of 2 to 4 students, were engaged in a process of undertaking and reporting on authentic investigations related to phenomena from everyday life.

Figure 1. General view

The intervention was organized into three parts.

2.1. 1st part: The teaching intervention

The first phase of the activity took place in a formal classroom setting during January 2005. The students were engaged in initial activities aiming at the development of investigative skills. The available teaching material consisted of a handbook for teachers and a student's workbook [1, 3, 4].

2.2. 2nd part: Preparation for the Science Fair

After the teaching intervention, pupils were asked to participate voluntarily in a school science fair. Firstly, they had to choose a topic related to their interest and work collaboratively to formulate answers. They could choose a topic from a given list or suggest a different one. They could also look for ideas on the program website [4].

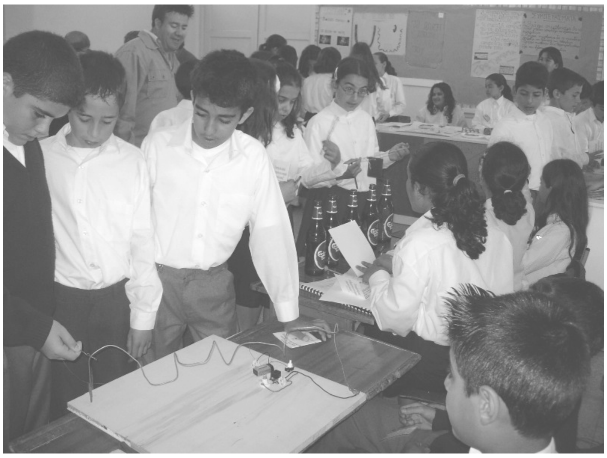

Figure 2. General view

In this part of the activity, the students were engaged in a process of designing valid experiments, collecting data and formulating answers to their questions. They also described their procedures in an investigations' booklet [2].

In preparation for the science fair, the pupils created posters for displaying their investigative procedure and their results. Moreover, they designed interactive activities, aiming at the involvement of visitors to the science fair in their investigations. Parents and teachers contributed to childrens' efforts during this phase in informal ways.

The students' projects undertaken for the purposes of this science fair focused on investigating factors that influence for example the growth of plants, the stability of hands, the flight of paper-made airplane models or the distribution of sound in guitars made by simple materials of daily use.

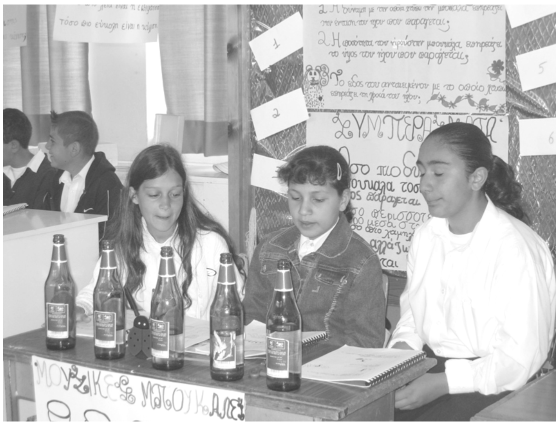

Figure 3. Which factors influence the characteristics of sound produced in music bottles?

2.3. 3rd part: The Science Fair

The Science Fair took place on the 21st of April 2005. A special invitation was prepared for inviting students from other schools, educators, parents and the general public to our Science Fair.

Figure 4. The invitation

During the science fair day, pupils interacted with the visitors in a non–formal way. They presented to them their investigative procedures and their results. Whenever it was possible, the students illustrated their experiments to the public. In some cases, ongoing investigations were implemented with the participation of the public (e.g. Which factors influence the stability of hands?).

Visitors were also engaged in interactive activities organised by the students in order to explain the investigative procedures they had followed or their results. The students often encouraged visitors to become involved in their investigations by giving them nominal prizes and award points. Hence the visitors became engaged in a contest of collecting points.

Figure 4. Which factors influence the flight of paper-made airplane models?

3. References

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http://www.ucy.ac.cy/lpg/sciencefair/index.html

Figure 4. A general view

Mechanical and Solar Energy Projects … in Action

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Abstract. *This is a brief outline of the projects undertaken by pupils of the 6th grade of the 9th Primary School of Rethymno focusing on mechanical and solar energy, which have been presented to fellow pupils and teachers, as well as local citizens, in an open school exhibition, a so called "science fair".*

Keywords. Mechanical energy, solar energy, science projects, science fair.

1. Introductory Framework

Thirty five (35) pupils of the 6th grade of primary school have dealt with the "energy" concept within a framework of a series of teaching interventions with experimental investigations (*formal science teaching and learning*), extra-curricular projects with mechanical & solar energy constructions (*non-formal science teaching and learning*) and a final presentation of project work by pupils to fellow pupils, teachers and general public in a science fair activity (*informal approaches in communicating science within a free choice environment*).

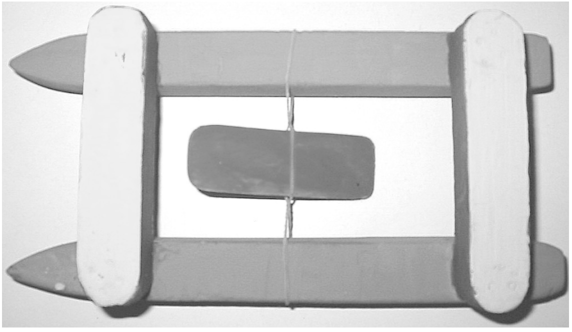
It has been reported extensively that the "energy" concept, being abstract in its nature, it is hard to teach and learn in science education (Duit, 1986; Solomon, 1992; Williams & Reeves, 2003; Leggett, 2003). Thus, the difficult task for teachers has always been to find creative ways in which the "energy" concept could characterized with more "concrete" accounts and registers for pupils, to "reify" some of its aspects in a sense, especially for primary school science. This can be combined with an approach of using or creating toys in the teaching and learning of "energy", within a more familiar framework for child life and culture (cf. Taylor, 1998).

It is claimed that specific project work undertaken by pupils, alongside with experimental investigations and discussions in class, has contributed significantly in the conceptual development of "energy" for the primary school children of this study (cf. Tsagliotis 2004; 2005). The "energy" conceptual framework that provides the basis for the project work, as well as the study in broader terms, is "energy change" and "energy degradation", with foreground hints for "energy conservation".

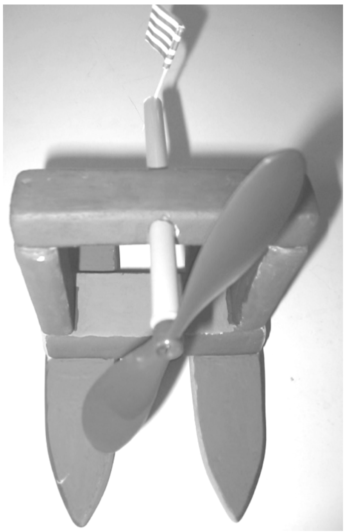
2. Project work on mechanical energy

The pupils worked in pairs and they all constructed in class catamaran boats out of stripes of expanded polystyrene (DOW), which moved with a paddle gripped on a stressed rubber band. The conceptual idea we elaborated on is that the rubber band has "stored dynamic energy" (potential energy), which is changed to "energy of motion" (kinetic energy) rotating the puddle and moving the catamaran toy (see photo below).

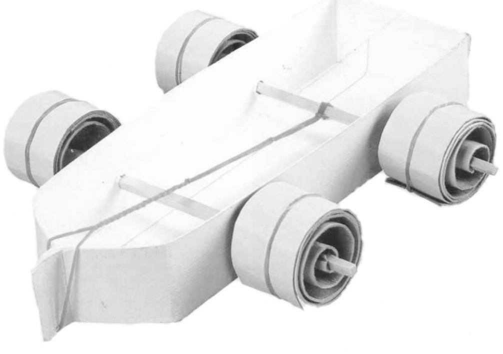
We also had to confront with "energy losses" due to friction or "the drag force" of the water as the catamaran moved in it. Thus, we had "energy degradation" due to "energy change into heat" when the toy catamaran with squared, uneven edges moved though the water. We had to deal with this "problem" by constructing more "hydrodynamic catamaran" toys, which moved faster and farther using more of the "available" mechanical energy, with less "energy degradation" to heat due to "friction with the water". This is of course a qualitative, macroscopic approach of "energy change" and "energy degradation", but with a reified potential, thinking over "real" objects and their performance (see the improved catamarans we presented in the science fair in the photo below).



In a similar context "airplanes" or "boats" that moved with helixes and rubber bands were constructed by pairs of children as project work (see photo below).



Furthermore, a couple of "toy cars" moving with elastic bands were constructed by a couple of groups of children as an additional project on mechanical energy. Some children liked these toy car projects with elastic bands, but we had no time to make more of this kind and work further on their designs (see photo below).



3. Project work on solar energy

The children worked in pairs and developed projects and constructions related to applications of solar energy, which had to be functional and tested; therefore they had to develop certain techniques and deal with particular problems throughout the development of their projects. Children's project work dealt with three groups of projects in the study of solar energy: a) *solar water heaters*, b) *solar cookers* and c) *solar toys*.

There are several designs of ***solar water heaters*** to choose from. The group of six pairs of children, who worked on these projects, chose to construct the following six solar water heaters:

- a "classic solar water heater" with flexible black tubes in horizontal and vertical arrays (see photo below)
- two "serpentine solar water heaters" with the flexible black tube arranged in an "S" shape
- a "spiral solar water heater" with the flexible black tube arranged in a circular form
- a "plastic bottles solar water heater" with the flexible black tube arranged in an "S" shape, passing through transparent, 1,5 litter soda bottles
- a "model solar water heater" with a spiral arrangement of a small plastic tube, where the water was gathered in a small container and circulated with a small water pump powered by 3 solar cells connected in a series.

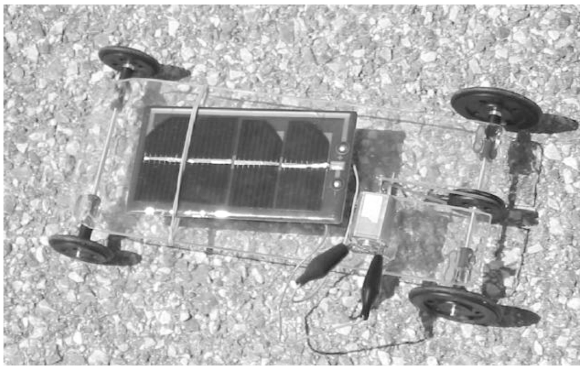
There is a variety of designs for ***solar cookers*** to choose from, within three main categories:

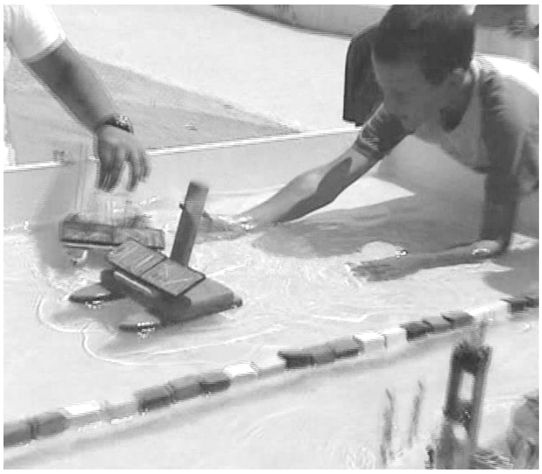
a) *box solar cookers*,
b) *open solar cookers with reflector panels* &
c) *parabolic solar cookers*.

In the latest school science fair we chose to construct *three box solar cookers* and *three open solar cookers* with reflector panels, whereas we avoided the construction of parabolic solar cookers, which are generally considered more technical and difficult. Nevertheless, a *parabolic solar cooker* will be presented in the Science Fair organized within the *2nd HSci Conference*, which was constructed in an earlier school science fair (see in the photos below one example from the three categories of solar cookers respectively).

The preparation and the experimental construction of ***solar toy cars*** and ***boats*** took some time and effort, since quite a few detailed problems had to be resolved and an appropriate combination of materials needed to be arranged and purchased. Furthermore, a suitable kind of solar cells should be used for each construction to be functional. Thus, for example light and powerful photovoltaic cells were needed for the toy cars, whereas they were not necessary for the solar boats, which could move with smaller and heavier photovoltaic cells made out of amorphous silicone.

The children constructed several solar toy cars and boats, more than we had originally planned to construct. This happened because all children, when completing their projects in the groups of solar water heaters and solar cookers, wanted also to build their own solar toys. This is perhaps a good indication that a playful approach of "science in the making" or dealing with "hands-on science activities" for the particular purposes of project work, tends to be more attractive for children, triggering their interest and commitment (see below two indicative photos of a solar toy car and solar boats … on the move).





Being consistent with the conceptual framework of "energy" we briefly described earlier that is "energy change" and "energy degradation", the children have identified solar energy changing into heat warming up the water in the solar water heaters or cooking their food in the solar cookers. They also had to confront with issues of "energy losses", mainly heat "escaping" out of their solar collectors, tubes or water tanks and boxes in their solar box cookers and they had to find out effective solutions, insulating their constructions in better ways.

In the case of solar toys, more "energy changes" have been pointed out, such as solar energy changing into electrical energy and then into kinetic energy and finally "degrading" into heat due to friction in the various parts of the toys, with the surface of the ground or with their movement through the water. Again effective solutions had to be found and applied in order to confront with these "energy problems" to the best possible extent (cf. Tsagliotis 2004).

On the whole, the mechanical and solar energy projects to be presented in the Science Fair of the *2nd International Hands-on Science Conference* at the University of Crete in Rethymno, appear to be of interest for pupils, science teachers and the general public because they highlight, in a rather concrete way, aspects of the "energy" concept, through the goggles of a child centered approach, linking science with daily life activities and with simple, easily accessible and familiar materials, applications and/or constructions.

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Science Fair Experiments and Activities from the Laboratorial Centre of Natural Sciences (EKFE) of Rethymno

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1. Introduction

The teaching of Natural Sciences with alternative methods and the projection of their beauty and usefulness are issues which have been repeatedly dealt with by the group of the EKFE of Rethymno. With our participation in the European interdisciplinary network "Hands-on Science" (HSci), a series of activities has been started from the year 2004 onwards, incorporated in the spirit and aims this Program. Last year in the *1st Conference in Ljubljana* we had promised that: "The main aim of our effort to be completed roughly within a year would be **"a work-package"** that would include:

1) **A Laboratorial manual (Book and CD)** with experiments with simple materials
2) **A DVD** with tens of videotaped experiments and constructions with simple materials.
3) **A book and a CD** with tens interesting questions and answers related with application of Natural Sciences in daily life.
4) A proposal to equip a **"Suitcase of Experiments with simple materials".**

Our eventual objective about this material is to be replicated and distributed to the teachers, as soon as it is completed, in order to provide assistance in difficult task of teaching science."

This year at the *2nd HSci Conference 2005 in Rethymno* we are in the pleasant situation to announce that we have already provided the teachers we trained this year with 2 DVDs and 2 CDs relative to the above mentioned material. The contribution of EKFE to the Science Fair organised within the 2nd HSci Conference 2005 focuses on the presentation of this material, more concretely:

a) A series of experiments on heat, fluids and biology with simple materials (a complete CD is available)
b) A parallel projection of videotaped experiments from members of the EKFE team of Rethimno (there are 2 DVDs available)
c) A completed demonstration of the "Suitcase of experiments".

Indicatively we report the titles of the experiments to be presented in the Science Fair, whereas one experiment is recorded extensively, in order to show the written structure of the presented material in a comprehensible way. The contents of the experiments presented in the CDs are compatible with the videotaped experiments the on DVDs.

2. Experiments to be presented in the Science Fair

- **FLUIDS**

1. The glass is upside down, but the water is not poured (Atmospheric pressure)
2. The bottle is upside down, but water is not poured. (Atmospheric pressure)
3. How we can we pick up a coin sunk in a plate with water, without getting our hands wet? (Atmospheric pressure)
4. How we will break a wooden piece of board covered with a newspaper? (Atmospheric pressure)
5. How we will carry water in a bottle with holes? (Atmospheric pressure)
6. The straw that does not suck liquids (Atmospheric pressure)
7. The bottle that sucks eggs and balloons (Atmospheric pressure)

8. When the air crashes the metals (Atmospheric pressure)
9. Powerful welding … without glue (Atmospheric pressure).
10. Transport of a liquid from one glass to other with a straw (Atmospheric pressure)
11. The air has weight
12. Dry paper under the water. (The gases have volume)
13. A small ball that overcomes gravity (Bernoulli Law)
14. When tap water acquires attributes of attraction (Bernoulli Law)
15. When the air acquires attributes of attraction (Bernoulli Law)
16. High depth, big pressure. (Hydrostatic pressure)
17. How do the aqueducts (water towers) work? (Hydrostatic pressure, communicating vessels)
18. Communicating vessels. Transfusion of liquids. (containers that communicate)
19. How can we transport air from one glass in another? (Attributes of gases)
20. How can we raise a sunken object with the aid of air? (Attributes of gases)
21. Lifting a glass using air only. (Attributes of gases)
22. Cartesian diver. (Pascal principle)
23. The liquids press every surface within them
24. Construction of a densitometer with simple materials (buoyancy)
25. The "egg – submarine" (buoyancy)
26. Molecular forces, surface tension
27. A simple observation of molecular forces
28. How will the coin fall in the bottle?
29. Automatic ink sprayer (Bernoulli Law)

- **HEAT**

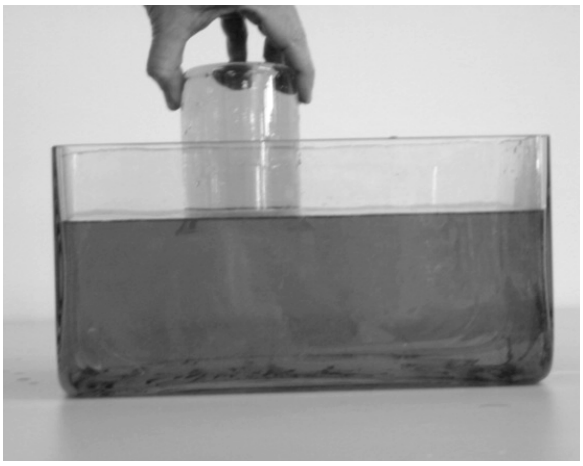
1. The water boils in a paper box
2. Thermal expansion – contraction of solids
3. Thermal expansion of liquids
4. Thermal expansion of gases
   1st way: Air bubles through water
   2nd way: The liquids go up in the pipe
   3rd way: The balloon inflates on its own
5. Thermal conductivity of solids
6. The metals are the best thermal conductors
   1st way: The cigarette cannot burn the handkerchief
   2nd way: Cutting the flame in the middle
7. The distribution of heat in the liquids is done with currents. - The hot coloured water climbs up
8. The distribution of heat in gases is done with currents - The turning paper snake
9. The distribution of heat in gases is done with currents - Which ice cube will melt faster?
10. Colours and the absorption of light
11. Emission of radiant heat
12. The greenhouse effect
13. The water boils with water
14. Evaporation
15. Condensation of Water – A rain maker

3. The structure of a recorded experiment

UNIT: Fluids

Experiment 1:
The glass is upside down, but the water is not poured

Aim:
To show the existence of atmospheric pressure



Process:

- In a basin filled with water (lightly coloured for better observation), we sink a glass, so as to fill it up with water completely.
- Having the opening of the glass turned downwards, lift it up slowly in a way that

most of the glass rises above the surface of the water of the basin.

- ➢ We observe that the water is held inside the glass and it is not poured out of it, contrary to the logic of the laws of gravity.

Explanation-theoretical elements:
The atmospheric pressure exerted on the surface of the water of the basin, is bigger than the hydrostatic pressure exerted by the water of the glass (in same horizontal level), and this does not allow the water to be poured.

Conclusion:
- ✓ The atmosphere exerts pressure on every surface with which it comes into contact.

Incorporation in science instruction: C, D, (atmosphere pressure).

This work is being developed further and we have already recorded experiments in chemistry, biology, mechanics and electricity. We aim, if possible, to have it completed within the following year.

Let's Learn Robotics and Chemistry Together!

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Abstract. *This is a brief outline of the projects developed on our center of development and investigation of our school: Gustave Eiffel located on the city of Amadora, very near Lisbon, the capital of Portugal. We had started, about 3 years ago, a very successful pedagogic experience, based on learning by making robots, and participating on robotics competitions. In this communication we will show that this pedagogic approach allowed for a significant increase of students' self-esteem, an increase for the motivation and the study for other subjects rather than robotics. The national and international competitions established in an increasing number of countries gives new challenges to students and unique opportunities of "learning by doing" and co-fraternize with other students and teachers. In a world more and more competitive it is necessary to have a multidisciplinary knowledge, and in these competitions for doing a competitive robot it is necessary for the student to obtain skills, on electronics, mechanics, physics, maths, chemistry, and a lots more subjects…*

Keywords. Robotics, Science Education, Hands-on experiments, New Pedagogic approaches

1. Introduction

NID (Investigation and Development Department) of the Vocational School Gustave Eiffel was created in the beginning of the year of 2004. One of the objectives of this department is to promote in our school the pedagogic approach of constructivism. In this approach the learning process is centred in the process of building or constructing something [1]. We had chosen the area of robotics as the centre of our projects, by the simple reasons that this area covers a lot of subjects and there are well established events at national and international level. For this kind of pedagogic approach to have success it is necessary some strong incentives to exist. One of the motivations was the participation of the project build in robotics competitions, were our teams obtained some significant prizes at national and international level. One of the most important was the a second position on the Dance competition in Padua, in Robocup Junior 2003, when we were the first Portuguese team to participate on Robocup. This prize opened the doors for more projects and allowed to create a structure to support a larger number of students to participate. Actually there are more than 30 students directly involved in the activities of the group, but many more indirectly. In 2004 in Lisbon, we were the schools with more teams present all over the world on Robocup Junior. In this competition we had won the competition of Rescue and another second place on Dance.

However, more important than the prizes, was the fact that these results brought a new life and new way of teaching in our school. In 2004, we began to involve in this project some mathematics, physics and chemistry teachers. Why these areas? Because these are subjects were the Portuguese students have traditionally major difficulties. Through the calculation of components and structures for the robots, in the case of the mathematics and physics, of special effects in the case of the chemistry, we get a significant increase of interest from students for these areas. More with the objective to enlarge and to consolidate this project we had established partnerships with English and German schools for 2006, through a *Comenius I project* for the development of soccer robots. It's our intention to expand this kind of projects in our school and create new partnerships with other European schools in the area of robotics and chemistry. In this communication we intend to demonstrate that it is possible to join these two areas of knowledge in an attractive and easy way for secondary level students. By joining together robotics and chemistry, we can achieve in an innovative way a greater motivation from the students for the study of a group of matters extremely vast, covered by these two areas.

2. Learning with robots

We have organized our electronics course in a way that the students have is first contact with robotics immediately in the first year of their courses. This is done by showing them some movies and put then in contact with older students that had already participated in robotics competitions. Some of then start immediately to build some very simple robots using Kits like Mindstorm [2] from Lego or even by doing something in the robots from students from last years. One of the most important things that we obtain with the construction of a robot is that, it is compulsory to the students to work in a group to achieve the goal of a competitive robot. But, there are many more aspects that we have gained by promoting this pedagogic experience in our school. Nominally:

- A greater motivation which leads to better school classifications… and not only on the disciplines directly connected with the area of electronics!
- A better and practical understanding of the subjects taught on the electronics courses;
- A great success, in the terms of the appetence by the students to stay in the school and participate on school activities;

But this kind of project has not only advantages from the point of view of the students… Indeed:

- The teachers gain immensely in his relationship with the students. One of my colleagues after one competition told me: “What you are doing with this kids, is the dream of any teacher!”. Sometimes they are more friends than students
- But the school as an identity wins a lot. The very good work that is done many times is not recognized simply because it is known. With the participations and prizes won in robotic competitions, the interest of the social communication has increased and took to a series of interviews and actuations on TC. This is publicity, and we don’t have to pay!

By these three experiences we can conclude that this practical approach with the goal of competition is one of the best way to increase the students’ the appetence for learning new matters and to develop their skills in a wide range of subjects, like mathematics, physics, mechanics electronic, actuators , sensors, programming, IA, etc..

2.1 Type of Robotics Competitions

The robotics competitions are organized at a national event, in Portugal the “Festival Nacional de Robótica”, and at a international level the Robocup. In the two types of events, the competitions are divided in senior leagues (students who are more than 19 years old) and junior leagues. There are basically three types of robotics competitions: Soccer, Rescue and Dance. In soccer there two robots on a field with the dimensions of 122cm by183cm with the floor painted with a greyscale. The ball is a very special kind of ball that emits infrareds for an easy detection by the robots.

Figure 1. Soccer Game, Robocup 2004

In rescue the robot must follow a black line and identify some “victims” with two different colours placed randomly across the line. All these competitions have the intention to introduce students to the world of robotics. The same kind of competitions exists in the senior league, but with a greater level of difficulty. The Rescue competition tries to recreate some conditions that could happen on a disaster scenario, were it will be very dangerous or even impossible to the humans to be present.

It’s our intention to present one of our rescue robots and show on the science fair how this competition works at the secondary teaching level.

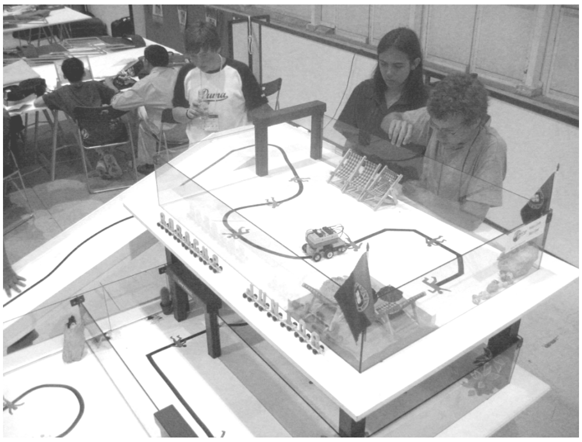

Figure 2. Rescue competition, Robocup 2004

The dance competition is the one that offers more opportunities to make original robots. In this competition the robots must dance on stage with the dimensions of 10mx5m (6mx4m in 2005, for the robots) synchronised with a music chosen by the team. The students could dance with the robots, but not touch them.

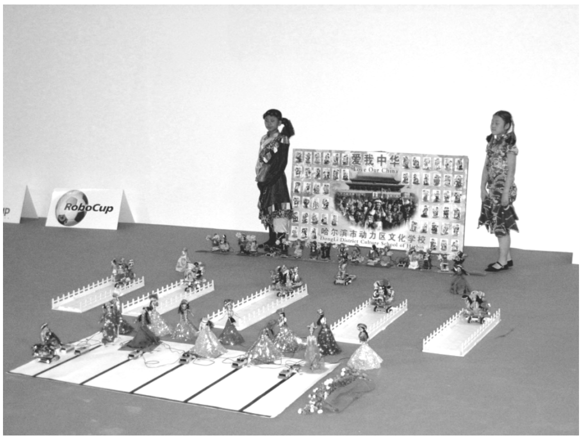

Figure 3. Dance competition, Robocup 2004

3. Robots and Chemistry

The project "Robots and Chemistry" that we will present on 2nd HSci conference intends to show that it is possible to join these two knowledge areas to motivate the students in their school activities.

This project explores the area of oxidation and reduction reactions to obtain some special effects and apply them to dance robots. This digression on the "chemistry of the fleeting perceptions", begins with the legend of Prometheus, when he gave the fire to the humans, and the peoples' fascination for the fire.

Since immemorial times, the man wanted to dominate the fire... But, the art of the pyrotechnics, just as we meet it today, was born with the discovery of the black gunpowder, in China in the IX century (in spite of some references many years before, to the "Greek" Fire).

Nowadays, the most recent pyrotechnic technology is used to do spectacles full of light and colour, a lot of times happening in simultaneous with music and… with our dance robots.

The amazing of fireworks hides the complexity of the Physical and Chemical reactions that happens on the simplest firework.

The fireworks are basically composed by gunpowder and a salt that it determines the shine and colour of the light produced in the explosion, for instance. By example the use of a strontium salt turns on the emission of red light:

$$2SrCl + O_2 \rightarrow 2\,SrO + Cl_2$$ (it shines red)

However, there can happen undesirable and/or dangerous secondary reactions as, for instance, the hydration of substances hygroscopic or the reaction of the chlorate with the products originated starting from the sulphur:

$$8\,Mg + 16\,H_2O \rightarrow 8Mg(OH)_2 + \boxed{8\,H_2} + \text{Energia}$$

$$\boxed{8\,H_2} + Ba(NO_3)_2 \rightarrow Ba(OH)_2 + 4\,H_2O + 2\,NH_3$$

$$S + H_2O \rightarrow H_2S_nO_6 \rightarrow H_2SO_4 + SO_2 + (n\text{-}2)\,S \xrightarrow{+KClO_3} ClO_2 + \text{Bum}$$

The introduction of polymers in this area, revolutionized the manufacture techniques of fireworks, products as the polyvinyl chloride will substitute the traditional and dangerous potassium chlorate. In this project we move many times back to the time of the chemist and metallurgist Alexander Parkes, who is one of the founders of the modern industry of the plastics. One of the substances that we use is cellulose nitrate - substance designated by gunpowder without smoke and used in some special effects in our robots. By recreating this discover and taking advantage of the redox effects of this substance, we can easily motivate our students to more complex experiences.

Figure 3. Some fireworks on public presentation of one of our dance projects "The pyramidal Dragon"

We will try to show one of our projects "The Pyramidal Dragon" in the science fair of the 2nd HSci Conference in Crete. It is our intention to show some special effects that we use on this project.

In the same area of oxidation-reduction reactions we started cooperation last year with a company that develops fuel cells. This allows us to show the viability of the hydrogen as an alternative source of energy to the traditional batteries, by using it then in our robots.

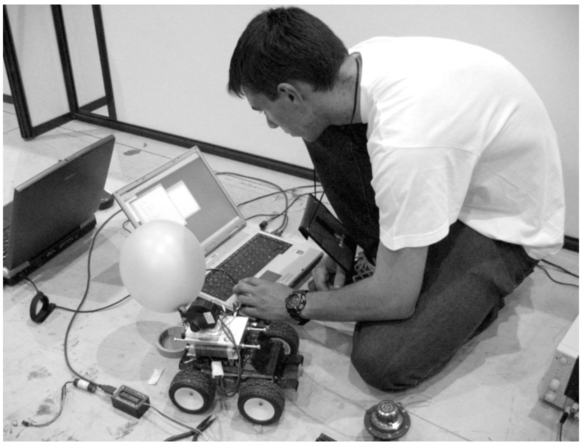

Figure 4. One of our projects powered by hydrogen fuel cells

4. Acknowledgments

The authors would like to acknowledge the support of Ciência Viva on the projects PR08 e PR09. The support from our school director Adelino Serras, who has comprehended that a school needs this kind of activities to be really a school! The support of the "Hands-on Science" Comenius 3 network, in particular the intensive course "School Robotics" held in April at Pontevedra, Spain.

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Technology Fair Projects

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Abstract. *This is a brief outline of the Technology Fair projects undertaken by pupils of Lycavitos Primary School of Nicosia, Cyprus in collaboration with pre-service teachers at the University of Cyprus. The Technology Fair projects were designed to focus on the technological problem solving process and to offer students and children an opportunity for extensive collaboration around a single project. The Technology Fair took place on the school grounds in November 2004. During the fair pupils presented their work to fellow pupils, pre-service teachers, teachers and parents in an open school exhibition.*

Keywords: Design and Technology, Problem-Solving, Decision-Making, Technology Fair.

1. Introduction

The Technology Fair is a new idea derived from Science Fair projects that have been taking place for many years in the Learning in Science Group at the University of Cyprus. Technology Fair initiatives encourage students to explore their technical environment in a systematic manner. The underlying principle is that participation in a Technology Fair stimulates student interest in science and technology while simultaneously promoting the development of technological problem solving and decision making as important life skills.

The project took place in the context of a compulsory University course in Design and Technology and a collaboration framework that this course has set up with local schools. Eighty two (82) primary school students from a local school with the assistance of (82) university students, studying to become teachers, were responsible for identifying a human need, formulating a technological problem, collecting information and developing an appropriate solution. Each university student was responsible for collaborating with one primary school student on a single technological project.

In this context, Technology Fair projects provide an opportunity for interaction between undergraduate student teachers and elementary school students so that they can work as a team with shared but different goals: the child aims to solve a problem and present both the problem and the solution during the Technology Fair; the student – teacher aims to use the interaction as a process for helping the child develop problem-solving and decision making skills through a systematic approach.

2. Technology Fair requirements

During the fair, each pupil with his pre-service teacher displayed a poster describing the design process (see figure 1 for an example)

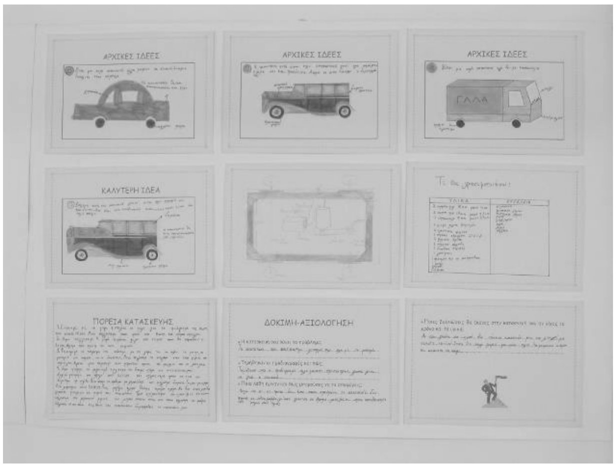

Figure 1. Typical poster shown the design process in the technology fair

Pupils and pre-service teachers also presented the artifact they constructed as a solution to the technological problem (figure 2)

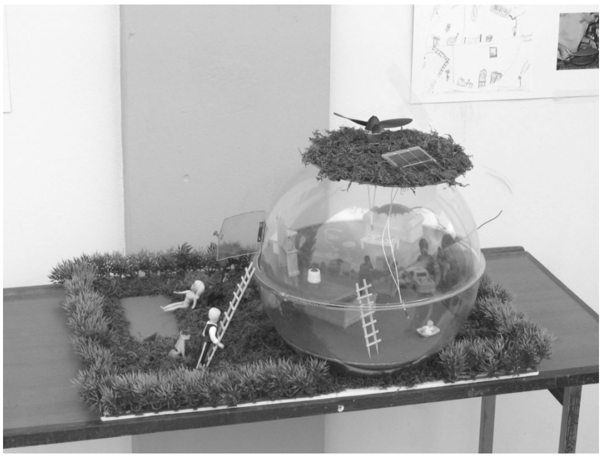

Figure 2. Solution for a reweable energy house

Additionally, the children engage the public in a specific aspect of their work through a specially design interactive exhibit (see the photograph in figure 3).

Figure 3. Children interaction during the Technology Fair

3. Technology Fair projects

The children and pre-service teachers worked in an one to one collaboration for the solution of their chosen technological problem. Below we describe some of the solutions presented during the Technology Fair.

3.1 Solar Car

The design brief required children to design and make a solar car. The car should be powered with a small photovoltaic cell. The artefact should be constructed with lightweight and cheap materials. The solution given by one child is shown in figure 4.

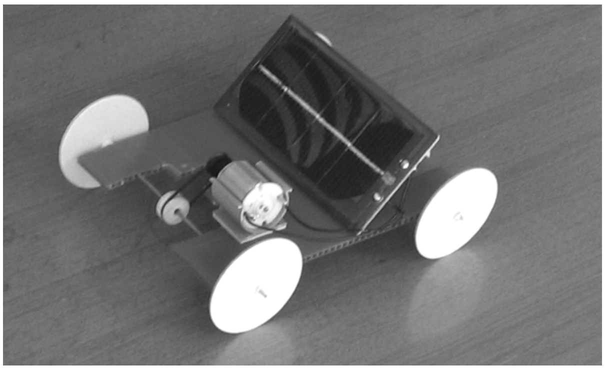

Figure 4. Solar car

3.2 Model of Bridge

The design brief required children to design and make a simple model of a bridge. The model should be able to allow small boats to pass below its surface. The solution given by one child is shown in figure 5.

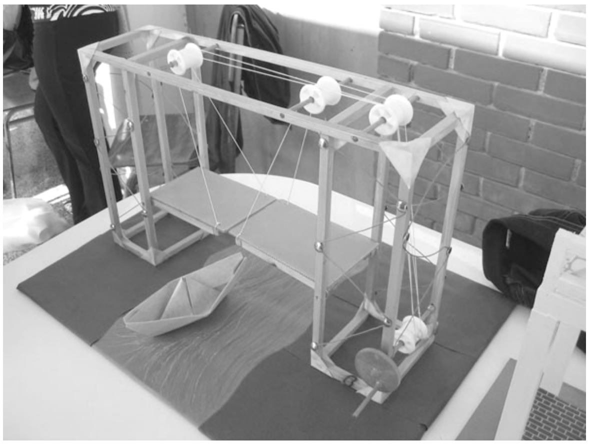

Figure 5. Bridge model

3.3 Catapult

The design brief required children to design and make a simple catapult. The catapult should be able to throw light materials to a minimum distance of 2 meters. The solution given by one child is shown in figure 6.

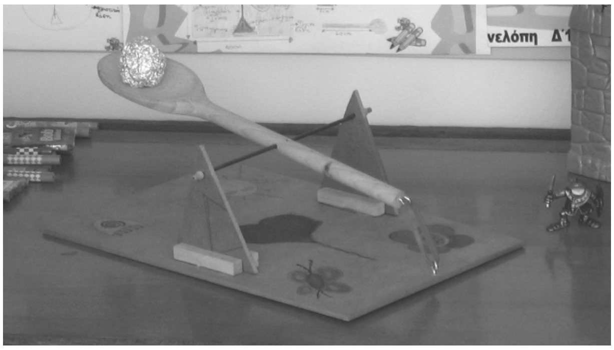

Figure 6. Catapult model

3.4 Electronic quiz game

The design brief required children to design and make an electronic quiz game. The game should be constructed using cheap materials and simple electric circuitry. The game should be interactive and have an educational purpose. The solution given by one childr is shown in figure 7.

Figure 7. Electronic quiz game

3.5 Traffic lights model

The design brief required children to design and make a model of traffic lights. The model should be built using simple electric circuitry. The solution given by one child is shown in figure 8.

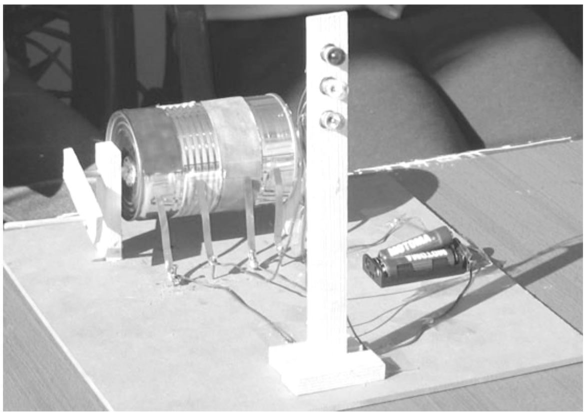

Figure 8. Traffic lights model

3.6 Windmill model

The design brief required children to design and make a model of a windmill. The model should be built following inspiration from a real windmill. The solution given by one child is shown in figure 9.

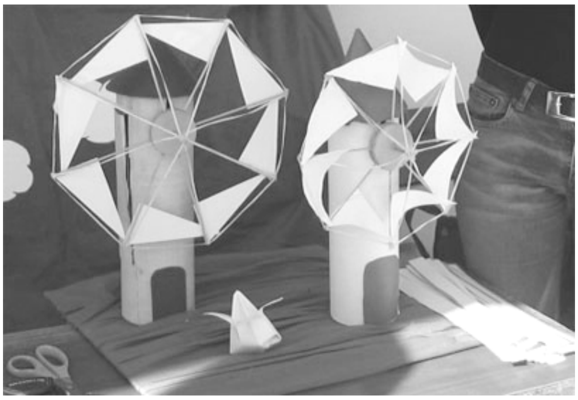

Figure 9. Windmill model

4. Conclusions

The purpose of the Technology Fair is to enhance technological problem solving skills. This particular fair centered around a University – school partnership and hence this raised the level of complexity both with administrative and scientific issues. The end result of such partnerships is that schools have the opportunity to demonstrate an educational innovation to their staff and the university teacher preparation program benefits from the contact with children afforded to students. The partnership also creates opportunities for educational openness and research.

A separate research study was carried out to examine the influence of the Technology Fair on pre-service teachers' and primary school pupils' cognition and emotions. The analysis of the results indicates that the Technology Fair has a significant influence on improving students' understanding and application of problem solving and decision making strategies within the area of design and technology. This study is reported in more detail elsewhere in this volume.

Important factors that emerge from previous research on the Science Fair and are confirmed by this study for the Technology Fair are the enthusiasm and the motivation that this kind of education conveys to students.

Further research will include the design of teaching material to support the Technology Fair activities.

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The Theory of Relativity in Primary Education(*).

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(*)Part of a study undertaken within the context of a degree dissertation from the Department for Primary Education of The University of Crete

Abstract *The main object of this study is to investigate, initially, whether the students of the sixth grade of primary school are in position to comprehend the basic concepts and elements of the Theory of Relativity.*

Keywords Relativity, time, velocity of light, gravity, primary education

Introduction

In the latest years, intense changes have been made in the textbooks of physics in primary school. However, it has been pointed out/ detected that sections which are referred in more far-fetched matters/ subjects/ issues as the Theory of Relativity of Einstein are absent.
Therefore, the anniversary year of 2005, as the year of Einstein and, also, the conviction that we can carry out and incorporate in the curriculum a series of courses, with a different subject from the already existed, gave rise to this study.

The necessity

The study of this specific cognitive subject causes great interest since, as we have to mention, it has not been incorporated in other country's curriculum. Also, it has to be mentioned that it is a very interesting subject of teaching and that the concepts of relativity beside the fact that they are very important, they may related to the daily routine of the children, therefore it helps in the better conception of their environment.

The sample

The class, in which this study will be carried out, will be the sixth grade of the primary school and will be consisted of eighteen to twenty pupils. The pupils will be divided in groups of four to five, with every group to be able to study and comment the worksheets given, so that they could participate and cooperate significantly to the conversation which will be conducted in the classroom.

Lessons' Plans

The way, in which the instructive part of the study will be realized, includes three lessons that aim to the presentation of the basic concepts covering the Theory of Relativity.

Primary Valuation

Before referring to the cognitive subject of the Theory of Relativity, the teacher must beware of his class' level around the concepts of physics that are essential for the teaching of the subject to be held. This will be done with the use of a structured questionnaire which the pupils should be able to complete within 20 minutes.

First Lesson

During this lesson, the pupils will be taught the concepts of velocity, velocity of light while also they will become aware of certain basic elements about the light and its characteristics
Additionally, during this lesson, the concept of gravity will be incorporated.
The pupils will have to study and take notes about the concepts that will be referred during this lesson, while they form the central axis of the concepts of the Theory of Relativity.

Second Lesson

The Instructional objective of this section is the study of the particular Theory of Relativity and the comprehension of its postulates from the children; nothing can run faster than the light despite the activity of the source.

The radiomeasure will be used as the nucleus of this section. By having as our purpose, during this lesson, the grasp of the corpuscular nature of the light by the pupils, they will also be asked what causes the rotation of the laminas that consequently rotate. Additionally, the pupils will be asked if they believe that there is anything that runs faster than the light. The answer to this question will ensue from the screening of a relevant video. It will be clarified to the pupils that all the conceivable experiments that Einstein did were referred to systems that were moving with or close to the velocity of light.
From the ending of the previous lesson, a three-page text, where the curvature of time is being presented in simple words, will be already distributed, in order to be studied by the pupils as an introductive knowledge for the current one. Inside the classroom, a digital experiment will be presented where a spaceship that sets out from earth moves to another planet and comes back later on. The surveillance, which the pupils will make on this, is to interrelate the text they studied and give an explanation for the results of the chronometers of the digital experiment. Furthermore, the experiment with the twins will be presented and commented.

The contraction of space will be taught through a series of digital experiments and there will be asked from the pupils to comment the disfigurements that happen to the objects as they approach the velocity of light. They will observe the reason for which the objects lose their regular size. If we were in a spaceship, which was moving in such velocity, would we realize the difference on us?

During the continuation of the lesson we will talk about the relativity of motion. Among others, the basic reasoning will be the following: "If your father is driving the car and you watch a fly on the mirror, what kind of movement do you think that the fly does? If you meet a friend on the street while you are moving and you greet him and he sees the fly, what kind of movement will the fly do regarding your friend?". Later on, a video referring to the relativity of the motion, according to Einstein perceptions, will be presented.

In the end of this lesson, a number of questions to be answered will be distributed to the pupils just like in the previous lesson.

Third Lesson

During the last lesson the pupils must comprehend the general theory of relativity. The point is to conceive the relation between the gravity and the acceleration, the way a black hole is created and their attributes and the cosmogonic theory as well.
The instruction will be focus around an experiment that will be accomplished in a construction, which will be composed of a little car that will be tied on its one side with a weight, which will pass through a pulley. The pupils will be asked to keep notes concerning the movement that the little car does, while the weight pulls it to the end of the construction as it fells on the floor. Additionally, they will have to observe what does happen while the weight has reached the floor, if this is related to the movement of the little car.

Afterwards, the pupils will be asked if does gravity exist on earth, and then if does gravity exist on the moon and for what reason does the moon revolves round the earth. At this point, an experiment will be occurred, while an electronic car is tied up alongside with a rope, which is steady on a big weight. The cyclical route that the little car will follow can be interrupted only in case that someone cuts the rope. In the same way, the power of gravity on the celestial bodies is explained. Furthermore, they will be asked about the reason for which the earth revolves round the sun and they will be required to draw them on the board. A picture of our galaxy will be presented and the pupils will be required to give several interpretations concerning the principle of the universe. Afterwards, an experiment will be accomplished, with a balloon on which there will be a dot, which begins to enlarge as the balloon inflates. That occurs in order to parallel the dot with the universe.

The pupils will be asked if they have seen black holes. If not, why do they think that it is possible to see. Do the black holes have gravity? Starting this conversation, we will talk about the position of the stars, and how does that influents their position on the map the curvature that causes the journey of light the mass of the sun. Since we cannot see where are the black holes it means that because of the great gravity that their mass creates, they change the direction of the light.

At last there will be an experiment in which, from a specific height we will let a square box to fell. Then, we will ask the opinion of an exterior observer concerning the movement that the box did while fallen and the person why declare that is inside the box as well. Then, we ask how does the observer who is inside the box conceive the fall, according to our opinion.

As a final point of this lesson, the pupils will answer a questioner that re- examine this instructional section.

Final Valuation

During a following didactic period, the pupils will be required to answer a paper with questions related to the subjects they studied through those three lessons. The duration of the test will be 40 minutes and its aim will be the valuation of the total lessons.

Conclusion

The Theory of Relativity spread a fear, through its words, for what it concerns its content and how far can easily become comprehensible from the teacher as much as from the pupil.
There is the strong conviction, that from a series of three lessons, the pupils can completely take in basic elements and concepts of Einstein around the two relative theories he formulated.

Related Litterature

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Science Fairs as mechanisms for University – School - Community collaborations in Cyprus

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Abstract. *This is an outline of the Science Fair projects jointly organized by the Learning in Science Group, University of Cyprus and local schools. In our approach, the Science Fair focuses on developing students' scientific thinking and investigative skills. This year, two science fairs were organized by the Learning in Science Group. During the fairs, elementary school students and undergraduate students worked together to undertake independent investigations and presented their work in an open exhibition where they also had the opportunity to demonstrate interactive exhibits.*

Keywords. Science Fair, scientific thinking skills, university - school collaboration.

1. Introduction

The Learning in Science Group at the University of Cyprus has a coordinated program of research into student thinking, scientific reasoning and conceptual development. The main purpose of our work is to design, develop and disseminate research based curriculum and educational processes that promote student inquiry through a sequence of formal, informal and non-formal activities.

As part of this overall activity we have designed a program of educational implementation of science fairs as a means of developing scientific thinking skills. In this report, we are describing this process and presenting results from the activities that have jointly been carried out between two local schools and the University of Cyprus during the 2004/2005 academic year.

2. The Science Fair Process

Science Fair projects have long been used as a mechanism for placing emphasis on learning through "doing". Making observations, asking questions, identifying problems, proposing solutions, and interpreting data are necessary skills for students in school and throughout their lives. Even though there is a general argument that science fairs are organized in order to promote such skills, there are relatively few examples of fairs that have clearly specified educational goals and are assessed for their learning outcomes. In many cases, schools organize science fairs in order to develop positive attitudes towards science and the activity is considered as a celebratory school event.

At the Learning in Science Group the emphasis is on using the science fair as an educational medium for rallying schools around the aim of developing scientific thinking skills. In our approach, students are typically guided to develop a common conceptual basis about science investigations and design experiments through a short sequence of lessons. Subsequently, they are assigned individual projects which involve undertaking an investigation with simple materials in which data is collected, analyzed, interpreted and the whole process and its results are communicated through specially prepared poster and exhibits.

Picture 1. Poster from the Chriseleousa science fair presenting an investigation about magnets

At the same time, parents and other community volunteers are involved by the school and the university in offering support for the projects. Once the work of children (10-12 year olds) and undergraduate students reaches a level where specific products are available, the school organizes a public event where each child with one undergraduate student that was assigned to her display a poster and an exhibit.

Picture 2. Interactive exhibit from the Chriseleousa science fair about factors that influence the speed of a boat

The poster describes the procedural aspects of their work. The exhibit engages the public in a specific aspect of their investigation through an interactive activity or a game. The involvement of parents in developing the interactive exhibits is of particular importance.

3. Science Fairs

During the 2004/2005 academic year two science fairs were organized by the Learning in Science Group, University of Cyprus, in collaboration with two different elementary schools (Chriseleousa Elementary School and 1st Egkomi Elementary School) as a part of an undergraduate science methods course. Each undergraduate student was assigned to an elementary school student and together they had to implement an investigation and present the results in a science fair. University faculty, university students, elementary school students and teachers were involved in this process. The final outcome was usually a poster and an activity/game that was related to the investigation.

The first science fair of the 2004/2005 academic year took place at Chriseleousa Elementary School. The 47 students that participated collaborated with their teachers, university faculty and 47 university students and parents to present the outcomes of their investigations during the fair, which took place on November the 21st 2004 on the school grounds.

The second science fair took place at the 1st Egkomi Elementary School. Sixty five undergraduate students, 42 elementary school students, 3 school teachers, university faculty and parents collaborated. The outcomes were presented in an open exhibition on April 9th 2005.

Below we describe some of the investigations that were presented at both science fairs.

3.1 Sinking or floating

During this project, the students had to investigate: (a) the factors that influence the sinking or floating of different bodies in the same fluid and (b) the factors that influence the sinking or floating of similar bodies in different fluids.

Picture 3. Sinking and floating at the 1st Egkomi Science Fair

The outcome of the investigation was a poster that presented the questions, the experiments and the conclusions. The public was also engaged in a game in which they had to build boats that would be able to float.

3.2 Rockets

During this project, the students had to investigate the factors that influence how far a rocket will travel. They had to design experiments and carry them out in order to come to conclusions.

Picture 4. Paper rockets at the 1st Egkomi fair

At the science fair the two students and the undergraduate students presented the process and the results of their investigation on a poster. Additionally, they asked the public to enter into a contest in which they had to make and test the best rocket with the provided materials.

3.3 Colourful flowers

During this project, the students had to investigate (a) whether a flower, a carnation for example, can change colour when placed in coloured water and (b) what factors influence how quickly the flower will change colour.

Picture 5. Colourful flowers at the 1st Egkomi fair

The interactive exhibit for the investigation included a workshop on how to easily dye flowers using colored water.

4. Conclusions

In the case of science fairs, our curriculum has matured through years of implementation and evaluation: for the last few years, it has been possible for individual teachers, in their own schools, to use our materials, with guidance, in order to organize their own fairs.

Our thematic areas focus on two important needs:

- The need to encourage students to develop an understanding of the relationship between science and society.
- The need to place greater emphasis on the reasoning strategies which underlie science and to use science as a medium for developing generic and transferable thinking skills.

The fairs that we organize in the context of teacher preparation programs at the University of Cyprus serve multiple purposes. First, it is possible to collaborate with a school and have one student teacher work with one child, an experience that is valuable for both. Secondly it is possible to use each of these events as a context for preparing future teachers to use this approach and the associated materials and participate productively in the organization of local science fairs in their own schools in the future. Finally, this also serves as a mechanism for creating links between the University, schools and local communities, which create new opportunities for communication and collaboration.

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"Fun Science Club"

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1. Brief presentation

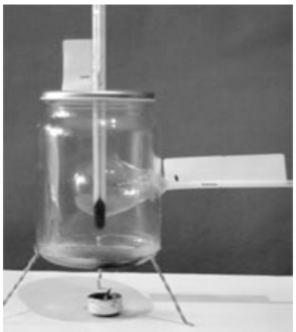
"**Fun Science Club**" was opened on March 16th-17th 2005 as a students' and the teachers' initiative of "Tudor Vladimirescu" Theoretical High School from Bucharest. It has appeared as a necessity to increase young people's interest for the study of sciences.

The first meeting gathered the following partners:
"Tudor Vianu" National College; "Edmond Nicolau" Technical College; "Doamna Stanca" Theoretical High School; "Elena Cuza" National College; The Study of Complexity Center"; The Teachers' House Bucharest and Theoretical High School "Tudor Vladimirescu" Bucharest, of course.
The general objectives are:

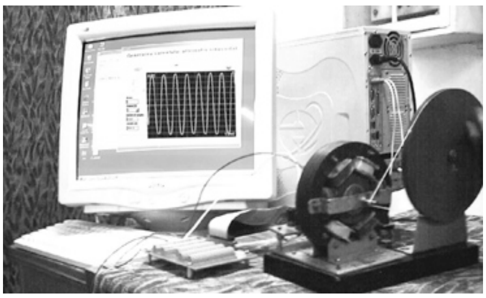
- To identify the activities which revive the interest of our students for science.
- To promote the experiments (real and virtual).
- To develop the "Hands on Science" group.
- To develop the pupils' technique creativity and inventiveness.
- To promote the interdisciplinary activities.

The most attractive activities for young members of this club are:

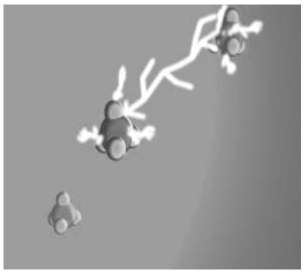
- The laboratory experiment where they had the opportunity to build their own device, and where they distinguished simple but original solutions;

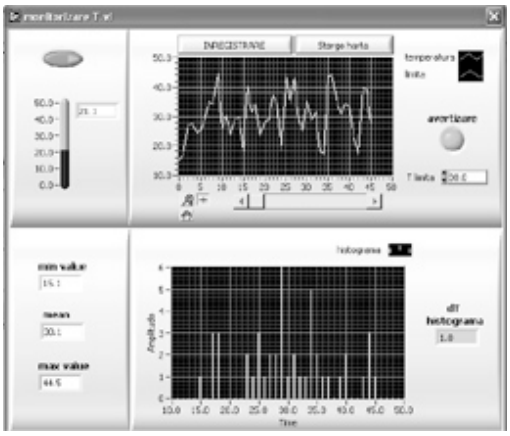


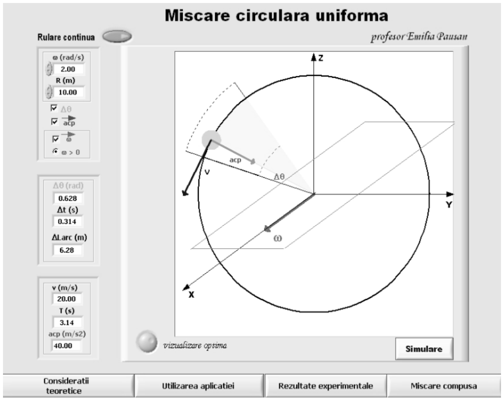
- The data acquisition of the processing dates, the signal analysis using specific software, in both cases;



- The achievement of some simulating software (physics, chemistry);







- The quality test for food products;
- The subjects connected with the environment and pollution;
- The secrets of nature and civilization.

The students' groups presented posters, sketches, poems, having different ways of expression; and also music interpretations were appreciated.
The scientific subjects were focused on these activities.

To promote these activities we decided to make a site, which will reflect the actions carried out by our club permanently.

At the beginning of this way, we try to identify the most suitable solutions in order to attract in this project, a large number of teenagers from different ages.

Global Science

Prof. Luminița Grigorescu, Prof. Maria Enache, Prof. Ovidiu Şerbanescu, Tehn. Lab. Eugenia Bâdrea, Prof. Corina Sibişeanu

With the assistance of the following students:
Claudiu Armean, Florentina Ungureanu, Mihai Ene, Andreea Panait, Valeria Ciocâlteu

Abstract. *The second „Science Club" activity has been organized by the High-School „Costin C. Kiritescu" on April 16 2005. The activity is part of the „Hands on Science" project (110157 – CP – 1 – 2003 – 1 – PT – COMENIUS – C3).*

The projects presented in this activity cover a large spectrum of classes: physics, chemistry, biology, computer science, ecology, consumer protection, health and security at the work place.

The projects were composed of: laboratory experiments, virtual laboratory experiments, the utilization of IT in the learning process, an exposition of teaching materials manufactured by the students.

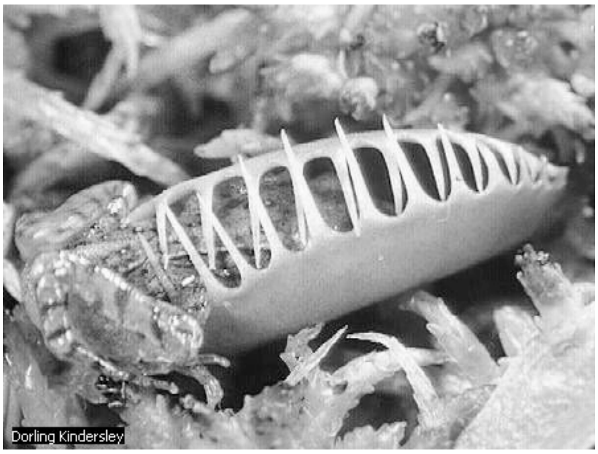
1. Activity purposes:

1. Laboratory experiment promotion (real and/or virtual)
2. The conception of simple experiments and with a maximum cognitive impact
3. Continuous interdisciplinary – up dating scientific information
4. Dissemination activities accomplish in the „Hands on Science" project
5. The extension of the „Hands on Science" group.

2. Activity program:

- **Projects**:

1. „Bio field phenomena" – represent the biophysics application of radiations in the medical area (unsolved problems of cancer illness)
2. „Carnivorous plants and their capturing mechanisms"



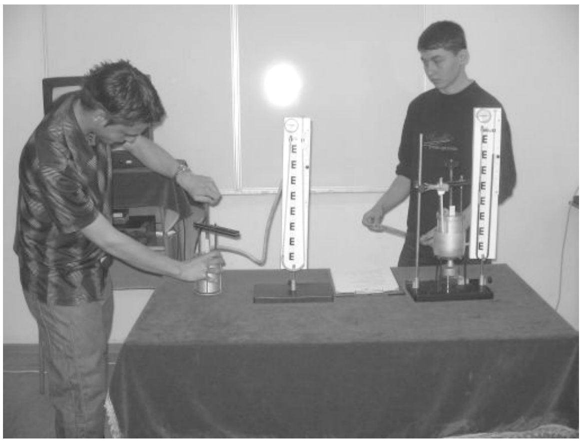
3. „Water pollution" – substances that pollute water and their effects; the main pollution sources
4. „Power and its effects" – its physiological effects are emphasized

- **Virtual presentations**

1. „Tourism and pollution" – which recommends different holiday locations where the vacation can be spent, a tourism firm is presented because there are polluted sectors, and an initiative is pointed out in order to stop pollution.
2. „Healthy alimentation reported to the blood type"
3. „Mobile communication and its pernicious influences" – a virtual enterprise is presented, which trades mobile phones, but warns about the way they are used so that pernicious influences are avoided
4. „Laws of the ideal gas" – Boyle-Mariotte, Gay-Lussac and Charles laws are introduced (mathematics equations and graphics), and also at the end a questionnaire to be applied.

- **Real experiments**

1. Laws of the ideal gas: the Boyle-Mariotte and Charles laws are verified using the experimental montages; measurements and than graphics can be made



2. Protection methods of the consumer
   The following experiments are performed:

   - determination acidity of candies

   - identification of starch substances

   - determination of the acidity of flour

   - physical-chemical characteristics of bread

   - quality characteristics of consumable milk

- **Mediation of the security and health in work campaign: „You learn today to beware a life time”**
- **Sketch: „Beware of drug dealers”**

- **Exhibitions:**

1. Lab experiments for the physics class: the checking of the law of Ohm, visualization of the magnetic field lines, the phenomenon of electromagnetic induction, the light dispersion (the optical prism), calorimetric reading, etc

2. Didactic material made by students

3. Parts and home use devices damaged due to incorrect use

The teachers from other high schools have participated at this activity too: „Tudor Vladimirescu” Theoretical High School, „Eugen Lovinescu” Theoretical High School, PPTC High School, „Tudor Vianu” National College, „Elena Cuza” National College and „Gheorghe Lazar” National College, “Sfântul Sava” National College.

3. A list of projects to be presented in the science fair.

- **Collaborating projects (virtual presentations)**

1. “Kirlian Effect”
   Authors: students – Andreea Marinela Panait, Alina Valeria Ciocalteu, class XI F
   Coordinating teachers – Maria Enache, “Economic High School Costin C. Kiritescu”
2. Oscillatory motion
   Authors: students – George Badea, Alexandr, class XI C

Coordinating teachers – Maria Enache, "Economic High School Costin C. Kiritescu"

3. <u>Laws" verification of ideal gas (Ideal gas laws verification)</u>
   Authors: students – Florentina Aurelia Ungureanu, Claudiu Armean, Mihai Ene, class XI D
   Coordinating teachers – "Economic High School Costin C. Kiritescu"
4. <u>Identification of textile fibres</u>
   Authors: students – Florentina Aurelia Ungureanu, Claudiu Armean, Mihai Ene, class XI D
   Coordinating teachers – Nicoleta Mada, "Economic High School Costin C. Kiritescu"
5. <u>Falsification of alimentary products</u>
   Authors: students – Alina Tanase, Cristina Blanaru, Mihai Florea, class X C
   Coordinating teachers – Crina Cornea, "Economic High School Costin C. Kiritescu"
6. <u>The tourism and pollution</u>
   Authors: students – Florentina Aurelia Ungureanu, Claudiu Armean, Mihai Ene, class XI D
   Coordinating teachers – Maria Enache, "Economic High School Costin C. Kiritescu"

- **Posters**

1. <u>Ideal gas laws</u>
   Experiment authors – Florentina Aurelia Ungureanu, Claudiu Armean, Mihai Ene, class XI D
   Coordinating teachers – Maria Enache, "Economic High School Costin C. Kiritescu"
2. <u>The identification of starch products for cream</u>
   Experiment authors: the student Georgiana Scripcaru, class XII H
   Coordinating teachers: Rodica Stoian and sampler technician Badrea Eugenia, "Economic High School Costin C. Kiritescu"
3. <u>The determination of flour's tartness</u>
   Experiment authors: the students – Catalina Anton, Rebeca Vasile, class Xii H
   Coordinating teachers: Rodica Stoian si sampler technician Badrea Eugenia, "Economic High School Costin C. Kiritescu"
4. <u>The physical and chemical characteristics of bread</u>
   Experiment authors: the student: Iulia Pandele, class XII H
   Coordinating teachers: Rodica Stoian and sampler technician Badrea Eugenia, "Economic High School Costin C. Kiritescu"
5. <u>The characteristics of consumer's milk</u>
   Experiment authors: the student: Maria Madalina Chiva, class Xii H
   Coordinating teachers: Rodica Stoian and sampler technician Badrea Eugenia, "Economic High School Costin C. Kiritescu"

- **Science friends:**

1. Role-playing: "The CPO (Consumer Protection Office) in surveillance"
   Authors: the students of the X D class
   Coordinator teacher: Nicoleta Vaduva, Economic "Costin C. Kiritescu" High School
2. Role-playing: "Bank negotiation between Japan and Belgium"
   Authors: the students of the XI G class
   Coordinating teacher: Nicoleta Vaduva, Economic "Costin C. Kiritescu" High School

3. Scene: "The little great physicians"
   Authors: the students – Elena Marcela Ene, Irina Teodorescu, Victor Dumitrache, Mihai Parva, the IX G class.
   Coordinating teacher: Maria Enache, Economic "Costin C. Kiritescu" High School
4. Rebus: "Foreign languages and sciences"
   Author: the student Sofia Diana Maria Galceava
   Coordinating teacher: Doinita Janulya Costache, School No. 156
5. Posters that have participated at the national tournament "Advertising Physics" dedicated to the International Year of Physics 2005.
   Authors: the students Mocioi Alexandru, Baskir Sorina, Constantinescu Sorana Elena, Tulea Claudia Oana, Ghergheleasa Mihai, Neamu Madalina, Vasile Violeta, Banisor Liviu.
   Coordinating teacher: Maria Enache, Economic "Costin C. Kiritescu" High School
6. Films:
   a) "The CPO (Consumer Protection Office) in surveillance"
   b) "Bank negotiation between Japan and Belgium"
   c) Identification and verification methods of textile fibers quality
   d) The faking of double refined alcohol and identification of albuminous substances
   e) Identification of the way to fake coffee
   f) Identification of milk faking

- **Real experiments**

1. Identifying the internal organization of the fish class

Authors – Eugen Ştefan
Coordinating teacher – Şerbănescu Ovidiu, „Costin C. Kirițescu" Economic High school

2. Falsifying double refined alcohol
   Authors – Mihai Florea, Gabriel Florea
   Coordinating teacher – Crina Cornea, "Costin C. Kirițescu" Economic High school
3. Identifying albuminose substances in whip cream
   Authors – Mihai Florea, Gabriel Florea
   Coordinating teacher – Crina Cornea, "Costin C. Kirițescu" Economic High school
4. Methods of identifying the quality of textile fibers
5. Learning physics with the aid of graphics
   Authors – Cociorva Alexandru
   Coordinating Teacher – Constantin Liliana Violeta, "Elena Cuza" National College
6. Projects (virtual prezentations)
   -Electrical circuit with fuses
      Author – Costin Marian Postolache
   -Learning the traffic rules
      Author – Sarah Taban
   -Lizzard man
      Author – Cosmin Mocanu
   -Light reflection from a plane mirror
      Author – Vasile Bogdan Claudiu
   -Lamp flashing
      Author – Alexandru Constantin
   -The Howercraft
      Author – Andrei Eremia
   Coordinating teacher: Elisabeta Radoi, School No. 45

The Science Truck
High level research coming into the school

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1. Introduction – Brief Presentation

Technical maximum performances often have a large fascination for children and young people. Unfortunately however it can be observed that only a few of them consider it possible that they will manage to work in this field of activity in later times. The own knowledge and efficiency are estimated as not sufficient for such a way. The Science Truck of the RWTH Aachen (Technical University) offers a new opportunity to get to know and try modern research by small experiments and at the same time get to know young people, who think themselves being capable of making science. They give tips and assistance, how the students can find an orientation during school time to be active in science/technical research later on. All exhibits are presented by university students, who are quite close in age to the visitors, so that a large identification is still possible. The whole project is organized by students and can be requested by schools.

Possible participation to science fair:
Poster and/or ppt.presentation :

Pictures and description of the several exhibits:

- *(synthetic materials in medicine;*
- *biosensor for verification of phenolic components;*
- *immobilization of yeast and use for fermentation;*
- *illustration of the action of an liquid buffer;*
- *anchoring in sand;*
- *designing a bridge (computer-simulation);*
- *function-model of a new Otto-motor (Opel);*
- *Why do nappies suck so much liquid? (What about the context with synthetic materials?);*
- *recuperator and fluidized bed;*
- *separating materials with different conductivity;*
- *smokeless fuels;*
- *miracle box of raw materials;*
- *sound absorption of TRITEC;*
- *enrgy-absorption of foamed aluminium;*
- *optimization of forming problems, methods of simulation;*
- *thermochemistry;*
- *transfer of speech, portable radio*

The multimedia album MATH' ON MUSICAL NOTES of the PROFU DE MATE (MATH' TEACH) band

Dragos Constantinescu (teacher)
High School of Art, Rm. Valcea, jud. Valcea, Romania
Tel: 0040350\401151, 0040724\146891,
E-mail: profudemate2004@yahoo.com, dragos@epsilon.ro, profudemate@gmail.com

1. Theme of interest:
Mathematics

2. Obiectives of the product:
- An original method of math teaching;
- Entertainment;

3. Target of the product:
- pupils age 13-17; math teachers, parents;

4. Short description of the content:
The multimedia album MATH' ON MUSICAL NOTES of PROFU DE MATE (MATH' TEACH) band is considered as an alternative in the process of math teaching for the pupils between 13 and 17 years old; it contains:

- 15 songs interpretated in different musical genders: folk-rock, country, R&B; the lyrics or the songs are theorems and short lessons of mathematics;
- animated cartoons;
- a videotape (Pytagoras' Theorem);
- the lyrics of the songs (in Romanian);
- photoes from shows and TV appearences;
- real lessons of mathematics;

More details of the activity of the band can be followed in the site www.profudemate.ro or http://www.epsilon.ro/formatie.asp?lb=ro

5. Interface with the user:
CD multimedia

Author's Index

Keywords Index

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The University of Crete

http://www.uoc.gr/

Department for Primary Education

Laboratory for Science Teaching

http://www.clab.edc.uoc.gr/

Laboratory for Science Teaching
Univercity of Crete Department of Education

Education and Culture

Project no. 110157-CP-1-2003-1-PT-COMENIUS-C3

http://www.hsci.info/ Hands-on Science (H-Sci)

Apple IMC (Greece & Cyprus)

http://www.rainbow.gr/

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