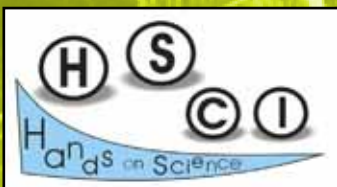


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Manuel F. M. Costa



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- Abstract
- Keywords
- Main text
- Footnotes
- Acknowledgements
- References

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All figures are to be included within the text. **Figure captions** are to be below the figures, in 9-point Helvetica (or a similar sans-serif font), boldface. Initially capitalize only the first word of each figure caption. Figures are to be numbered consecutively with Arabic numerals throughout the paper, for example: "Figure 1. Database contexts", and are referred to in the text as Fig. 1, Fig 2, etc.

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Figure 1. Helvetica or Arial, 9 points, boldface

High resolution color photos or pictures are welcomed. However it will be printed b/w in the printed version of the journal and of the conferences/workshops proceedings. Videos or computer simulation can be included for the electronics (online) version of the Journal.

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Equations should be numbered serially on the right-hand side by Arabic numerals in parentheses, and referred to in the text by citing the equation number.

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Use footnotes sparingly (or not at all) and place them at the bottom of the column on the page on which they are referenced. Use Times 8-point type, single-spaced. To help your readers, avoid using footnotes altogether and include necessary peripheral observations in the text (within parentheses, if you prefer, as in this sentence).

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- [1] Barghaf V., Poursni R., editors; Information Technology for Pseudo-Knowledge Management. Paris: ETCr Publishing; 1998.
- [2] Hkang JR, Ceiw W, Inger BD, Lea FR. Graphs in Computer Simulations. LIAM Journal on Computer; 18(2): 244-57, 1999.
- [3] Divjak S. Instructions to Authors. In: Proceedings of the International Conference on Hands on Science. Divjak S, editor. 2004 Jul 5-9; Ljubljana, Slovenia. Ljubljana: University of Ljubljana; p. 5-15; 2004.
- [4] The Knowledge Creating. Tinaka I, Tagchi H. Berlin University Press; 1895.
- [5] Schulzrinne H, Casner SL, Frederick R, Jacobson V. RTP: A Transport Protocol for Real-Time Applications. Internet Engineering Task Force; 2001. <http://www.ietf.org/internet-drafts/draft-ietf-avt-rtp-new-10.txt> [10/31/2001]

International Journal on Hands-on Science

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Educating for Science and through Science

The International Journal on Hands-on Science is a high quality reference open access journal in the area of Science Education in all levels and contexts, subjects and perspectives.

The Journal is open to contributions in all fields of Science and Education but also from all pedagogical approaches and perspectives. We advocate, however, an active investigative learning with an extended use of hands-on experimental work in the classroom and in *non-formal and informal contexts*.

The main language of the journal is English. However submissions will be welcomed in other languages: French, Portuguese, Spanish, Greek, Italian, Russian, Polish, Hindi, Romanian, Czech, Turkish, others to be added. A translation of the abstracts to English is appreciated or will be provided by the editors for all papers.

Only quality full-papers, and short communication or letters to the editors (*in English only*) will be published. All submission will be expert peer-reviewed. The reviewing process runs in two stages:

- the manuscript is first read in order to locate and remove everything that may identify the authors (*names and affiliation, self citations, references,...*) – when a self-reference is removed the cited text will be provided to the expert referees –;
- finally the manuscript, removed of all authors' identification, will be reviewed by two referees experts in the field.

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Editorial


With a broad open understanding of the meaning and importance of Science to the development of our societies, each individual and of the humankind, the main goal of the International Association “Hands-on Science Network” is the development and improvement of science education and scientific literacy by an extended use of investigative hands-on experiments based learning of Science and its applications.

Among the many different activities the Hands-on Science network developed since 2003 a large number of books experiments’ guides and scientific and pedagogic papers were produced in order to assist teachers, and all persons involved in science education, in the effort of improving the quality and effectiveness in science and technology teaching. Workshops and conferences were also successfully organised resulting in the presentation of over 500 meaningful communications. From that ensemble the most relevant papers were selected reviewed and published in the book “Selected Papers on Hands-on Science” (ISBN 978-989-95336-2-2) a tool of the highest interest to the Science and Science Education community.

The International Journal on Hands-on Science intends to be a high quality open access multilingual journal of reference in the area of Science Education in all levels and contexts, subjects and perspectives. The Journal is open to contributions in all fields of Science and Education but also from all pedagogical approaches and perspectives, although we advocate a focus on an active investigative learning with an extended use of hands-on experimental work in the classroom, but also in non-formal and informal contexts.

We expect IJHSCI to become an invaluable pedagogic resource to teachers and educators of all school levels from kindergarten to the university,

educating for Science and through Science



Manuel Filipe Pereira da Cunha Martins Costa
(Editor-in-Chief)



Nanotechnology Education on a Local Scale

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Abstract. *Progress in nanotechnology depends on availability of well educated specialists. The response from European higher education institutions to the need for nano-education focuses mainly on Masters courses, but other forms of education are also being developed. At Rzeszow University this problem is of high importance because the Nanotechnology Center will be launched in 2010 to become a technology and research base in the southern-eastern Poland for BA, MA and PhD degree courses and for research projects. The most important matter while developing educational materials in nanotechnology is a rapid growth of new information and a quick transition from generating new ideas to implementing those ideas in industry. This makes e-learning the most efficient teaching strategy. Its potential is used to compile a laboratory course on nanostructure characterization. A 7 step strategy is developed to conduct workshops on the methods of characterization based on teacher-guided reading the research literature.*

Keywords. E-learning, nanotechnology, Web, a laboratory course, an electronic tutorial, reading strategy.

1. Introduction

Nanotechnology is a too complicated phenomenon to have a single definition. The simplest one defines nanotechnology as the engineering with anything smaller than 100 nanometers with novel properties. It integrates multiple disciplines, technologies, materials, and processes to enable the creation, assembly, measurement, or manipulation of materials,

devices and integrated systems at the nano and molecular scales with great potential. Further progress in this field depends on availability of well educated specialists.

The fields of nanoscience and nanotechnology are broad and still exploratory, with connections to almost all disciplines and areas of relevance. Thus the most important matter to be taken into consideration while developing educational materials in nanotechnology is an exponential growth of new information and an accelerated transition from generating new ideas to implementing those ideas in industry.

In this communication we examine the training in the nanotechnology, which derives from microelectronics, surface and interface science, and focuses on fabrication of structures in silicon, carbon and other inorganic materials that will be, as we expect, one of the main direction of the evolution for the nanoelectronics.

2. Current issues in nanoscience education

While planning educational initiatives for nanoscience and nanotechnology, it is very useful to have estimates of how many specialists are needed, because "training people is a key component for long-term success" [1].

According to M.C. Roco, Senior Advisor for Nanotechnology of the National Science Foundation, a need for a multidisciplinary trained nanotechnology workforce in the years 2010-2015 is of 900 000 in the USA, 400 000 in Europe, and about 2 million persons in total [1].

There is an interesting estimate for a proportion of staff with different qualification levels: "experts have estimated that future demands will require 15 trained technicians for

each scientist in a nanotechnology manufacturing business" [2].

2.1. International initiatives in nano-education

The response from European higher education institutions to the existing need for nano-education focuses mainly on Masters Courses, but other forms of education including short courses, formal PhD programs and undergraduate education, and vocational training courses are also being discussed and developed. European or international standards for good quality education in nanosciences and nanotechnology should be developed and initiatives taken for sharing best practices between professors and vocational trainers. The EU can stimulate this under the People programme in FP7 for university graduates funded by DG Research and the new Lifelong Learning programme funded by DG Education (2007-2013) [3].

A five-year goal of the U.S. National Nanotechnology Initiative (NNI) is ensuring access to the full range of nanoscale research facilities to 50% of US research institutions' faculty and students, while students' access to education in nanoscale science and engineering is enabled in at least 25% of the research universities [1].

The European Materials Research Society (EMRS) is planning an "European Whitebook on Nano-Science Education" with contributions from scientists of diverse backgrounds and disciplines presenting an overview of the state of the art in this existing fields from European and global (by the International Union of Materials Society - IUMRS) international perspectives [4].

Four leading research and educational institutions in Europe (Chalmers Tekniska Högskola, Sweden; Technische Universiteit Delft & Universiteit Leiden, the Netherlands; Technische Universität Dresden Germany and Katholieke Universiteit Leuven, Belgium) have proposed a joint Erasmus Mundus Master Course entitled "Nanoscience and nanotechnology". This is an integrated program, with a strong research basis and an international outreach. The objective of this course is to provide top quality multidisciplinary education in nanoscience and nanotechnology [5].

2.2. The Nanotechnology Center at Rzeszow University

However this does not mean that less known educational institutions are not able to train specialists for this field. E-learning is just right to ensure a high quality of education.

At Rzeszow University this problem is of an increased importance because the Nanotechnology Center currently being under construction will be launched in 2010. To meet the forthcoming demand for nanotechnologists, we have to develop and implement relevant teaching strategies here and now. The Nanotechnology Center will become a technology and research base in the southern-eastern Poland for BA, MA and PhD degree courses as well as for research projects concerning the growth, characterization and application of nanostructures based on II-VI semiconductor materials. This decides which methods we pay special attention; however students will be given an overview of basic instrumentation and metrology needs across all nanoscience and nanotechnology. Everybody goes his/her own way to the nanoscience guided by previous research experience; and a way we choose decides what we will do in a new field. We have been kept to the straight and narrow path leading from microelectronics to nanoelectronics - low dimensional structures, such as: quantum wells, quantum dots and superlattices grown by MBE-technology.

2.3. E-learning in nanotechnology

Combination of multiple time-limiting factors in nanotechnology makes e-learning the most efficient teaching strategy. We have used the e-learning potential to compile a laboratory course on nanostructure characterization. This is a very important component of a curriculum for nanoscience education because a proper measurement of nanostructure parameters critical to realizing its underlying physical ideas is as challenging as the development of nanostructure technology because even classic methods become specific when applying to nanostructures.

Presently a central problem is not how to locate a proper material in the Internet, but how to implement it in a right way. There are both general-purpose and specialized resources. The first to be referred to among general-purpose

resources is NanoEd Resource Portal launched by NCLT (National Center for Learning and Teaching in Nanoscale Science and Engineering, available at <http://www.nanoed.org/>). The site is designed to both gather and disseminate information on nano-education related topics, including education research, nanoconcepts, teaching materials, seminars, and degree programs. The NCLT is the first national center for learning and teaching of nanoscale science and engineering education in the United States. The center was created in October 2004, through a National Science Foundation award of \$15 million for five years. The mission of NCLT is to develop the next generation of leaders in nanoscale science and engineering teaching and learning. Its educational materials are addressed to science teachers and students in grades 7-12, college and university students and faculty, researchers, and post doc students. Additionally the National Science Foundation provided a five-year \$20 million grant to the Nanoscale Informal Science Education (NISE) Network (<http://qt.exploratorium.edu/nise-resources/>) to bring researchers and informal science educators together to inform the public about nanoscience and technology.

However extensive materials relevant to our goal, i.e. teaching the nanostructure characterization, are developed by many university laboratories and analytical equipment producers. Some examples of their web sites are discussed below.

3. Characterization and imaging methods in the nanotechnology curriculum

Advances in fundamental nanoscience, design of new nano-materials, and ultimately manufacturing of new nanoscale products will all depend to a great degree on the capability to accurately and reproducibly measure properties and performance characteristics at the nanoscale. The revolution in nanoscale science and technology requires instrumentation for observation and metrology, otherwise we are not able to see and measure what we build. Though Richard Feynman challenged the scientific community to explore the "space at the bottom" since 1959, nanoscale R&D activities have been initiated on a full-scale only few years after Gerd Binnig and Heinrich Rohrer have invented the scanning tunneling microscope for seeing and touching nanostructures on surfaces in 1981.

Instrumentation and metrology have been identified by the U. S. National Nanotechnology Initiative (NNI) as one of critical nanotechnology areas as they are both vital to the success and commercialization of nanotechnology.

3.1. Characterization techniques

However a number of methods used in nanostructures research has turned a hundred. Additionally, they are being improved and updated according to specific research goals. Therefore it is a primary task to select the most relevant methods and explain students why they answer the purposes of research. Over the past 30 to 40 years a wide range of surface and microanalytical techniques found an application in nanotechnology have evolved. Each technique has its own unique capabilities that are related to the particular physical interaction involved with that technique. With the exception of SPM/AFM, all of the techniques involve the interaction of some type of particle (electron, ion, or photon) with the sample material. The physics of each particular interaction affect the limits of lateral resolution, depth resolution, and detection sensitivity for each technique. Understanding these interactions, and more importantly the limitations they impose on a technique, can be crucial when selecting an analytical technique for specific problems to be solved. The main parameters characterizing technique - the required spatial resolution and the sensitivity (detection limits) are strictly interconnected.

Students study many of surface analysis techniques being used today: AES -Auger Electron Spectroscopy; XPS / ESCA - X-Ray Photoelectron Spectroscopy / Electron Spectroscopy for Chemical Analysis; SIMS - Secondary Ion Mass Spectrometry; TOF-SIMS - Time-of-Flight Secondary Ion Mass Spectrometry; Raman Spectroscopy.

All these techniques are the "classical" methods developed to surface analyses, however recently their main parameters have been substantially improved to keep pace with nanotechnology increase resolution.

3.2. Nanoscale imaging

Because nano-devices can operate on the level of a few molecules, or even a few atoms, accurate atomic-scale imaging is important. The sphere of nanoscale imaging belongs largely to

electron microscopy and scanning-probe microscopy. Electron microscopy relies on the fact that electrons have much shorter wavelengths than visible-range photons and can thus resolve much finer details while maintaining a large depth of focus. Electron microscopy is now the most universal and *de facto* obligatory technique for atomic-scale structural characterization.

It is divided into two very different techniques: scanning electron microscopy (SEM), and transmission electron microscopy (TEM). In SEM, a focused electron beam is scanned across a conductive surface, releasing secondary electrons that are collected by a detector placed above the object at an angle that determines the perspective view. Magnification is changed by adjusting the size of the scanning area. Resolution ranges down to a couple of nanometers for the most-advanced tools-not fine enough to resolve atomic detail. Transmission electron microscopy takes a different approach: electrons are passed through the specimen, producing a shadow that is magnified by magnetic lenses and projected onto a sensing screen.

In scanning transmission electron microscopy (STEM), a variation of TEM, an electron spot is raster-scanned across the specimen and the secondary transmitted electrons detected. Magnification ranges up to 1 million, allowing the imaging of atomic lattices. High-resolution aberration-corrected electron microscopes (both TEM and STEM) already today can provide valuable measurements at the sub-Ångström level. In general, resolution is accepted as the ability to determine if an image feature represents two objects rather than one. In high-resolution electron microscopy these objects are atoms.

Scanning probe microscopy (SPM) is a branch of microscopy that forms images of surfaces using a physical probe that scans the specimen. An image of the surface is obtained by mechanically moving the probe in a raster scan of the specimen, line by line, and recording the probe-surface interaction as a function of position. By using such a probe, researchers are no longer restrained by the wavelength of light or electrons. The resolution obtainable with this technique can resolve atoms.

Scanning Probe Microscopy is a general term, used to describe a growing number of techniques that use a sharp probe to scan over a surface and

measure some property of that surface. Some examples are STM (scanning tunneling microscopy), AFM (atomic force microscopy), and NSOM (Near-Field Scanning Optical Microscopy). Many scanning probe microscopes can image several interactions simultaneously. The manner of using these interactions to obtain an image is generally called a mode.

3.3. Web-based resources

A useful list of excellent surface science courses, from introductory to graduate levels, each emphasizing different aspects of the subject is available on the UK Surface Analysis Forum (<http://www.uksaf.org/tutorials.html>).

Evans Analytical Group has collected and presented on its web site (www.eag.com) materials on most known methods of surface characterization, their practical use and the interpretation of measurement results.

Interesting materials on specific techniques are posted on web-sites supported by producing companies, e.g. Kratos (www.kratos.com) provides materials on XPS, and Jeol (www.jeol.com) – on SEM and TEM.

Though in comparison with other methods SPM is a fairly new one, nevertheless there are extensive e-collections related to different aspects of those methods. We would like to emphasize some of them. First of all – the James Madison University SPM Education website (<http://spmeducation.virginiananotech.com/>) – the clearinghouse for SPM experiments, techniques, labs and ideas that have been published in the scientific educational literature or developed by educators to be used primarily for educational purposes.

As to SPM producing companies, NT-MDT Co. should be mentioned first and foremost (<http://www.ntmdt.com>).

Nanoscience Instruments publishes the Nanoadvisor educational newsletter, which offers reviews on nanoscience programs, funding, resources, and nano-teaching information (<http://www.nanoscience.com/>).

4. Literature-based study of imaging and characterization methods

Research publications, both printed and electronic, provide information on the most current accomplishments which is indispensable to successful learning any subject. In

nanotechnology, however, they also somehow compensate a lack of expensive equipment which many educational institutions can not afford.

4.1. Formats of research publications

Published research generally follows an established format. It is important that students understand each part of the research paper. Typically it includes the following parts [6]:

- **Abstract** “serves to briefly answer the basic questions about what was studied, how it was done, and the results. Its primary purpose is to allow readers to make an initial evaluation of whether a study is of interest without having to read the complete paper”. Structured abstracts make it easier for readers to select appropriate articles. The introduction, methods, results, and discussion (IMRAD) format [7] is well known and widely adopted for structured abstracts in original articles.
- **Introduction** “explains *why* the study will be conducted... It also expands a little more on *how* the research will be conducted. The introduction can be divided into two major parts: the *Background* section and the *Purpose* section:
Background ... should reflect a comprehensive knowledge of the body of research on the subject and should brief the reader on both the previous studies that support the concepts or theories of the current study and those that do not...
Purpose ... dictates how a study will be conducted: the research design, the variables that will be measured, how information will be collected and analyzed, and what conclusions may be drawn”.
- **Methodology** “...explains how the research was conducted and should give information in enough detail for the reader to evaluate the study. It should also enable the reader to understand to whom or what the study results apply”.
- **Results** section provides the data and its analyses.
- **Discussion** section “gives the reader some insight into the study subject area and often sheds new light on the results and their meaning. Alternative explanations for the results and the implications of the research may also be presented”. Sometimes

conclusions may be not adequately supported by the data for many reasons (collection of insufficient or inadequate data, overgeneralization of results, methodological problems, or inherent limitations of the study design). This is why it is important to review the methodology section.

- **References** always can tell experts “if key research has been omitted from the reference list...Also, a reference list that includes both older and newer relevant research can reassure the reader that the author has thoroughly reviewed the entire body of research for background and has not just considered the last few or first few studies conducted on the topic”.

4.2. Reading strategy to study techniques applied in nanotechnology

A workshop which involves a thorough consideration of research articles is the final stage of learning characterization and imaging methods. These articles are selected by teachers according to their instructional utility and are analyzed by students according to the following 7-step strategy:

1. Students' reading is controlled in a step-by-step manner when they are offered all parts of an article one after another.
2. An object of studies is analyzed, e.g. a method of fabrication, possible application, methods providing the most complete characterization. Students suggest a set of methods, the research purpose is discussed.
3. Methods used by authors are considered; specific equipment used in experiments are discussed with a focus on its potentials and limits; user manuals available from a producer or on a Web site are read. Students make assumptions regarding an outcome to be achieved if the selected methods are applied.
4. Sample preparation for the investigation methods are considered (e.g. ion beam milling, angle lap etc.). This stage is not always paid a proper attention. However it is this point that ensures correct findings, especially for nanostructures.
5. Results achieved with each specific method are analyzed with a focus on their completeness, reliability and informative capacity.

6. All results are considered as whole; authors' conclusions are discussed.
7. Directions of further studies are suggested. Two options are possible depending on a purpose of the research under discussion:
 - a purpose was to characterize a structure. Possible continuation may be additional studies with an extended set of methods,
 - a purpose was to study a particular phenomenon. Then the question is whether this structure is optimum to observe that phenomenon and, if it is not, which structure would be better. Answering the latter question requires not only the knowledge of research methods and nanostructure physics, but basic experience in materials science and technology as well.

Students' efficient work during the workshop is supported through continuous referring to different resources including not only common electronic tutorials developed at our university but mostly web-based resources, both research and industrial. The quality of students' learning depends on how accurate is teacher's selection of materials to be used at workshops. This requires that a teacher should make a great deal of pre-workshop literature research.

5. Conclusions

Nanotechnology poses new challenges to education in many ways because existing paradigms are evolving – new physical ideas are being discovered and then some technologies are revolutionary transformed, other ones are getting out-of-date, or completely new approaches are introduced to solve the problems which seem to have been solved.

E-learning allows a timely response to new trends regarding the fundamentals of nanotechnology methods and provides application examples to explain students which method or combination of methods is good for a particular experiment, how to plan an experiment, and how to interpret its results.

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Science in Your Pocket

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Abstract. *Science education is necessarily grounded by exploratory laboratory experiments. What would change if students had a science lab in their pocket their every waking moment? An educator's fondest wish is that students explore beyond the classroom; but for the data driven experimental sciences, scientific exploration requires collecting data which generally requires lab equipment. While the average school lab fits neither a student's budget nor in their pocket, cell phones and gaming systems are a required possession for most. Using such devices, we demonstrate classic physics experiments to show that students have the means to explore science on their own. Further, because the devices fit either in ones pocket or hand, the equipment is both available and mobile, allowing for new types of student experiments. We share the preliminary results of our attempt to create a mobile laboratory from consumer electronic devices commonly possessed by students. We first present a brief overview of the motivation for using cell phone and gaming technology in science experiments, then demonstrate experiments using a cell phone-based sound frequency analyzer and an accelerometer, and close with suggestions for other experiments.*

Keywords. Acceleration measurement, cell phone, mobile laboratory, sound frequency analyzer, Wiimote.

1. Introduction

In the world of students today, cell phones are a necessity; mobility of communication and entertainment devices ordinary. What possession is student most likely have with them all the time? And who could blame someone caught in a stream of students leaving a class for thinking

that checking and answering email, text and phone messages immediately after class was a course requirement? But the ever-present cell phone can be more than just a social networking device; it can also be a tool for science education. The idea of a pocket-sized scientific analyzer is not new, a number of mobile devices have been used in science education for some years (e.g. LabQuest [5]). What is new is that students carry devices that have the capacity to perform some of the same data collection and analysis tasks; often requiring only cell-phone software and a little imagination to be added. In the following, we first present a brief overview of the motivation for using cell phone and gaming technology in science experiments, and then demonstrate two examples of science with devices available to most students: a cell phone sound frequency analyzer and a video game hand wand for acceleration measurement. We close with suggestions for other experiments.

2. Why Cell Phones?

Cell phones have become pocket-sized personal computers, albeit with an expensive calling plan. The most compelling reasons for their use in science education are ubiquity and mobility; cell phones are with almost all students almost all the time. The cell phone is also small, reasonably affordable and ruggedly packaged for carrying; just right for throwing, dropping from a window, or bringing together a bunch for a group experiment. The beauty of cell phone science is that it is always there when the chance comes to use it and is small enough to be tossed around or used in some unplanned manner. And, of course, it is the means of choice by which students communicate through text and talk with their peers; perhaps, we hope, sharing the results of

their latest experiment. Transforming a cell phone into a scientific instrument can make science more impromptu and familiar, just part of the technology package students carry in their pocket.

Cell phones, in addition to being programmable, also possess measurement devices for sensing external phenomena and for communicating with other devices. All phones possess a microphone for sound, a display and keyboard for user interaction, can determine their geographic location, and many possess cameras and accelerometers; all useful for data collection. Cell phone communication capabilities are also a very important component of data collection. These include human-level messaging by voice or text over the cell phone network, useful to coordinate experiments that require multiple data collection points; Internet connections that can be used to aggregate data at a common collection point; and, local wireless networking that allows a cell phone to collect data from another device. The last point is likely the most important as it implies that a cell phone can collect data from most any phenomena; in an example given below, the cell phone collects acceleration data from a video game hand wand. With computational, sensing and communication capabilities along with ubiquity and mobility, cell phones present an opportunity for extending science education beyond the space and time constraints of a traditional laboratory.

Developing software for a cell phone or computer is very similar. Common languages include scaled down derivatives of Python, Java and C++ [3]. This is an important point when creating software as you can use familiar languages and development tools, incorporate existing software libraries, and develop and test algorithms on the computer before transferring to the cell phone. To promote phone software development, many manufacturers provide extensive development and test environments at little or no cost. After development, the application can be installed to a phone over a public or local network in a manner similar to computer software.

2.1 The Problem with Cell Phones

Similar to their larger computer relatives, many current phones are programmable, can input sound and visuals, and can connect to other local devices or the Internet. One would then expect software that runs on your phone to run

on that of a student. Unfortunately, where personal computers are open systems that share a common hardware and software architecture, some slower or faster but capable of doing basically the same thing, cell phone models are designed as snowflakes, each unique.

For the time being, the cell phone hardware and software are controlled by service plan providers who have a financial interest, and go to considerable lengths, in making their models different and often incompatible from everyone else's, even their own. If computers were sold under the service plan providers' model, your computer could only run the programs available through the computer seller. The result, for the time being at least, is that cell phone programs running on one model are unlikely to run on another. However, phones that share a common operating or program execution system can often share programs; examples include the Symbian and Microsoft operating systems and the Java programming language. The good news is that the closed system of plan providers is being challenged, particularly open systems projects such as Google's Android [4] to encourage a software development and distribution model where the owner has more control over what runs on the phone.

2.2 Development Details

The cell phone used in the following demonstrations is a Nokia 61; considered very capable at birth but now, at two years old, is barely ordinary. The phone runs Symbian OS on an ARM 9 220 MHz processor. For comparison, the latest iPhone has a 600-700 MHz ARM processor running a version of Apple's OS X. The implementation language used is Java ME, promising that applications will run on other systems that support Java ME. The applications were developed using a standard text editor to write the Java ME code and a very simple, freely available development environment called the Sprint Wireless Toolkit.

3. Two Examples: Sound Frequency Analysis and Acceleration Measurement

To validate and explore a range of possibilities, we chose to implement two experiments in areas common to most basic physics courses, that of sound frequency analysis

and acceleration measurement. The experiments also illustrates the cell phone alone as a scientific instrument and in conjunction with a separate, consumer electronics device often available to students, in this case a video game hand wand.

3.1 Example 1: Sound Frequency Analyzer

Sound frequency analysis is a familiar topic in a basic physics course. Students are often introduced to Fourier analysis through sound experiments in a laboratory setting using a microphone connected to a computer. A sound frequency analyzer operates by capturing some time interval of a digitized sound signal and performing a Fourier time-to-frequency transformation on some portion of that signal to produce a corresponding frequency power spectrum. Some related experiments possible are the frequency analysis of the harmonic and overtone structure of sound sources such as musical instruments and determining the Doppler shift of a moving sound source.

A modern sound frequency analyzer requires the following hardware, all of which are common to cell phones:

1. Sound digitization capable of recording at twice the highest expected frequency.
2. An interface (e.g. buttons) to control the analysis and a display to see the results.
3. A processor to perform the Fourier time-to-frequency transformation algorithm.

Complicated procedures and equipment are a bane to science education. In creating a learning tool for student use, one danger is that the lesson to be learned is overwhelmed by the tool; the hoped for learning insights are lost in the complexity of running the experiment. The sound analyzer uses only a cell phone and its use is less complex than text messaging. The basic start-to-finish procedure for a student, as illustrated in the examples, is simple: download the analyzer software from a Web site, start the analyzer, record a sound, and analyze the sound; only four steps are required to capture and perform a Fourier analysis of a sound. Raw data can be exported for sharing or computer analysis, or, as the figures below demonstrate, the analysis screens can be captured and emailed or uploaded for review. Figs. 1-6 illustrate the use of a sound

frequency analyzer as implemented in Java ME on the Nokia E61 cell phone.

To some, that a cell phone can perform a Fourier transform might be surprising, given that real numbers and mathematical functions are required. That a phone can do so with reasonable quickest is a pleasant bonus. From the above example, determining the frequency of the sound sampled over an approximately 4 second interval at 8000 kHz was performed by a Fast Fourier transform on 32768 samples, took about 10 seconds and produced results with accuracy comparable to that of commercial analysis software running on a PC.



Figure 1. CellPhone FFT as one of several applications; it was downloaded from the school site using the phone Web browser.

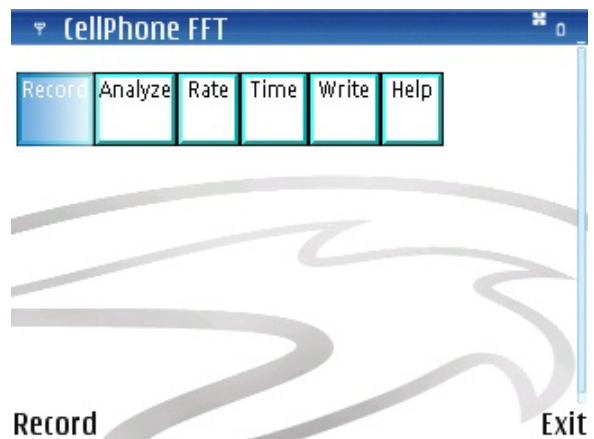


Figure 2. Menu options, Record a sound, Analyze recording, Time and Rate are parameters for data collection, and Write sound data to cell phone file.

The analyzer is primarily an educational tool for studying sound. As such, a key question to be asked is “does the tool help or hinder learning?” As noted earlier, the tool use should simple, nearly transparent, so that attention can be focused on what is being studied. Further, of

course, a measurement tool should be reasonably accurate. An additional challenge for interactive devices when large amounts of data must be processed is that it produces results quickly. The above example demonstrates that a cell phone can meet these criteria, providing a viable complement to traditional laboratory experience. Revisiting the points on ubiquity and mobility, sound analysis on a cell phone provides the opportunity for experiments at a different time and place than the traditional laboratory; available whenever or where ever the occasion arises.

3.2 Example 2: Measuring Acceleration

Experiments involving acceleration are some of the most fundamental and engaging in science. Along with the cell phone, video games are one of the most available of consumer electronics devices useful for science. Acceleration can be measured by video game and cell phone accelerometers used to determine the device orientation or the directional force to which the device is subjected. The hand-held Wii Remote (aka the Wiimote), for Nintendo's Wii video gaming system, includes a three-axis accelerometer to read a game player's gestures as game input and Bluetooth wireless networking to share the accelerometer measurements with the game console. Fig. 7 illustrates the Wiimote and the 6 directions in which acceleration can be measured.

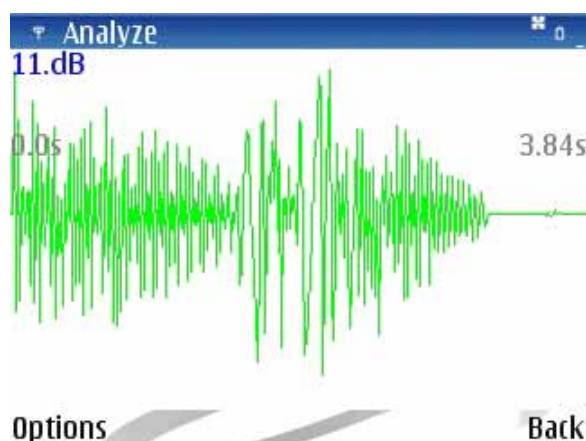


Figure 3. Selecting *Analyze* initially displays the complete raw signal recorded.

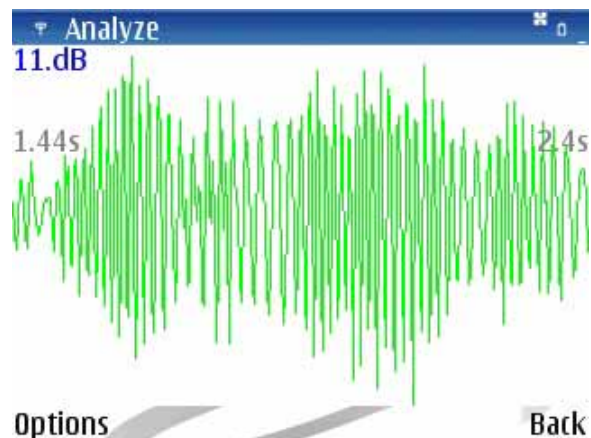


Figure 4. Cell phone directional buttons on allow panning (moving over time) or zooming (increase or decrease time interval displayed) to select a subinterval to view or analyze.

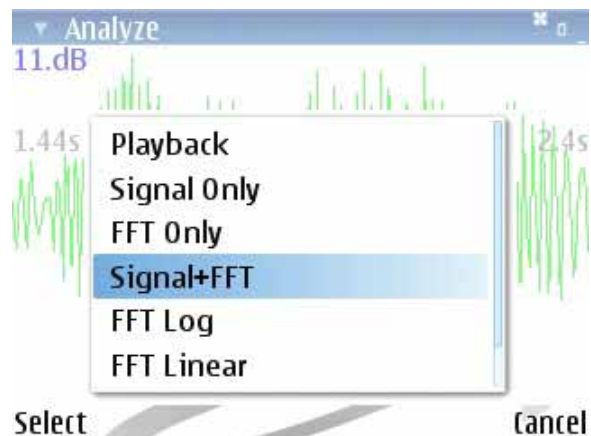


Figure 5. Analysis options that can be applied to the signal section selected includes sound *Playback* and multiple display views of results.

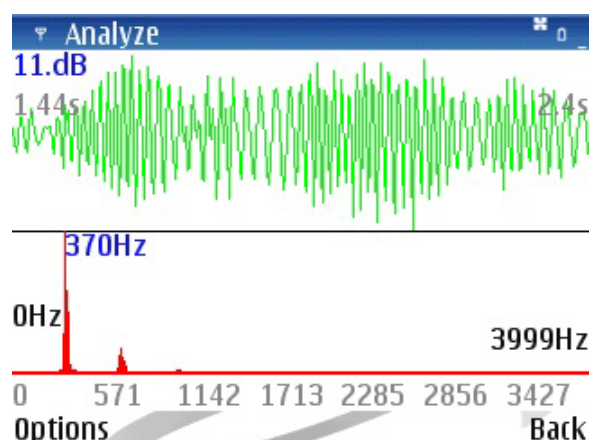


Figure 6. A combined graph of selected raw signal subinterval and Fourier transform.

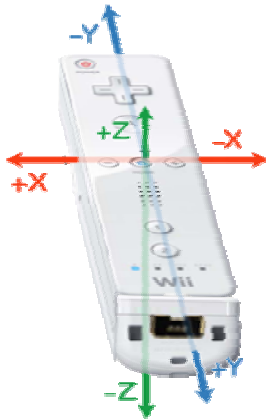


Figure 7. The three axis orientation of a Wiimote accelerometer [6].

A Wiimote and cell phone can form a mobile scientific instrument for measuring acceleration, such as that experienced on a rollercoaster or in the range of $-3g$ to $+3g$. The two devices are linked through the Wiimote Bluetooth port that transmits accelerometer data to the cell phone which records and analyzes the data. This approach, using small, widely available mobile equipment, creates the opportunity to study acceleration in a familiar setting - such as riding an elevator or a car.

A cell phone and the Wiimote combination can measure acceleration simply and is adaptable to a variety of experiments. The implementation is entirely in cell phone software requiring no hardware modifications or connections. The Wiimote's data is transmitted via Bluetooth local networking so the cell phone and the Wiimote need only be within about 10 meters of each other. The Wiimote accelerometer provides data on the force applied in six directions; at rest, a horizontal Wiimote should report $+g$ in the vertical direction and in free fall, zero g ; the accelerometer data is transmitted continuously and read by the cell phone at predefined time intervals.

A common experiment is to measure acceleration and velocity while traveling along a single axis. Using the Wiimote and phone combination, the basic procedure for measuring acceleration is: orient the Wiimote to the direction of travel, calibrate the accelerometer, start data collection, start travel, stop travel, stop data collection, analyze the data. The following instructions provide a student's view of the experimental procedure, given to illustrate the overall simplicity of use. The steps common to all experiments are:

1. Press the 1 and 2 buttons on the Wiimote to initiate a Bluetooth connection.
2. Run WiiConnect [2] cell phone program to establish a Bluetooth connection with the Wiimote. Press the Wiimote *Home* button when connected.
3. Run Acceleration cell phone program.

The remaining instructions would be specific to the experiment being performed. For measuring the linear acceleration of a vehicle, the instructions are:

While stopped, place the Wiimote on a horizontal surface with the $+y$ axis pointing toward the direction of travel and start recording data. From a complete stop, accelerate to a predetermined speed, then stop the car, and stop collecting data. Analyze the acceleration and velocity on the y -axis. Compare different vehicles (e.g. car vs. bicycle). If you have a helmet or hat, try duct taping the Wiimote to it; compare your personal acceleration with that of other vehicles.

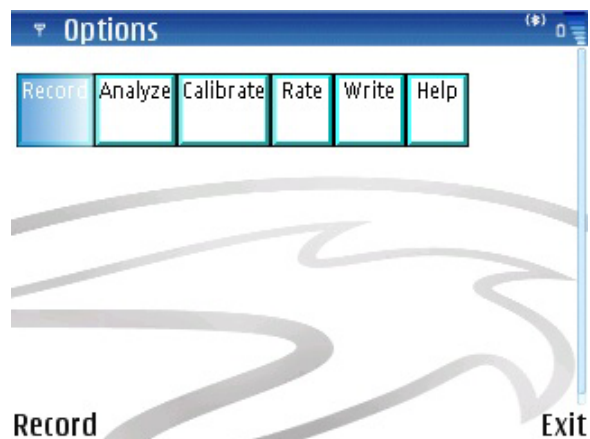


Figure 8. Menu options: *Record* records acceleration, *Analyze* acceleration. *Calibrate* calibrates the Wiimote accelerometers, *Rate* sets parameters for data collection and *Write* saves the data to a cell phone file.

3.3 Measuring the linear acceleration and velocity of a car

Linear acceleration and velocity of a vehicle is a familiar experience from riding in a car, elicits natural curiosity in many drivers but is not easily studied using traditional laboratory equipment; using a cell phone and Wiimote,

measurement is relatively simple. For this experiment, following the above instructions, the Wiimote was placed on the stopped vehicle's floor oriented in the expected direction of travel and acceleration recording began on the cell phone; the vehicle was then accelerated on a straight road having a few small hills and bumps to an analog speedometer reading of about 40 mph. or 18 m/s. and was then braked to a complete stop.

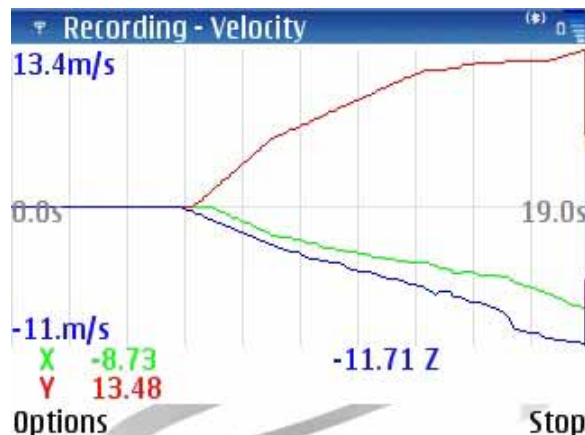


Figure 9. Recording acceleration data while displaying velocity as a speedometer.

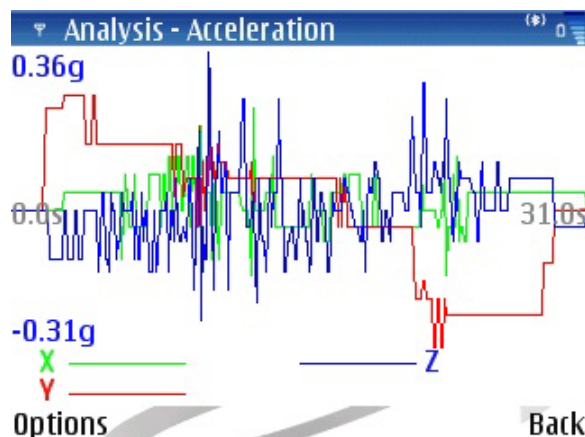


Figure 10. Selecting *Analyze* initially displays the complete acceleration data for the three axes recorded. Notice the acceleration spikes on the z-axis due to road bumps.

Figs. 8-14 illustrate the procedure and results of the acceleration experiment. In Fig. 9, velocity is graphed for each of the three axes along with a real-time display to provide a speedometer; the y-axis is the direction of travel. In Fig. 10, acceleration is shown recorded along all three axes with the travel direction on the red or y-axis; the z-axis showing the hills but most

obviously the greatest acceleration being the bumps in the road; the x-axis shows relatively small sideways acceleration. Fig. 13 shows the difference in acceleration following changes to higher gears and braking. In Fig. 14, the velocity corresponding to the acceleration over time is shown alone, illustrating the decline in the rate of increase in velocity as the vehicle shifts into higher gears.

List Acceleration			
Time	X	Y	Z
4.00	0.03	0.15	0.00
4.10	0.03	0.15	0.00
4.20	0.03	0.15	0.00
4.30	0.03	0.15	0.00
4.40	0.03	0.26	0.00
4.50	0.03	0.26	0.00
4.60	0.03	0.15	0.00
4.70	0.03	0.15	-0.13
4.80	0.03	0.15	-0.06
4.90	0.03	0.15	0.04

Figure 11. Listing raw acceleration data where Y is the linear acceleration and Z the road bumps.

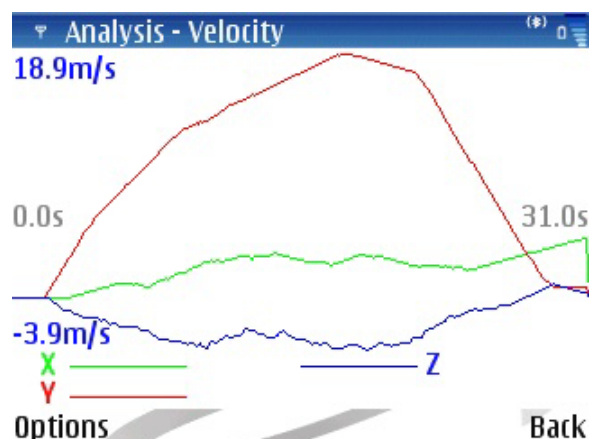


Figure 12. Display of the complete data velocity for the three axes.

3.4 Other Experiments

Keeping in mind that this purpose of this project was to demonstrate the use of widely available, mobile devices in science education, what other experiments are possible with a cell phone? The answer largely depends upon whether the cell phone is used alone or with other hardware such as a Bluetooth enabled device like the Wiimote. Hardware common to a cell phone can digitally record and play sound at

CD quality data rates (44.5 KHz), track the phone's orientation with accelerometers, determine global position by GPS, digitally record images, and communicate globally over the Internet or locally with nearby devices using Bluetooth. As pointed out by the Wiimote example, connectivity with other devices is fundamental to expanding the nature of measurements possible. Other potential hardware options are to construct measurement devices based on inexpensive Bluetooth-capable consumer electronics, such as headsets, that could be modified to serve as an alternative input device such as a force probe, which measures applied force directly.

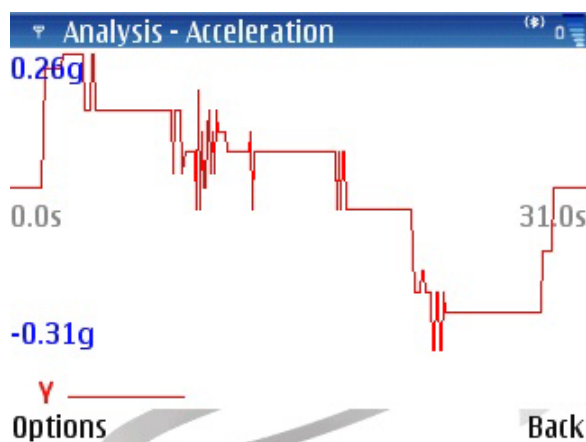


Figure 13. Viewing y-axis shows greatest acceleration in lowest gear with declines following each higher gear change until acceleration is zero and maximum velocity is reached. Negative acceleration is braking.

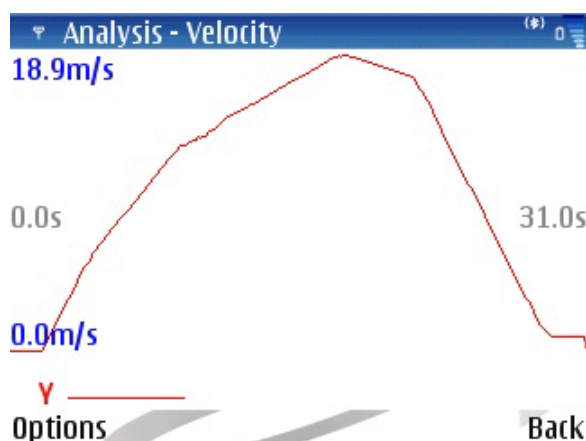


Figure 14. Viewing the y-axis velocity shows the car accelerating to 18.9 m/s, a shift from low to 2nd gear, and braking to a stop.

Many other experiments are only possible with measurement devices that are mobile. The following list is not intended to be exhaustive;

the expectation is that students will invent experiments that are far more original than those listed below. Note that time did not permit these experiments to be performed using the cell phone and Wiimote combination but are similar to, and should be within the parameters of those devices, as the experiments demonstrated above.

- **Centripetal Acceleration around a Corner** – Take a vehicle to a large, empty parking lot. While stopped, place the Wiimote on a horizontal surface pointing 90 degrees to the direction of travel and start recording data. From a complete stop, make a full-circle left turn at constant rate of speed and then stop. Stop recording data. Compare circular turns of different radii.
- **Acceleration in an Elevator** - While stopped at the bottom or top floor, place the Wiimote in a corner with the y-axis pointing up and start recording data. Start the elevator and when it stops, stop recording data. Compare upward and downward travel.
- **Acceleration of the Vertical Loop on a Roller Coaster** - Secure the Wiimote to your lower leg with the y-axis pointing up (long socks might help too) and start recording data. Compare the accelerations at the top, bottom, and sides of the loop.
- **Roller coaster** – Place someone at the front middle and back of a roller coaster and compare accelerations. An example of simultaneous multiple data measurements.
- **Acceleration of a Skydiver [1]** – Secure the Wiimote to your lower leg with the y-axis pointing up (duct tape might help) and start recording data. Jump out of the airplane, fall, open parachute and land. Stop recording data and analyze the accelerations on each of the three axes throughout the dive.
- **Bumpy Road** - Measure the force produced by a vehicle hitting a bump in the road.
- **Doppler shift** – Determine the sound frequency as a train approaches, reaches and retreats from a vehicle crossing. Calculate the Doppler shift and the corresponding speed of the train.
- **Other Acceleration ideas** - Record acceleration experienced when dropping the Wiimote, riding on bicycle, car, boat, trampoline, skiing etc.

4. Conclusions

As has always been the case, science depends upon investigative tools for exploring ideas and quantifying the results. The purpose of this paper has been to demonstrate a small portion of the possibilities for placing investigative tools quite literally in the pockets of students. The ubiquitous cell phone, particularly when combined with commonly available consumer electronics, can complement the traditional science laboratory experience with one that is nearly always available and is highly mobile; adding to the number and range of investigations possible while reducing the constraints of time and space.

Classic sound and acceleration experiments have been presented to demonstrate the feasibility of the cell phone as an investigative tool. Students will certainly create other, more original experiments. While building investigative tools from cell phones and other mobile consumer electronics is not without challenges, the educational rewards are tangible and, given the strong economic forces driving improvement in cell phone and consumer electronics technologies, the power, ease of use, and potential of these devices in science education can only accelerate.

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Hands-on sustainability: How can we contribute to the construction of a sustainable future?

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Abstract. *The scant response of citizens to reiterated calls for attention to the serious problems affecting all humanity leads to a belief that there are serious obstacles that must be studied in order to understand how to overcome them. In this work we will focus on one of the more important of these problems – the widespread yet incorrect perception that the action of the individual is of little importance – and we will attempt to show from an eminently practical viewpoint the relevance, for the construction of a sustainable future, of what each one of us does or does not do, in general – as a consumer, professional and citizen – and in particular – in the sphere of education.*

Keywords. Planetary emergency, Environmental Education for a sustainable future, Hands-on Science.

1. Introduction

Until the second half of the 20th century, our planet seemed huge, practically limitless, and the effects of human activity remained locally compartmentalised. These compartments, however, have begun to fade over recent decades and many problems have taken on a global character that has made “the world situation” a direct cause for concern. News on climate change, environmental deterioration, excessive, unchecked consumption of energy and raw materials with the subsequent exhaustion of resources and, in short, the serious situation of planetary emergency in which we are immersed [1-3], have all jumped to the front pages and opinion sections of the media. Calls by the international scientific community, NGOs and the UN itself, are multiplying. At the same time, there are over twenty international agreements on environmental protection linked to the same number again of protocols putting them into

practice [4-5]. And yet most citizens, including policy makers and educators, continue not to react in the face of serious threats of social collapse [6] and even the extinction of our species [7], which is in principle in contradiction to existing positive social interest, as seen in innumerable information resources regarding necessary respect for the environment [8-11].

It can be concluded, therefore, that there are serious obstacles which hinder necessary changes in attitude and behaviour and impede even a determined involvement of educators at all levels of formation for citizens who are aware of the situation of planetary emergency and its causes, and prepared to adopt the necessary measures to face up to the situation [12].

It is necessary, then, to keep up efforts to bring these obstacles to light and study how to overcome them. In this article we focus on one that most directly hinders finding a positive answer to the key question “How can each one of us contribute to building a sustainable future?” This is a reference to the widespread perception that individual actions are irrelevant. We will critically analyse this misconception and put forward some proposals for action to overcome it.

2. Are individual actions irrelevant?

Participants in courses and workshops on education for sustainability often express doubt about the effectiveness of individual actions, small changes in our habits or our lifestyles, that education can foster: The problems of exhausted energy resources and pollution – they usually state, for instance – are due, fundamentally, to big industry; what each one of us can do regarding this is, comparatively, insignificant.

Quite simple calculations that participants themselves can make with regard to everyday situations (figure 1) show, however, that

individual commitment has a global repercussion. For example, although small reductions in energy consumption mean a small per capita saving, when this is multiplied by millions of people it can mean huge amounts of energy, with the subsequent reduction in pollution.

These calculations and estimations can be reinforced with hands-on activities [13-14] such as, for example, determining how much water is lost from a badly turned off dripping tap.

It should be stressed, therefore, that not only is it not true that our small actions are insignificant and irrelevant, but also that we are dealing with necessary, indispensable measures if we want to contribute in progressing towards a sustainable future and increased involvement of citizens.

For the future is going to depend to a great extent upon the model of living we follow and, although attempts are made to impose this on us, the capacity we all have to change it should not be underestimated [11]. Agenda 21, fruit of the first Earth Summit, already indicated that participation by civil society is a vital element in the advance towards sustainability.

A systematic effort is therefore necessary to incorporate education for sustainability as a key objective in the formation of future citizens, and make the need understood for actions that contribute to a sustainable future in several spheres: responsible consumption, professional activity and action by citizens.

A careful follow up of these actions is also needed. Continued educational activities are therefore required that transform our conceptions, our habits, our perspectives... and that guide us in the actions to be taken.

But its not enough to understand the importance of our actions and have a general view of the fields of action: we need to move into action. In the same way that scientific education calls for hands-on experiments, education for sustainability demands involvement in specific actions that need to be defined and transformed into a commitment to act.

3. Specific proposals

In different workshops imparted to secondary and university students and trainee and working teachers, we have been able to ascertain that collective work in small groups, followed by group sharing, gives rise to numerous proposals for concrete action that can become the basis for real commitment that can be (self) evaluated for the building of a sustainable future.

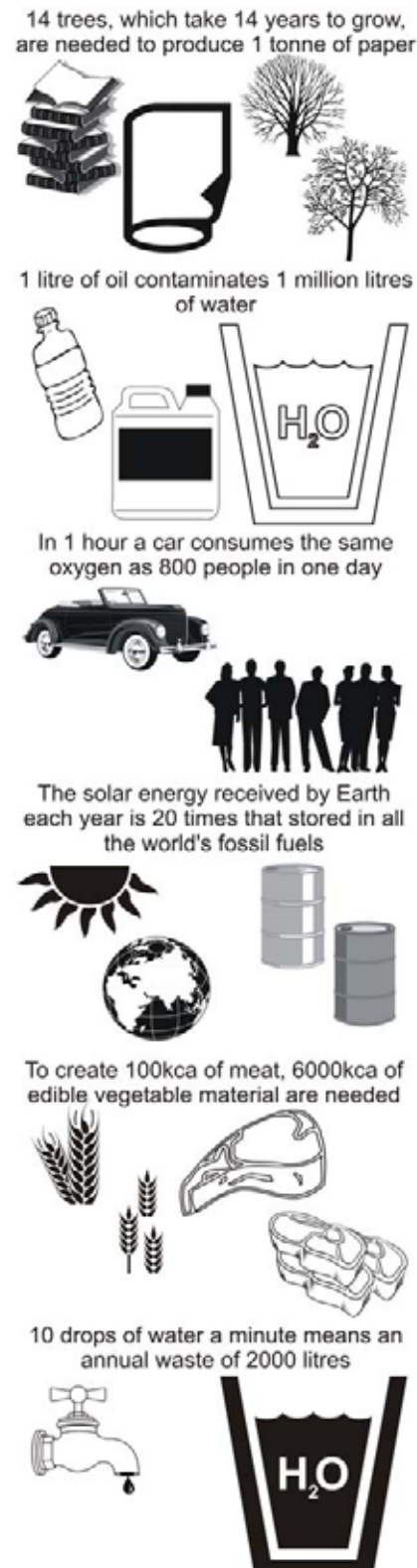


Figure 1. The importance of individual actions

Together with the classic “3Rs” (*reduce, reuse and recycle*), that correspond to us as consumers and that can give rise to numerous specific proposals of interest, another three guideline principles arise that also respond to our roles as professionals and citizens:

- *Use technologies that respect the environment and people*
- *Contribute to the education of citizens* (we are all educators as we interact with each other)
- *Participate in socio-political actions* for sustainability

And it is equally understood that there is a need for continual evaluation of the effects of our actions that introduces, if needs be, *corrective offsets*.

They are proposals that occur again and again in the workshops, as the fruit of collective work, and they turn out to coincide essentially with what is collected in wide-ranging literature [18-22]. Below (Boxes C1 to C7) we outline the most frequently formulated specific proposals:

C1. Reduce (Do no waste resources) [26-30]

Reduce water consumption, for hygiene, watering, swimming pools...

Short showers

Turn off taps (whilst cleaning teeth, putting on soap, etc.)

Drip feed watering

Reduce energy use for lighting

Use energy saving light bulbs

Switch off unnecessary lights (beat inertia)

Make the most of natural light

Reduce energy consumption in heating and cooling

Insulate housing adequately

Do not program very high temperatures (wear warmer clothing) or very low temperatures (ventilate better, use canopies...)

Switch off unnecessary radiators or air conditioners.

Reduce energy consumption in transport

Use public transport

Use a bicycle and/or go on foot

Organize shared transport

Reduce speed, drive efficiently

Avoid plane travel whenever possible

Avoid lifts whenever possible

Reduce energy consumption in other household appliances

Load washing machines, dishwashers, etc. appropriately

Turn off the TV, PC, etc completely when not in use

Defrost the freezer, check boilers and heaters, etc.

Reduce energy consumption in food, improving it at the same time

Eat more vegetables, pulses and fruit, and less meat

Respect closed seasons and do not eat small, young fish

Avoid exotic products that demand high cost transport

Eat products in season and produced organically

Reduce paper use

Avoid printing documents that can be read on screen

Write, photocopy and print on both sides of the paper

Do not leave excessive margins

Combat Consumerism

Analyze advertising critically

Mute commercials

Do not be pulled in by commercial campaigns around St Valentines, Festive season, etc.

Program purchases with a needs list

C2. Reuse [23-24]

Print on the other side of already used paper

Collect sink and shower water for the WC

Also collect rain water for watering or WC

Do not use disposable objects

In particular, avoid plastic bags and wrappers, aluminium foil, paper cups, etc.

Substitute them with reusable ones, repair these when necessary for as long as possible

Use recycled and recyclable products (paper, toner, etc)

Encourage the reuse of computers, toys, clothes, etc.

Donate to charities that manage this

Rehabilitate housing

To make it more sustainable (better insulation, etc.) and avoid new construction

C3. Recycle [9,26,31]

Separate waste for selective collection

Take what cannot be left in the usual bin to "civil amenity sites":

Batteries, mobile phones, computers, oil, toxic chemicals, etc.

Do not pour waste down WCs or drains

C4. Avoid products that do not respect the environment and people [9,26,32]

Personally apply the precaution principal

Do not buy products without finding out how harmful they are: check the ingredients of foodstuffs, cleaning materials, clothes, etc., and avoid those that do not offer guarantees
Avoid sprays and aerosols (use hand sprays)
Apply safety norms at work, at home, etc.

Opt for renewable energies at home, in the car, etc.

Use efficient, low energy, low contamination (A++) household appliances

Reduce battery consumption and use rechargeable ones

C5. Contribute to civil education and action [33-38]

Get well informed and discuss the situation with others (family members, friends, co-workers, students, etc.) ***and, above all, what we can do***

Carry out dissemination and encouragement tasks:

Use the press, Internet, video, ecology fairs, schools materials, etc.

Help raise awareness of sustainability problems and those closely linked to consumerism, population growth, environmental decline, imbalance, etc.

Inform about actions we can take and encourage them to be put into practice, promoting campaigns such as the use of energy saving light bulbs, reforestation, responsible parenthood, forming associations, political work, etc.

Aid in conceiving measures for sustainability as an opportunity that guarantees the future of everyone and not as a limitation

Encourage social recognition of positive measures

Study and apply what one can do for sustainability as a professional

Research, innovate, teach...

Contribute to promoting the environment at work, in the neighborhood and city where we live, etc.

C6. Participate in socio-political actions for sustainability [1, 19, 39]

Respect and help others respect legislation that protects the environment and biodiversity

Avoid adding to noise, light or visual pollution
Do not smoke where this might damage others, and never throw cigarette butts to the ground

Do not leave rubbish in the woods, on the beach, etc.

Avoid moving to housing that contributes to the destruction of ecosystems

Take care not to damage wildlife

Comply with traffic norms for the protection of people and the environment

Denounce continued growth policies that are incompatible with sustainability

Report ecological crimes:

Illegal tree felling, forest fires, waste dumping, predatory development planning, etc.

Respect and help respect Human Rights

Report any discrimination based on ethnic, social gender or other reasons

Collaborate actively and/or economically with associations that defend sustainability:

Aid programs for the Third World, environmental defense, aid to people in difficulty, human rights promotion, etc.

Call for the application of the 0.7 aid for the Third World and contribute personally to this

Promote Fair Trade:

Reject products produced through predatory practices (such as tropical timber, animal pelts, over fishing, predatory tourism, etc.) or that are obtained using a workforce without labour rights, child labour

Support fair trade enterprises

Demand clear informative policies on all the problems

Defend the right for research without ideological censure

Demand the application of the precaution principle

Oppose unilateralism, wars and political predators:

Demand respect for international law

Promote democracy in world institutions (IMF, WTO, World Bank, etc.)

Respect and defend cultural diversity

Respect and defend language diversity

Respect and defend lore, customs and traditions (that do not contravene human rights)

Vote for parties with more favorable policies on sustainability

Work so that governments and political parties take on the defense of sustainability

Demand local, state and universal legislation for environmental protection

"Cyberactivism": Support solidarity and sustainability campaigns from the computer

C7. Evaluate and offset [40-41]

Carry out personal behavior audits

At home, with transport, civil and professional action, etc.

Offset the negative repercussions of our acts
 (CO₂ emissions, use of contaminating products, etc.) ***through positive actions***

Contribute to reforestation, help NGOs, etc.

4. The educational role of action

It is essential, without doubt, *to understand* the relevance our actions have – what we do or do not do – and construct a global view of the measures in which we can become involved. But educative action cannot be limited to achieving this understanding, taking for granted that this will lead to effective shifts in behaviour: a fundamental obstacle in obtaining the involvement of citizens in building a sustainable future is the reduction of educative action to conceptual study

It is necessary, therefore, *to establish action commitments* in education centres, workplaces, neighbourhoods and in households themselves, in order to *put into practice* some of the measures [42] and carry out follow up of the results obtained. These actions, *properly evaluated*, become the best procedure for profound understanding of the challenges, and the impulse for new commitments.

With this aim it is helpful to transform the specific proposals given above into a follow up or (self) evaluation network, starting with the acquisition of concrete commitments that can be evaluated periodically, such as can be seen in Figure 2.

POSSIBLE ACTIONS		Are you doing it?	Are you going to do it?
REDUCE			
Reduce water consumption, for hygiene, watering, ...		<input checked="" type="checkbox"/>	<input type="checkbox"/>
Short showers		<input checked="" type="checkbox"/>	<input type="checkbox"/>
Turn off taps (whilst cleaning teeth, putting on soap, etc.)		<input checked="" type="checkbox"/>	<input type="checkbox"/>
Drip feed watering		<input checked="" type="checkbox"/>	<input type="checkbox"/>
Reduce energy use for lighting		<input type="checkbox"/>	<input checked="" type="checkbox"/>
Use energy saving light bulbs		<input type="checkbox"/>	<input checked="" type="checkbox"/>
Switch off unnecessary lights (beat inertia)		<input checked="" type="checkbox"/>	<input type="checkbox"/>
Make the most of natural light		<input type="checkbox"/>	<input checked="" type="checkbox"/>

Figure 2. Network of concrete and (self) evaluation commitments

But before implementing this task in our courses and workshops, *it is necessary to create our own network of commitments that can be evaluated*, both in the realm of consumers and citizens (which allows us to aim better at those we work with, thanks to knowledge gained through our own experience), and with regards to our professional realm: In what way are we contributing, *as educators and researchers*, to the Decade of Education for Sustainable Development? What is our response to the call from the United Nations aimed at educators from all areas and levels for us to contribute to the formation of citizens prepared to contribute to the building of a sustainable future?

5. Conclusions

We end by remembering that we are at the start of a Decade that will be decisive for the future of humanity in one sense or another: sadly decisive if we cling to our inertia and do not become aware of the need to reverse a process of decay that constantly sends us unmistakable signs in the form of global warming, anti-natural catastrophes, loss of biological and cultural diversity, millions dying through starvation and war – the suicidal fruit of short term interests and fundamentalisms, of dramatic migrations, etc. Fortunately decisive if we are able to create a universal movement in favour of a sustainable future *that has to start today*. That is the objective that we can and must set ourselves, aware of the difficulties, but determined to contribute, as educators, as scientists and as citizens, to forging the conditions for a sustainable future.

6. Credits

This communication has been conceived as a contribution to the Decade of Education for Sustainable Development [43] instigated by the United Nations for the period 2005-2014.

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Permanently Expanding the Use of Standard Laboratory Equipment to New Applications

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Abstract. *One important resource to cheaply improve Experimental Physics training, in schools and universities and to offer more experimental opportunities to the interested pupils and students, is to use the existing standard teaching laboratory equipment to perform new experiments outside the initial scope the equipment has been designed, produced, advertised and sold for. These new experiments may refer to: larger ranges, a better precision, smaller quantities, more complex investigated objects, new phenomena (eventually interdisciplinary) and higher levels of the processing of experimentally got data.*

In the paper, there is described a new application of the standard equipment designed for the measurement, in a Physics didactic laboratory, of the velocity of light in air, based on the modulation of light in intensity. The author has used the existing equipment to determine the two velocities of propagation of light in the core and in the cladding of the optical fibers of a light cable and the corresponding refractive indices. The experiments performed by students, on four types of light cables, show that the determination of velocities of light in light cables is possible with simple equipment, with a small relative error. The processing of experimental data is also improved as compared with the producing company recommendations.

Keywords Light speeds in optical fibers, new uses of laboratory standard equipment, improving precision of measurements, accurate self evaluation of results.

1. Introduction

For decennials, the General Physics Laboratories of the University "POLITEHNICA" in Bucharest have not received financing to buy

new equipment, the old one applying little to electronics and informatics.

This restriction has lead to develop a creative activity of extending the uses of the existing equipment, beyond the initial scope.

This attitude is preserved being applied now, when, with the financial assistance of European Union (where Romania was accepted as a member), during the summer of 2007, has been bought new equipment for the General Physics teaching laboratory.

A new setup, offered for the determination of velocity in air during a standard laboratory work, has been offered to sophomores of UPB, by the laboratory of General Physics.

A possibility to determine the velocity of light would be to measure: the wavelength in the medium (usually around ~ 0.5 micrometers - possibly to be done with the existing equipment) and the frequency of the light wave, $\nu_0 = \sim 6 \cdot 10^{14}$ Hz, this being a too large frequency to be measured in a school or university General Physics laboratory.

Another possibility to determine the velocity of light, would be to measure the time of propagation, t , of a known signal over a measurable distance, l . Because the velocity of light is very high ($2.997 \cdot 10^8$ m/s, in air) and the usual operational distance in a teaching laboratory is in the meter range, distance which may be measured with a standard lineal, with an absolute error of the order of a mm, there is necessary to be measured a time of ~ 3 ns, too small a time for the precision of the equipment available in Physics didactic laboratories.

Other different methods could be used to measure the speed of light like the rotating mirror, short pulse and periodic modulation methods.

The principle of the periodic modulation method, now used in the UPB student labs to measure the velocity of light in air, is to periodically modulate, in intensity, a light wave,

with a piezoelectric modulator, stabilized in frequency (f. e. $\nu = 60.000$ MHz), and to let the modulated signal to propagate through the studied transparent material (air), supposed to be homogenous.

In his way, the phase difference introduced by propagation between the light source and the detector is reduced $\sim 10^7$ times, but, nevertheless, this new difference of phase is too large to be measured with a simple oscilloscope.

The solution is to multiply this signal with another signal of approximately equal intensity, but with a frequency ν' , which is differing from the modulating signal ν_{with} only ~ 100 kHz (precisely automatically measured). The resulting mixed signal may be monitored with a cheap oscillator, after filtering the higher frequency component, with the frequency equal to $\nu + \nu'$.

The author has managed to use the existent setup designed to measure the speed of light in air to offer sophomores and eventually, seniors, a laboratory work by which they may determine the difference of the refractive indices of the core and cladding of the optical fibers assembled in optical and light cables.

2. Theoretical approach

Let's consider a periodic light signal with intensity, I , periodically modulated:

$$I = I_0 + \Delta I_0 \cos(2\pi \nu t) \quad (1)$$

which may be used to measure the light speed.

The light signal is detected and measured using a receiver (transducer) which converts it into a variable electrical tension, U , proportional to the received intensity, which is described by the equation:

$$U = U_0 \cos(2\pi \nu t) \quad (2)$$

If the distance between the transmitter and the receiver is changed with the distance d (Fig. 1), then a t delay would appear, equal to:

$$\Delta t = \frac{d}{c} \quad (3)$$

(where c is the speed of light in the propagation medium) and also a phase difference, $\Delta\phi$, equal to:

$$\Delta\phi = 2\pi \nu \cdot \Delta t = 2\pi \frac{\Delta t}{T} \quad (4)$$

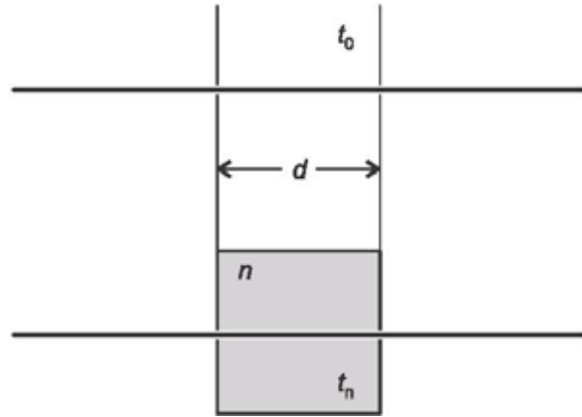


Figure 1. Propagation in vacuum (up) and in a material (down).

where ν is the modulation frequency of the light signal and T is the period of the modulation in intensity of the light signal.

This change may be measured as a phase shift $\Delta\phi$ between a reference and a receiver signal.

Neglecting some losses in intensity, the receiver measures a signal with a $\Delta\phi$ delay:

$$U = U_0 \cos(2\pi \nu t - \Delta\phi) \quad (5)$$

Using (3) and (4), the light speed, c , may be determined in the material of thickness d , measuring the phase difference $\Delta\phi$:

$$c = \frac{d}{\Delta t} = \frac{d}{\Delta\phi} 2\pi \nu \quad (6)$$

If the modulation frequency, ν , is very high, then, even on short Δx distances, considerable $\Delta\phi$ phase differences may result.

In this experiment, where the modulation frequency, ν , is 60.000 MHz [1], for a distance d of 5 m results a phase difference of:

$$\Delta\phi = 2\pi \cdot 60 \cdot 10^6 \text{ s} \frac{5 \text{ m}}{3 \cdot 10^8 \text{ m/s}} = 2\pi \text{ rad} \quad .$$

But, this high frequency could not be displayed on a low frequency oscilloscope.

Because this experiment uses a simple oscilloscope to determine the phase difference $\Delta\phi$, the solution has been to electronically multiply the signal received by the receiver, with an other signal with the frequency of $\nu' = \sim 59.900$ MHz, displayed in real time by the equipment, so that:

$$U = U_0 \cos(2\pi \nu \cdot t - \Delta\phi) \cdot \cos(2\pi \nu' t) \quad (7)$$

Using the trigonometric relationship:

$$\cos a \cdot \cos b = \frac{1}{2} [\cos(a+b) + \cos(a-b)], \quad (8)$$

the resulting signal becomes the summation of two signals, one with the frequency of $(\nu+\nu')$ and the other one with the frequency ν_1 ($\nu_1 = \nu - \nu'$).

By using a filter to cut high frequencies, the high frequency component in the summation may be suppressed, so the signal displayed will be:

$$U = \frac{1}{2} U_0 \cos(2\pi\nu_1 t - \Delta\varphi). \quad (9)$$

This signal may be displayed on the simple oscilloscope used, because his frequency is only ~ 100 kHz. The multiplication of the two signals does not alter the phase difference $\Delta\varphi$.

After multiplication, this $\Delta\varphi$ may be associated to a measurable apparent time difference Δt_1 . The period of this last signal, T_1 , can be read on the display and the phase difference can be computed using the relationships:

$$\Delta\varphi = 2\pi \frac{\Delta t_1}{T_1} = 2\pi \frac{\Delta t}{T}, \quad (10)$$

where Δt_1 is the apparent change in the propagation time.

The actual time difference, Δt , introduced by the propagation of light along the distance d , in vacuum, may be obtained from,

$$\frac{\Delta t}{T} = \frac{\Delta t_1}{T_1}, \text{ as:}$$

$$\Delta t = \Delta t_1 \frac{T}{T_1} = \frac{\Delta t_1}{\nu T_1}. \quad (11)$$

By using equations (6) and (11), the final equation for the light speed in the material may be obtained:

$$c = \frac{d}{\Delta t} = \frac{d}{\Delta t_1} \cdot \frac{T_1}{T} = \frac{d}{\Delta t_1} \cdot T_1 \cdot \nu. \quad (12)$$

In order to determine more exactly the phase difference there is used a reference signal.

This reference signal is synchronized electronically, with the signal from the transmitter, and also it is multiplied with the same $\nu' = 59.900$ MHz signal and filtered exactly like the one from the receiver. Because the delay introduced by the wires and the experimental equipment are unknown but can't be neglected, firstly the transmitter is placed at the distance s from the receiver.

The reference signal is synchronized with the signal from the receiver, by adjusting a compensation phase difference system to have the two signals, in phase. After this synchronization, the transmitter is placed at the distance $\Delta s = s + d$ from the receiver. The phase difference that can be seen on the display (Fig. 2) is caused by the delay time Δt , only.

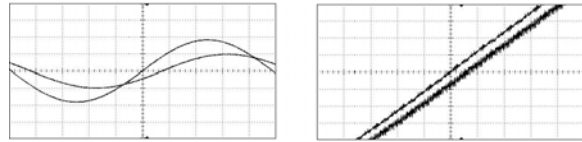


Figure 2. Reference and receiver signals for propagation in a material (left) and a detail for a thin cylinder or a light cable (right).

3. Measurement of a speed of light in a homogenous transparent material

The velocity of light c_n in a medium depends on the refractive index n of that medium. This material-dependent quantity relates the velocity of light in the medium c_n , to that in vacuum, $c_0 = 2.998 \cdot 10^8$ m/s, via:

$$c_n = \frac{c_0}{n}. \quad (13)$$

Different velocities of light correspond to different propagation times, along the same geometrical path length.

The propagation time in a medium of refractive index n is (see 6):

$$t_n = \frac{d}{c_n} \quad (14)$$

whereas the propagation time in vacuum, t_0 , is (see equation 3)

$$t_0 = \frac{d}{c_0} \quad (15)$$

By introducing the definition

$$\Delta't = t_n - t_0 \quad (16)$$

and using the equations (14), (15) and (16), the velocity of light in the medium, c_n , may be computed as being:

$$c_n = \frac{c_0}{n} = \frac{c_0}{1 + \Delta't * c_0 / d} \quad (17)$$

From Eqs. (11) and (17) one, finally, finds:

$$c_n = \frac{c_0}{n} = \frac{c_0}{1 + \Delta't_1 * c_0 / (d * v * T_1)} \quad (18)$$

and the refractive index (equations 13 and 17) is

$$n = 1 + \frac{\Delta't * c_0}{d} = 1 + \Delta't_1 * c_0 / (d * v * T_1) \quad (19)$$

The quantities d and $\Delta't_1$ are to be measured in the laboratory after the alignment and the optimization of the adjustment and of synchronization of the devices [1, 2].

The period T_1 is displayed by the equipment.

The frequency of intensity modulation, v , is precisely known (60.000 MHz).

The results obtained have a convenient precision if the transmitter and the receiver are stable mechanically, thermally and optically. It is to start the experiment after both transmitter and receiver have been turned on and the components of the setup are fastened since half an hour.

For the purpose of this laboratory work and considered the actual level of relative errors, the propagation in air may be considered to a good approximation of the propagation in vacuum the refractive index of air differing from the refractive index of the vacuum with only a part in three thousand parts.

4. Measurement of the velocities of light in optical and light cables

The optical cables, largely used in communications, are bundles of optical fibers

assembled together. Single fibres are also used in communications and as remote sensors, to connect a non-fiberoptic sensor to a measurement system and for many other purposes.

An optical fiber is a cylindrical dielectric waveguide that transmits light along its axis, by the process of total internal reflection (Fig. 3).

The fiber consists of a core surrounded by a cladding layer. To confine the optical signal in the core, the refractive index of the core must be larger than that of the cladding. The boundary between the core and cladding may either be abrupt, in step-index fiber (like in these experiments done in UPB General Physics Laboratory) or gradual, in graded-index fiber.

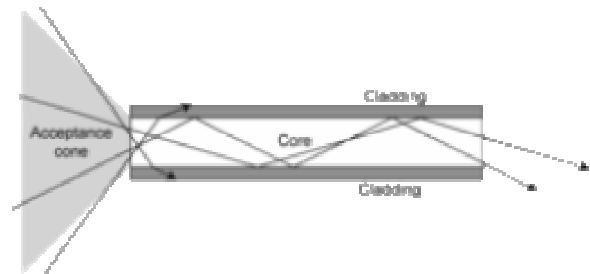


Figure 3. Propagation of light through a multi-mode optical fiber.

When light travelling in an optically dense medium hits a boundary at a steep angle, measured from the normal, larger than the "critical angle", θ_c , for the boundary (see "acceptance cone" in Fig. 3),

$$\theta_c = \arcsin n_{cl}/n_{co} \quad , \quad (20)$$

the light will be completely reflected.

Light travels along the fiber bouncing back and forth off of the boundary. This range of angles which ensure total reflection is called the acceptance cone of the fiber. The size of this acceptance cone is a function of the refractive index difference between the fiber's core and cladding. The sine of this maximum angle, θ_c , is the numerical aperture (NA) of the fiber. Fiber with a larger NA requires less precision to splice and work with than fiber with a smaller NA.

Fiber with large (greater than 10 μm) core diameter may be analyzed by geometric optics.

A high numerical aperture allows light to propagate down the fiber in rays both close to the axis and at various angles, allowing efficient coupling of light into the fiber. However, this high numerical aperture increases the amount of

dispersion as rays at different angles have different path lengths and therefore take different times to traverse the fiber. A low numerical aperture may therefore be desirable for the determination of light speeds in core and in cladding in a students' laboratory.

As an optical waveguide, modelled using the wave equation, the fiber supports one or more confined transverse modes by which light can propagate along the fiber. Fiber supporting only one mode is called single-mode fiber (less than 10 micrometers in diameter). The behaviour of larger-core multimode fiber can also be modelled using the wave equation, which shows that such fiber supports more than one mode of propagation (hence the name). The results of such modelling of multi-mode fiber approximately agree with the predictions of geometric optics, if the fiber core is large enough to support more than a few modes. Optical cables made out of such fibers are chosen for the laboratory work.

The waveguide analysis shows that the light energy in the fiber is not completely confined in the core. Instead, especially in single-mode fibers, a significant fraction of the energy in the bound mode travels in the cladding as an evanescent wave, which may impair the clarity of the curve on the display corresponding to the propagation in the cladding. Therefore, thorough choice of the type of the optical fibers used for measuring the velocities is compulsory.

The properties of the fibers are tailored to a wide variety of applications. Glass optical fibers are almost always made from silica. Like other glasses, these glasses have a refractive index of about 1.5. Typically the difference between core and cladding is 1-2 one percent.

In practical fibers, the cladding, also transparent, is usually coated with a tough resin *buffer* layer, which may be further surrounded by a *jacket* layer, usually plastic, not transparent.

These layers add strength to the fiber but do not contribute to its optical wave guide properties.

Optical fiber can be used as a medium for telecommunication and networking because it is flexible and can be bundled as cables.

Because the aligning of an optical cable or its placing in contact with the device to which it is to couple is much easier than the aligning of fiber, in the newly developed laboratory work are used optical cables with a diameter comparable

with the diameter of the diameter of the laser pencil used.

Although fibers can be made out of transparent plastic, glass, or a combination of the two, the fibers used in long-distance telecommunications applications are always made out of glass, because of the lower optical attenuation.

For the new lab work there have been used optical fibers made out of glass.

5. The determination of refractive indices and velocities of light in core and cladding of optical fibers forming optical cables.

The optical cable, with the entry and exit area polished, is fastened on a bank, connecting source and detector. Its length is measured (d).

The news in the standard procedure is the appearance of double sinusoid as the signal received by the propagation of the modulated light, due to different refractive indices and speeds of light in core and respectively, in cladding of the optical fibers of the cable.

There are measured **two** new delays, corresponding to propagation through core and cladding:

$$\Delta t_{co} = t_{co} - t_0 \quad (21)$$

and

$$\Delta t_{cl} = t_{cl} - t_0 \quad (22)$$

If we define Δn , the difference of the refractive indices of core and cladding, as:

$$\Delta n = n_{co} - n_{cl} \quad (23)$$

and make use of the equations (19) and (23), we find the difference, Δn , of refractive indices equal to:

$$\Delta n = (\Delta t_{cl} - \Delta t_{co}) * c_0 / (d * v * T_1) \quad (24)$$

The two velocities of light are (equations 17, 21 and 22):

$$c_{co} = \frac{c_0}{n_{co}} = \frac{c_0}{1 + \Delta t_{co} * c_0 / (d * v * T_1)} \quad (25)$$

$$c_{cl} = \frac{c_0}{n_{cl}} = \frac{c_0}{1 + \Delta n_{cl} * c_0 / (d * v * T_1)} \quad (26)$$

Attention must be paid that the cable be well aligned and fastened to have a correctly measured d , considered in the computing formulae.

6. Processing of the experimental data

The results are computed using the experimentally found data, known quantities and the relationships (24), (25) and (26).

The absolute and the relative standard errors are found by using error compounding formulae.

7. Results

The results obtained by the students have been:

$$\begin{aligned} \Delta n &= 0.20 \pm 0.02 \\ n_{co} &= 1.46 \pm 0.02 \\ n_{cl} &= 1.44 \pm 0.02 \\ c_{co} &= (2.05 \pm 0.03) \cdot 10^8 \text{ m/s} \\ c_{cl} &= (2.08 \pm 0.03) \cdot 10^8 \text{ m/s} \end{aligned}$$

8. Conclusions

One important resource to cheaply improve Experimental Physics training, in schools and universities and at the same time, to offer more experimental opportunities to the interested

pupils and students, is to use the existing standard teaching laboratory equipment to perform experiments outside the initial scope the equipment has been designed, produced, advertised and sold for.

These new experiments may refer to: larger ranges, a better precision, smaller quantities, more complex investigated objects, new phenomena (eventually interdisciplinary) and higher levels of the processing of experimentally got data.

For example, the new application of the standard equipment, designed for the measurement, in a General Physics teaching laboratory, of the velocity of light in air, has been used to study the two velocities of propagation of light in a light cable and to determine the difference of the refractive indices of core and cladding of the optical fibers, assembled in a light cable, without any new financial or material investment, based only upon creative investment, a resource at disposal in every laboratory, *rich or poor*.

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Computer Simulations of Physics Phenomena Using Flash

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Abstract. *One of the most powerful tools used in both teaching physics concepts and developing measurement and analysis skills are software simulations. This paper describes physics simulations designed for the study of the virtual evolution of physics phenomena, based on Adobe Flash CS3 computer applications. The simulations help the students understand several important physics phenomena and laws more easily while improving their abilities of making measurements and information' processing. The simulations also provide the students with the opportunity of using the experimental data for performing calculations and plotting. They can also be considered tools for checking the results obtained from experimental work.*

Keywords. Computer simulations, Flash, Physics learning, Physics phenomena.

1. Introduction

In the last decade the great development of the programmable web and new computational technologies lead to the development of specific platforms like HTML, JavaScript, Flash and Ajax. This had also an important influence on the implementation of the new computational methods in engineering education. The use of

computational methods does not require a complete renunciation of the traditional methods. Even in the next future a quick and efficient way of improving knowledge would consist in the using at large scale of the Web technology. Recent developments in this area have shown that computer assisted learning processes [3], [4], [5], [6], [14], [15], [16], [17] are one of the most promising ways to improve the educational results.

Our experience in the field of physics [7], [8] has demonstrated that processing data using the computational methods is of great help for our students in the learning process. In the last years we have focused our efforts to the acquisition of new computational programs designated to improve the study of physics. In this way, we are able to use a powerful teaching methodology [10] for developing students' abilities [1], [2], [7], [8], [9], [12], [13] to understand the scientific content of our courses, and use the computational programs for simulatying physical phenomena. Our main goal is to improve our physics course and laboratory, and this implies providing a framework for the integration of new computational tools, and especially of the computer simulations of physics phenomena. A first step was done by adding to our seminars some "teaching-while-quizzing" tests [10] that

were proposed for improving the physics learning and which are already on use by our students. Also, this computational method has improved the teaching of physics and developed the students' abilities. The next step consists in the implementation of the computer simulations [11], which will do not replace completely the traditional methods of learning physics, but will allow the good understanding of physics laws and phenomena, and will develop skills of measurement and analysis. Very important is their property of being not affected by the errors generated by the measurement process and the sensibility of apparatus.

At our physics laboratory, the students use the computers as tools for collecting, analyzing, visualizing and modeling real data which are picked up during experiments. For our students, it is very important to get familiar with both the laws of physics and the phenomena in the theoretical lectures and some computer programs that can make the understanding of physics concepts easier. These activities facilitate the development of the students' ability to apply these concepts to physical situations and reason with them. As a result, the students will be able to use these theoretical ideas and the newly acquired skills in practice. For us, it was important to decide which are the laboratory activities that need computer simulation applications, and which of them are the most important.

In this paper we provide a concise description of a set of physics simulations elaborated in Adobe Flash CS3 for the study of Stefan-Boltzmann law of thermal radiation and the determination of Planck's constant using the photoelectric effect. These computer simulations discussed here have been implemented and tested at our physics laboratory, and for their elaboration we used modern software and technologies [18].

2. Computer Simulations for Physics Phenomena

We realized a set of physics interactive simulation computer applications that describes some important phenomena and laws of physics, and which are used in our physics laboratory. We have a suite of 10 simulations of our laboratory works based on various physics phenomena, which cover many of the areas of physics studied in our course of physics. Very important has

been to decide what are the physics laboratories that needs a computer simulation application, and among them which are the priorities. We established the most important experiments, and after this elaborated the computer simulations with respect that the experimental results must be the same as the results yielded by the computer simulations. The software can be run during or after the experiment and allowing the students of making a comparative study between experiment and simulation.

The simulations were elaborated in the animation and programming environment Adobe Flash CS3 [18]. This is professional software by means of which applications, animations and web pages may be created and processed. The operations, the functions and the easy handling give to the ones who develop Flash applications the access to many possibilities. This makes Flash to be a good environment in developing applications. Our computer simulation applications were implemented using the data obtained further to physical experiments to simulate as accurately as possible the behavior/the indications of the lab equipment. There have also been used the physical formulas necessary to obtain the wanted results. By means of experimental data taken from certain sites within a given span of time, an interpolation of 1st degree could be implemented in these applications, so that the user has the possibility to use values from the same span of time that he would have used with the lab equipment. This gives the user the freedom to choose a value, being not constricted to use a limited number of values or even the used experimental values. We notice that these applications have a menu in Romanian and English, which may be used depending on necessity of preference. As examples, we present the applications for the study of Stefan-Boltzmann law of thermal radiation and determination of Planck's constant using the photoelectric effect. Each of these applications allows the students to verify the experimental data and to perform the calculation and carry out the graphs.

First we describe the application for the Stefan-Boltzmann law of radiation. The screenshots of the applications interface are presented in Fig. 1 and Fig. 2. In Fig. 1 is given the computer interface image for the lab objectives, the apparatus and equipment, and the measurements and procedure. The aim of the computer simulation is the verification of the

Stefan-Boltzmann law of radiation. When opening this application, the students have to press the switch of the circuitry. After that, they have to enter values for the feeding voltage U and the variable resistance R_3 , yet these values shall enter the specified range beside the data input area. Otherwise, a warning indicated by a red box flashing next to the wrongly entered value will be provided. After the values that observe the possible value ranges are entered, the button Upgrade will be pressed as it displays the newly obtained values of R , I and T , upgrading at the same time the graphic and the indication of the galvanometer. The user should try to adjust R_3 for a certain value of U , so that the reading of the galvanometer should be 0.

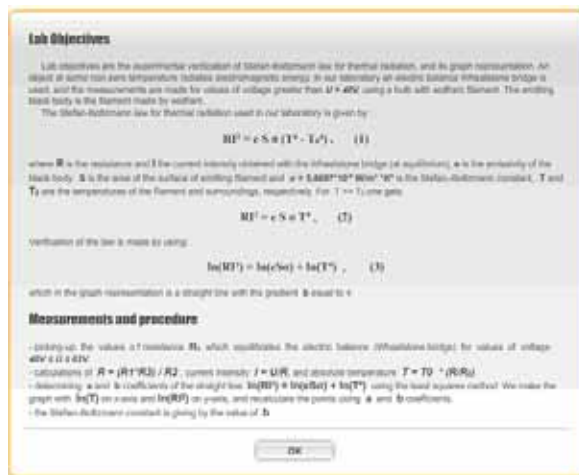


Figure 1. Lab objectives, measurements and procedure for the Stefan-Boltzmann law.

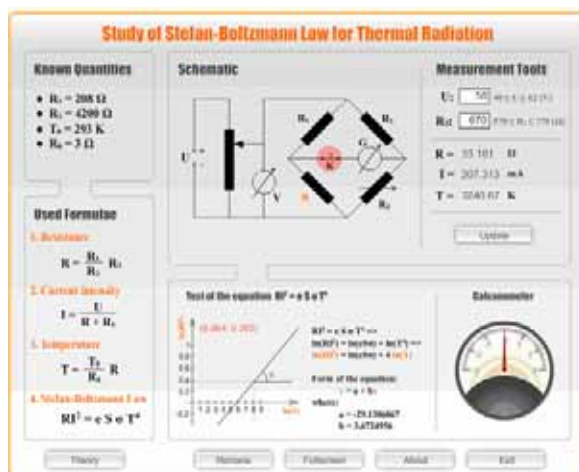


Figure 2. Screen-shot of the application interface.

The next example is the one of the computer simulation of the determination of Planck's constant using the photoelectric effect.

For the determination of Planck's constant the Einstein's equation for the photoelectric effect is used. The lab objectives, the apparatus and equipment, and the measurements and procedure are presented below as the computer interface image in Fig. 3. The students learn about the theory and experimental method.

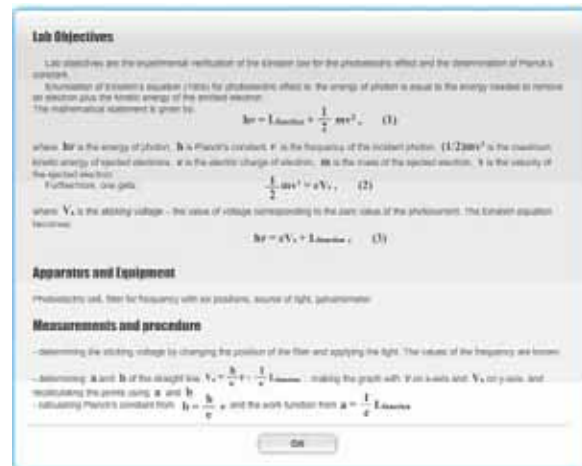


Figure 3. Lab objectives, apparatus and equipment for the photoelectric effect.

The second computer interface image for this program is presented in Fig. 4. The user should first choose a certain value of the wave length of the color to be experimented, after which he should adjust the value of the sticking voltage V_s (or another denotation in Romanian is V_b), so that the reading of the galvanometer should be 0. When this requirement is met, the obtained frequency may be extracted.

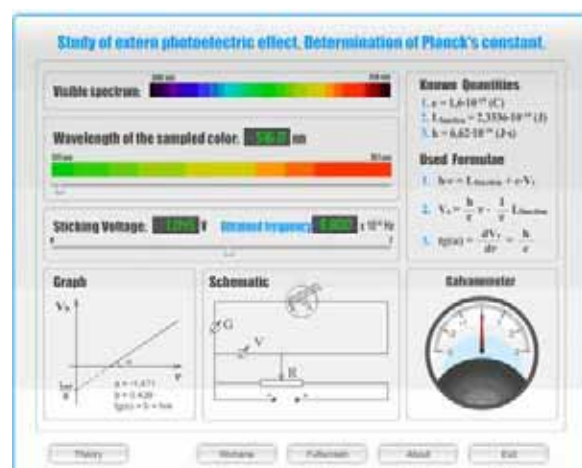


Figure 4. Computer interface image for the photoelectric effect.

In our physics laboratory we use a filter with six known frequencies and we pick up the corresponding values for the sticking voltage,

and after this we determine Planck's constant using the least square method. The computer simulation gives the possibility to determine by interpolation the corresponding values of the sticking voltage for a large number of values of wavelength.

We present the function "my update" of the interface in the case of the application for the Stefan-Boltzmann law of radiation (partially in romanian):

```
function my update():void
{
  if(k_mc.currentLabel=="inchis")
  {
    var u:Number = (Number)(u_txt.text);
    var r3:Number = (Number)(r3_txt.text);
    var r3Ideal:Number = 0;
    var i:uint = 0;
    var divRez:Number = 0;

    var R:Number = 0;
    var I:Number = 0;
    var T:Number = 0;

    if(u>=40 && u<45)
      i = 0;
    if(u>=45 && u<50)
      i = 1;
    if(u>=50 && u<55)
      i = 2;
    if(u>=55 && u<60)
      i = 3;
    if(u>=60 && u<=62)
      i = 4;

    divRez = (arrR3[i+1] - arrR3[i]) / (arrU[i+1] - arrU[i]);
    r3Ideal = Math.round(divRez * (u-arrU[i])) + arrR3[i];

    rotatie = Math.round((r3Ideal - r3) * divRot);
    galv_mc.indicator_mc.rotation = rotatie;

    const R1:Number = 208;
    const R2:Number = 4200;
    const T0:Number = 293;
    const R0:Number = 3;
    const a:Number = -29.1386967;
    const b:Number = 3.6724956;

    R = (R1/R2) * r3;
    I = u/(R+R1);
    T = (T0/R0) * R;
```

```
r_txt.text = R.toFixed(3);
i_txt.text = (I*1000).toFixed(3);
t_txt.text = T.toFixed(3);

//pentru grafic
lnT = Math.log(T);
lnRI2 = Math.log(R*I*I);

grafic_mc.panta_mc.x = Math.round((90 * lnT)/9);
grafic_mc.panta_mc.y = Math.round(-(75 * lnRI2));
grafic_mc.xy_txt.text = "(" + lnT.toFixed(3) + " + " + lnRI2.toFixed(3) + ")";
}}
```

and, also for the determination of Planck's constant using the photoelectric effect

```
function myupdate():void
{
  var lu:Number = luSlider_mc.value;
  var vb:Number = vbSlider_mc.value;
  var vbIdeal:Number = 0;
  var frecv:Number = 0;
  var i:uint = 0;
  var divVb:Number = 0;
  var divLU:Number = 0;

  //[701, 637, 577.5, 528.5, 520, 511];
  if(lu<=701 && lu>637)
    i = 0;
  if(lu<=637 && lu>577.5)
    i = 1;
  if(lu<=577.5 && lu>528.5)
    i = 2;
  if(lu<=528.5 && lu>520)
    i = 3;
  if(lu<=520 && lu>=511)
    i = 4;

  divLU = (arrLU[i] - arrLU[i+1]) / (arrVb[i+1] - arrVb[i]);
  divVb = (arrVb[i+1] - arrVb[i]) / (arrFrecv[i+1] - arrFrecv[i]);
  vbIdeal = Math.abs(lu - arrLU[i])/divLU + arrVb[i];
  //trace(vbIdeal);

  //divFrecv = (arrFrecv[i+1] - arrFrecv[i]) / (arrVb[i+1] - arrVb[i]);
  frecv = Math.abs(vb-vbIdeal)/divVb + arrFrecv[i];
```

```
//trace(frecv);
rotatie = Math.round((vbIdeal - vb) * divRot);
//trace(rotatie);
galv_mc.indicator_mc.rotation = rotatie;
```

```
frecvVal_txt.text = frecv.toFixed(3);
}.
```

It is worth emphasizing that we have noticed an improvement in the understanding of physics phenomena and laws due to the implementation of computer simulations in our physics laboratory.

3. Discussion and Conclusions

In recent years the development of efficient and accurate tools for physics computer simulations has become of great interest for both students and physicists. In this paper we present two physics simulation computer applications elaborated in Adobe Flash CS3 program that we developed for our physics laboratory. They are used for the study of the Stefan-Boltzmann law of thermal radiation and the determination of Planck's constant using the photoelectric effect. Moreover, they are part of a set of physics simulations elaborated in Adobe Flash CS3, which help our students to achieve a better understanding of physics phenomena and laws.

There are some important arguments that support the necessity of introduction of this way of physics study. First, picking up experimental data is a process that can be perturbed by errors, and this can be avoided by using virtual tools like computer simulations. Moreover, the computer applications also work as checking tools of the results yielded by experimental work. Future computer simulations can be envisioned for improving the learning process. Thus we open a window for the students to the virtual labs and simulations, and they can learn to use a comparative mode of learning and how to experiment and use software applications. The set of physics simulations they use can be further implemented in the distance learning via the Internet (e-learning), which is partially or entirely based on Web and Internet courses and assignments.

Moreover, at our courses, seminars and laboratories, we are just beginning to develop this kind of new learning activities, as for long time we missed the necessary resources, equipment and technical systems. Our simulation

programs themselves are inexpensive aids in the study of physics.

4. Acknowledgements

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Research Interpretation at University

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Abstract. *Interactive centers are significant informal learning sources for Science and Technology where interpretation and hands-on activities are employed as learning tools. An interdisciplinary science and technology museum at formal learning environment has been designed, consisted on interactive modules with hands-on experiments related with scientific research done in the Higher School of Mining Engineering (Escola Técnica Superior de Enxeñeiros de Minas or ETSEM) at the University of Vigo. In this essay we present the more noteworthy results in relation to the context and methodology used, a description of the selected contents and the creation process, the design and implementation of the activity and the degree of fulfillment of the objectives which were analyzed through questionnaires given out to a notable sample of over 250 people who visited our tailored interactive centre in ETSEM.*

Keywords. Science Education, Hands-on Science, Interpretation, Research, Interactive Center.

1. Introduction

The currently accepted paradigm for learning scientific-technological subjects requires, among other things, the use of collaborative strategies such as group work and critical thinking, and skills for practical problem solving, which, in addition, take the subjects closer to an individual's social, cultural and personal concerns [1,2]. The use of hands-on activities can contribute to such objectives as yet another tool to make learners active participants in the process: constructing in order to learn and learning in order to construct [3]. A hands-on activity in a knowledge acquisition context means the use, whether in a formal learning environment or not, of any real material or object employed with the intention of learn a properly contextualised concept, principle, law or application [4]. These are well-known methods

for presentation and communication regularly employed in interactive centres or science museums, where the message being transmitted appears in an informal, fun context [5-7]. In this case the interpretation is chosen for revealing meanings and relationships by using original objects, direct personal implications and illustrative means instead of mere audiovisual communication of the facts [8-10], in an inclusive experience in which personal, social and physical contexts of participants intervene to a unique, individual experience [11].



Photo 1. Key ideas for the ETSEM activity: its installations and research

There are innumerable examples of such resources being imported into the educational sphere [12-15] backed up by the use of everyday items, videos, simulations, models and demonstration teaching material or instruments themselves from research laboratories [4,16]. Thus, the teacher can integrate [17-18] them into traditional, large group, master classes as subject area experiences [4,16], propose to learners the creation of a hands-on experimental module in the form of a challenge activity undertaken

individually or in small groups [19-20] or even suggest the cloning of a science and technology museum within the educational environment, a collective and cooperative activity in which learners are co-responsible for its definition, set up and monitoring [21-24].

Within the framework of Science Week 2007, organised by the General Direction for Research, Design and Innovation (R&D&i) of the Xunta de Galicia Regional Authority [25], the above strategy of using hands-on activities as a link between learning and popularisation was used to carry out an interpretive experience related directly to research undertaken in the Higher School of Mining Engineering (Escola Técnica Superior de Enxeñeiros de Minas or ETSEM) at the University of Vigo [26]. The main aim was to show the relationship between this research and energy, new materials and the environment (Photo 1), in a similar way to a science and technology museum, but run by student monitors and employing real hands-on activities backed up by tailor-made audiovisuals, with representative photos, videos and simple, clear, direct, easy-, and quick-to-read texts that in all events transmitted the correct message to create “places of informal fun learning” within the ETSEM itself. This activity fitted within the aims of the Social Communication and Awareness Programme of the Galician R&D&i Plan inasmuch as it attempted to create an experience in educational innovation at the university by trying, amongst other things, to promote greater social recognition of its research activities, make potential students aware of these or even promote the ETSEM’s participation in science and technology experiences by means of contextualised hands-on activities.

The educational innovation experience was centred on work with a small group of selected students from the ETSEM who were involved in a process in which part of the teaching staff carried out corresponding tasks in a coordinated, collective and cooperative way. The students worked as guides, interpreters, intermediaries, monitors or mediators with the visitors for whom a two-hour guided tour was designed: science and technology pupils from nearby secondary and high schools (14-18 year olds), usually accompanied by two or three teachers (Photo 2).

2. Context and methodology

Mining Engineering studies, with a long tradition and great prestige in the EU, started in

Spain in 1777 and were the first Civil Engineering qualification to be created there. Its name originally comes from the traditional location of mineral and energy sources. Nowadays the versatility of qualifications means it can be adapted directly to new technologies. Mining engineers are essentially responsible managers of the Earth’s natural resources and contrary to popular opinion, most of them do not work in mining exploitations, as the fields for work are numerous and, at the same time, unknown to the public, such as, for example: energy and fuels, metallurgy, the iron and steel industry, resource and environmental management, geology, civil works and construction, business management, explosives or safety and risk prevention in the workplace.



Photo 2. The public during the activity

The studies were established at the University of Vigo in the 1992-1993 academic year. ETSEM is now one of five offering higher level qualifications in Spain and the only one in Galicia.

The recently built installations made it possible to unify the technology area of the University Campus at Lagoas-Marcosende (Vigo), given the fact that the ETSEM occupies a space in the centre, with corridors going out from it to the three Higher Engineering Schools of the Vigo Campus. Sixteen years on from its start up in Galicia, the scientific and technological activities related to the ETSEM are in part unknown by the general public and for this reason the theoretical proposal for this activity was aimed essentially at

showing close up and explaining the work going on in the labs, showing the great range of career possibilities available to future graduates and what is on offer in terms of education and services from the ETSEM, and, furthermore raising awareness of participants with regard the importance of preserving the Earth's natural resources (energy and materials) and the environment, with the specific objectives of:

- 1) Increasing interest for scientific and technological aspects developed at the ETSEM.
- 2) Bringing the ETSEM's scientific and technological research to the public.
- 3) Showing scientific technological applications at the ETSEM in a fun, interactive way.
- 4) Making society aware of the importance of preserving the Environment and our Heritage.
- 5) Showing the scientific technological work at the ETSEM as an interdisciplinary task.

In order to achieve these objectives an educational innovation experience was drawn up under the general, eye-catching title of "Energy, materials and environment: this qualification is a mine", which consisted of a guided visit designed to take visitors around the ETSEM facilities whilst everyday teaching and research activities were going on.



Photo 3. Some students as guides, interpreters, intermediaries, monitors or mediators

Within this architectural framework, which in itself warrants a guided tour, the monitor work (Photo 3) was essentially carried out by final-year students from the ETSEM, in a context of explanation among peers or equals. The teaching staff worked together to establish the contents, the corporative image of the audiovisual presentations and the protocols for interpretive presentation. It was understood that the media could not offer more than someone had thought, prepared or represented, and should therefore be complemented by the direct personal contact of the interpreter [10]. Likewise the students worked on their own to prepare the material for providing more or less support depending on the case, which was then unified with all the modules. Some of the activities required additional training or preparation of the students by the teaching staff, so that they could handle instruments easily and with confidence. This design and interactivity work with the students was completed by their presence every day in the modules, verbally presenting the contents, carrying out hands-on activities and generally dealing with the visitors. This all resulted in them achieving important learning goals regarding the particular abilities for this type of activity, and the strengthening of several linked competences: some instrumental (ability to analyze and sum up, problem solving or organization and planning skills, etc.), some personal (teamwork, interpersonal relationship skills, critical reasoning, etc.), and some systemic (autonomous learning, creativity, initiative, enterprise spirit, etc.).

The two-hour visits are distributed sequentially and in parallel in several of the ETSEM's spaces and with various timings, which were maintained to a greater or lesser extent. Two morning sessions were scheduled and were used for most of the five days that the activity lasted. On most occasions the visitor groups needed to be split into smaller groups for ease of work, enjoyment and to take better advantage of the visit. After a general reception in the ETSEM's main lobby by two people from management who introduced themselves, the ETSEM, and its facilities, the support material for the visit was handed out in the form of a leaflet together with general information about the education on offer and services at the University of Vigo, and material provided by the General Direction for R&D&i.

Also in the main lobby, two monitors ran activities dealing with energy, aided by audiovisual material projected onto a portable screen. Later, one of the monitors took a group to the upper floor to be shown some of the ETSEM services: photocopying, academic administration and the library. Later, on the upper floor, the visitors were received in the degree hall by a teacher who gave an informative talk on the qualification and the visit. This was finished by forming small groups of visitors who were circulated independently around the rest of the interactive themed modules (new materials and environment) located at various areas within the facilities, all of which were backed up with the corresponding audiovisual presentation. At the end of the visit all of the visitors converged once again in the lobby as a meeting point and received a souvenir gift of their visit to ETSEM and an individual evaluation questionnaire to take back to their centers for later return. After the event they received further support documentation about what they had seen and a photo report made during their visit, which included, for example, 2D thermal images or 3D scans of themselves.

3. Contents and undertaking

The hands-on modules attempted to relate the contents with the participants' own experience, employing whenever possible some everyday elements to link the unknown to the familiar. They were focused on a specific research topic, around which the general context and applications were shown at the same time (Photos 1 and 4). Thus the visitors could:

a) attend a handling demonstration of different explosives (a specific Mining Engineering function) provided by the former "Spanish Explosives Union", now MAXAM, together with explanations of tasks and procedures that mining engineers carry out in underground civil works (tunnels, car parks, etc.) and quarries; or individualized demonstrations of rock compression resistance testing;

b) take part in fieldwork demonstrations undertaken at the ETSEM with actual technology from the research labs, such as 3D scanning of part of a building or different structures by using high precision 3D laser scans of the area, such as those used by Mining Engineers to analyse bridges, heritage sites, etc. Here, data collection was taken of the group itself for them to see afterwards on the screen used to project the accompanying audiovisual;

c) get to know the possibilities of alternative energies in general and biomass in particular, by watching the operation of a real research model, moved from the lab into the lobby, in which detailed study is made of the combustion process for this type of renewable energy; or the features and properties of the most representative materials in industry (ceramics, metals, hybrids and polymers), explaining, for instance, how a PET mineral water bottle or a toothpaste tube is manufactured by using injection, or, with the help of the student monitors, the creation of polyurethane, or carrying out nickel plating as an example of corrosion protection or;

d) participate in taking non-destructive 2D thermal images with a thermal camera such as those employed in heat efficiency studies on buildings. Here, visitors saw different applications and participated in small experiments such as viewing the thermal contours in a small piece of PVC tubing which was subjected to internal sedimentation with silicon, or even the observation of their own body temperature, in which case, once the activity was over, a thermal image was taken of the group as a souvenir.

The teaching staff and students involved took responsibility for general organisation and coordination of activities, planning and design of work, and the compilation of graphic and bibliographic documents for the interpretative audiovisuals, poster and leaflet. They were also involved in defining the guided tour of the ETSEM, in design and creation of the audiovisual presentation material, in acquiring material and booking the equipment and instruments for demonstration. Teaching staff were involved in the training of the student monitor guides.

A plan for diffusion, follow up and evaluation was drawn up. A section of the ETSEM webpage was prepared, where general information on the activity along with downloadable PDFs of the poster and leaflet were published beforehand together with preparatory background reading for accompanying teachers aimed at gaining a more useful educational experience. When each daily session was over, a selection of photos was sent to the General Direction for R&D&i [25] and five galleries were published. The activities undertaken were also diffused in the media (press, radio, web and TV) thanks in good measure to the work of the University of Vigo Press Office [27]. All this meant a significant increase in the ETSEM's external visibility during the days of activity.



Photo 4. Some examples of the hands on activities developed: 2D thermal imaging, 3D scanning, explosives handling demo, and materials with shape memory

4. Evaluation

The questionnaires employed for evaluation of the activity were designed by the General Direction for R&D&i of the Xunta de Galicia for Science Week 2007. The questionnaires of around 250 participants were analysed. The main results, in the form of percentages reached for each of the possibilities, can be seen in Figures 1-3, where general information on the origin and membership is given for the visitors who were essentially a captive audience, obliged to attend the activity during school hours, exposed to an optional learning activity and without the possibility of free choice about participating, which is an important factor to take into account. There is also information about their knowledge of other similar activities and experiences, whether part of the Science Week organised by our government or of a different origin. With regard to evaluation of activity undertaken at the ETSEM, it appears that they far exceeded the participants' expectations. Predictably, lack of initial knowledge was great, whereas after the visit there was a palpable perception that it had helped in the acquisition of new knowledge, increasing interest in the contents presented. Also of note was that the majority of the participants felt that the contents were suitable for their degree of knowledge, which means there has been relative success in the process of adapting and presenting the contents in a way

that is understandable to the layperson, an idea supported by the high average overall rating obtained (7.6 out of 10). Finally, and also very high, was the rating for the work of the monitors, the material and the organisation.



Figure 1. Evaluation: characteristics of the sample with regard to their origin and experience in popularisation activities

5. Conclusions

This work presents the methodology for planning, organisation and coordination together with the most noteworthy results gained during an educational innovation experience related to the creation of an interactive museum and a guided tour of the ETSEM facilities at the University of Vigo as part of Science Week 2007, organised as a learning activity aimed at acquiring essentially transversal competences, knowledge and skills by means of autonomous work carried out by a small number of selected students, oriented by teaching staff acting as coordinators.

The activity attempted to engage participants with research going on at the ETSEM, recreating it technologically and increasing empathy towards it by employing interpretive resources for demonstration and participation. It is understood that the questionnaires reveal a high degree of satisfaction among participants, who consider it to have been a special and novel experience that was important to them. The activity, fun, enjoyable and motivating, appears to have awoken their interest in the contents presented and shifted in the majority of cases, the ignorance and ideas previously held. The participants thought that the experience was a fount of useful information and that it was possible to learn new things from it.

A large part of the success achieved must be put down to the student monitors who, with clear and straightforward messages offered a general broad-ranging idea of their modules within the context of the ETSEM, including details with their own personal impressions, awakening the interest and desire to see new things, becoming the vital medium to aid in understanding and help enjoy these facts. The enthusiasm seen by participants during the activity also constitutes an important achievement. Finally, it is important to also mention that in general the rest of the teaching staff and students of the ETSEM not directly involved in the activity also felt highly satisfied with the experience, as did most of the accompanying teachers from the visiting schools.

6. Acknowledgments

Thanks go to the General Direction for R&D&i of the Xunta de Galicia for funding as part of the Science Week 2007 programme. Thanks also go for the logistic support of the OTRI (Aristides Huerga and Javier González) at the University of Vigo, the diffusion tasks to the media by the University of Vigo Press Office and the demonstration material provided by MAXAM. Finally, thanks go to the teachers, students and support and service staff of the ETSEM who participated by giving their help, particularly to: Pedro Arias, Natalia Caparrini, Enrique Granada, Carmen Pérez, Fernando Cerdeira, Enrique Orche, Javier Taboada, Fernando García, Pedro Merino, Marta Cabeza, Ramón Nóvoa, Iria Rodríguez, Jaime Martínez, Diego Copena, Antonio Soliño, Carmen Moreira, María Rodríguez and Karolina Biskup.

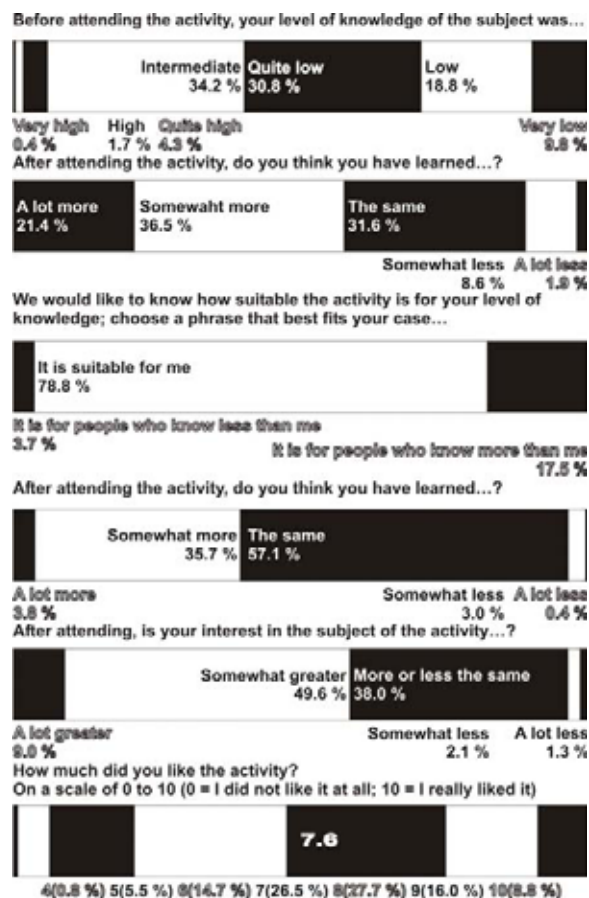


Figure 2. Evaluation: degree of suitability, knowledge, learning and satisfaction

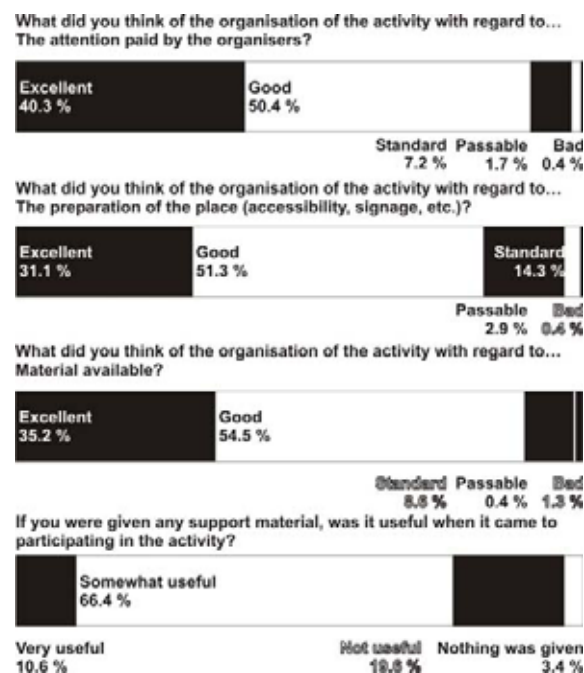


Figure 3. Evaluation: attention paid, material and organisation

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- [27] <http://www.duvi.uvigo.es/>

Handmade Series Direct Current Motor

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Abstract. *It is possible to build a variety of very simple – and yet functioning – electric devices using common materials. These devices can be used to verify Electromagnetism fundamentals. Electric currents within magnetic fields originate forces and that is the basic principle of operation of electric motors. This paper describes a universal series motor made with iron bars, insulated copper wire, two small brass plates, insulating tape, six screws and a couple of hoops. The motor is fed with a personal computer 12V DC switched power supply. Rotor speed can achieve several rotations per second.*

Keywords. Electric Motors, Universal Series Motor.

1. Introduction

The device described in this paper (Fig.1) is a handmade *universal series motor* [1]. It is called *universal* because it works both with direct current (DC) or alternating current (AC) and *series* because the windings of the stator are in series with those of the rotor [2]. Both windings must have the same polarity.



Figure 1. Handmade universal series motor.

An electric current flowing in a solenoid originates a magnetic field in the surrounding

space and two magnetic fields interact with each other originating forces [3,4]. These are the Electromagnetism fundamentals that explain the principle of operation of the constructed motor. Direct current was used to feed it.

Materials used to build the motor are listed in Section 2. Construction details are given in Section 3. The principle of operation of the motor is explained in Section 4.

Conclusions are presented in Section 5, followed by the due acknowledgements (Section 6) and the list of references cited (Section 7).

2. Materials used to make the motor

The following materials were used to build the motor:

- 20cm x 20cm wood board;
- 68cm x 10mm iron rod;
- 18cm x 15cm x 3mm iron sheet;
- 25cm x 10mm x 3mm iron bar;
- copper wire 10cm of length;
- 25m of varnished copper wire;
- copper tube with 14mm inner diameter and 2cm of length;
- two handles, each with a 13mm hole;
- roll of insulating tape;
- six medium screws.

3. Motor construction

To build the core of the stator, a 53cm *per* 10mm iron rod is bent as shown in Fig. 2 and the 140mm sides of the resulting piece are covered with insulating tape.

Then, the stator windings are coiled over the insulated portions of the core as shown in Fig. 3. Each winding is made of 200 turns of varnished copper wire. Special care has to be taken in order to coil the windings in opposite directions, as Fig. 3 suggests. After this, the finished stator should look like the one depicted in Fig. 4.

The traverse bar of the rotor core is made of two equal 12,5cm x 10mm x 3mm iron bars. An

arch is made at the middle of each bar (the side view of the bars is shown on Fig. 5). The bars are then fastened on a 15cm x 10mm iron rod using insulating tape, as shown in Fig. 6. The rod is previously insulated with tape (only its extremities are left without insulation).

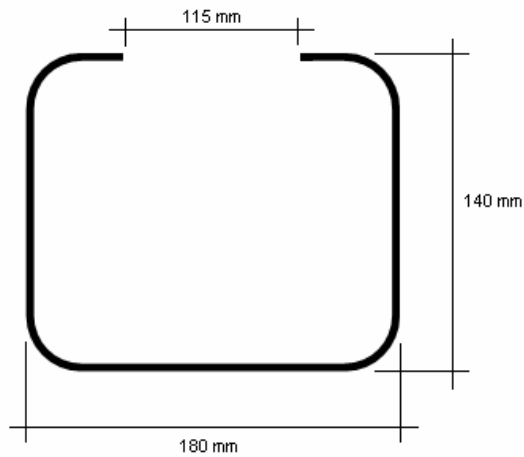


Figure 2. Core of the stator.

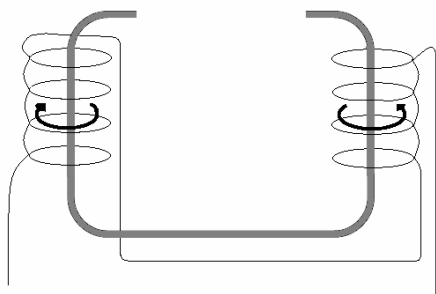


Figure 3. Making the windings of the stator.

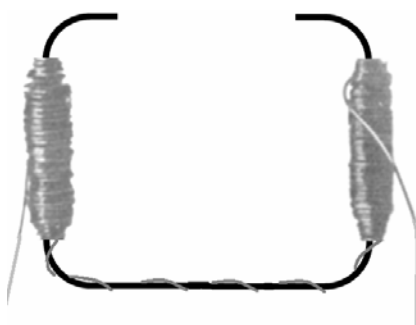


Figure 4. Final aspect of the stator.

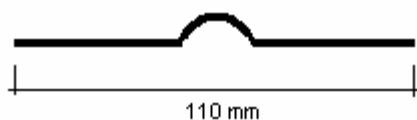


Figure 5. Side view of the iron bars used to make the traverse bar of the rotor core.

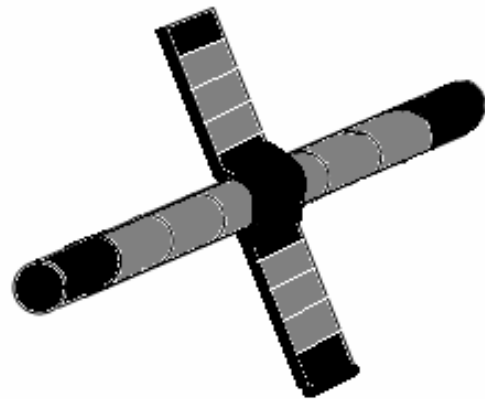


Figure 6. Core of the rotor.

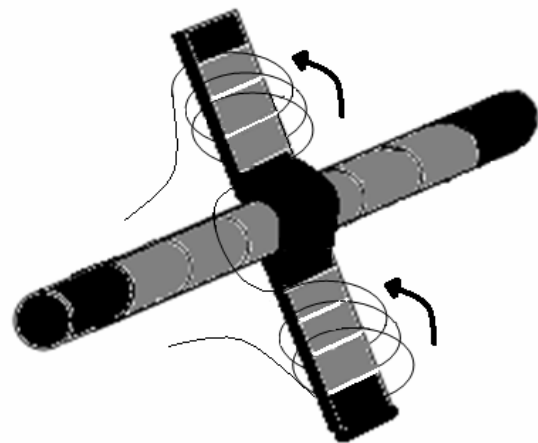


Figure 7. Making the windings of the rotor.

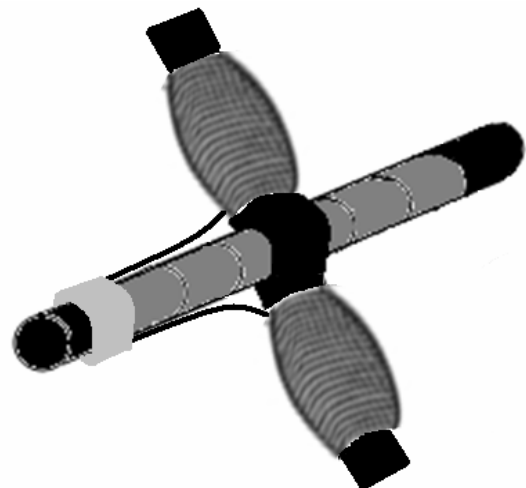


Figure 8. Final aspect of the rotor.

The rotor windings are coiled over the insulated portions of the traverse bar of the rotor core (Fig. 7). Each winding is made of 200 turns of varnished copper wire. Special care has to be

taken in order to coil the windings in the same direction, as Fig. 7 suggests.

A copper tube is cut to half. Each of the resulting halves is connected to one of the terminals of the rotor windings. The two halves are then fastened on the rotor, forming the collector. The finished rotor looks like the one depicted in Fig. 8.

To hold the rotor, two identical pieces of 3mm iron sheet were made according to the blueprint depicted on Fig. 9.

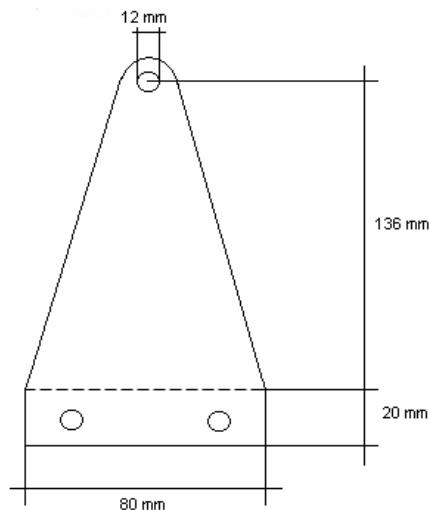


Figure 9. Support of the rotor.

Two terminals of the stator windings are connected to a personal computer 12V DC switched power supply. The other two are leaned on the collector. Connections must be made according Fig. 10.

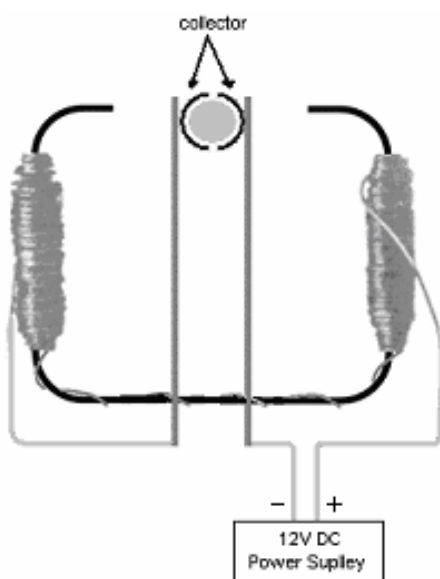


Figure 10. Connections of the stator windings terminals.

4. Motor operation

Feeding the windings of the stator with a constant current originates a constant and uniform magnetic field in the space between the two magnetic poles shown in Fig. 11.

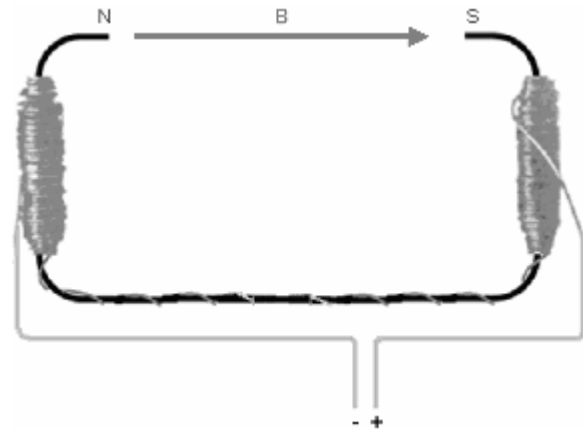


Figure 11. Magnetic field of the stator.

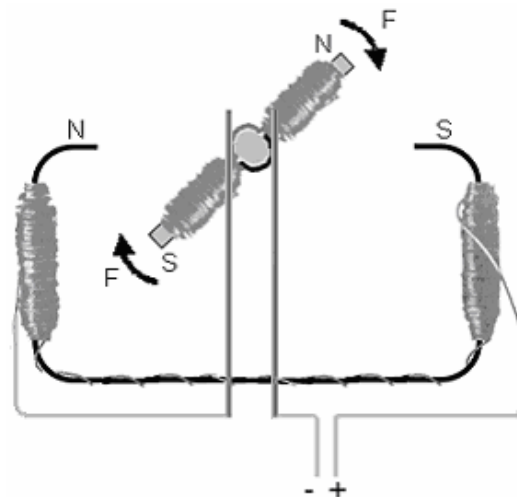


Figure 12. Forces actuating on the rotor.

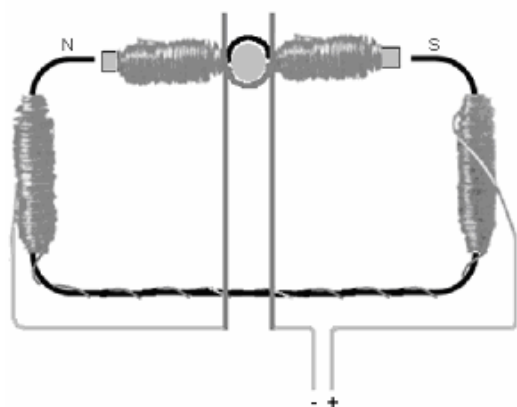


Figure 13. There are no forces actuating on the rotor.

When the rotor is connected in series with the stator, the current passing in the stator windings flows through the rotor windings, too, creating a second magnetic field around it. Since the rotor is within the magnetic field of the stator, the two fields interact with each other, originating forces that move the rotor. These forces, which determine the sense of rotation of the rotor, are such that opposite poles attract each other and similar poles repel each other (Fig. 12).

When the rotor reaches the position depicted in Fig. 13, the current flowing in its windings falls to zero due to the connections between collector and brushes. There are no forces in this situation. However, the rotor keeps turning due to inertia. Immediately after, its current is re-established but with the opposite direction, which changes the polarity of the magnetic field of the rotor. Forces appear again, keeping the rotor turning in the same direction (Fig. 14). Without the polarity change of the magnetic field of the rotor – which occurs every half turn – the rotor would stop in the position shown in Fig. 13. Rotor speed can achieve several rotations per second.

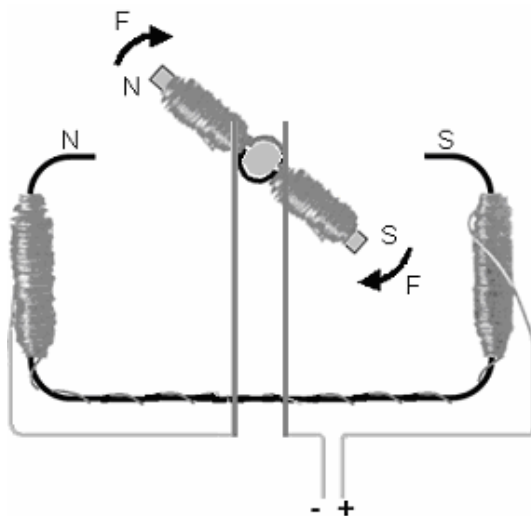


Figure 14. Forces actuating on the rotor after a polarity change of its magnetic field.

5. Conclusions

A handmade universal series motor has been presented. The device, very suitable for science fair events, was built with common materials and can be used to verify *electromagnetism*' fundamentals that explain the operation of all electric motors. Feeding the motor with 12V DC makes the rotor turn at a speed of several rotations per second.

6. Acknowledgements

The authors are grateful to João Sepúlveda and João Luíz Afonso for the explanations and to Cátia Chamusca for the revising of this paper.

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Alternating Current and Direct Current Generator

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Abstract. *Spinning a wire loop within a uniform magnetic field in a convenient fashion induces a voltage between the loop terminals. This effect can be used to build an electric power generator, such as the one described in this paper. A coil attached to a shaft spins within the magnetic field of a "U" shaped magnet. Three conveniently designed conductive disks allow the electrical load of the generator to be fed either with alternating current or direct current.*

Keywords. Alternating Current, Direct Current, Generator, Magnetic Field, Induced Voltage.

1. Introduction

Although diverse forms of energy (mechanical, thermal, chemical etc.) can be converted into electrical energy, the expression *electric generator* is reserved, in the industry, only for the machines that convert mechanical energy into electrical energy. The generators that produce direct current (DC) are called *dynamos* and the ones that produce alternating current (AC) are called *alternators*.

The device described in this paper is a generator capable of supplying an electrical load with the desired type of current: alternating current or direct current.

2. AC generator principle of operation.

Figure 1 illustrates the principle of operation of an AC generator. A wire loop rotates within the magnetic field generated by a magnet, which induces an AC voltage between the loop terminals. The periodic change of the voltage polarity is due to the change of the position of the coil relatively to the magnetic poles. The amplitude of the voltage depends on the magnetic field strength and is also directly proportional to the rotating speed [1, 2, 3, 4]. If the magnetic field is uniform and the rotation speed is constant, the voltage induced between

the loop terminals is sinusoidal with zero mean value (Fig. 2). Its frequency is equal to the number of revolutions per second executed by the loop.

Each terminal of the loop is connected to a metallic ring. The contacts with rings are made by means of fixed brushes. If the brushes are connected to an electrical load, an alternating current will be established in the circuit.

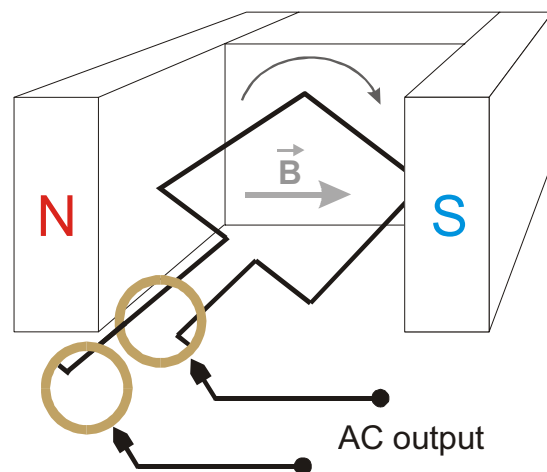


Figure 1. AC generator.

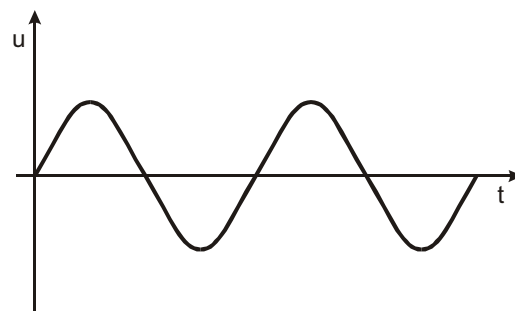


Figure 2. AC generator output.

3. DC generator principle of operation.

The described AC generator may be transformed into a DC generator, substituting the contact rings by a mechanical switch. As illustrated on Fig.3, a simple switch may be done

with a metal ring divided into two isolated halves (segments), which are mounted in the axis. This type of commutator is denominated collector.

Each terminal of the loop is connected to a segment of the collector. When the loop rotates, an AC voltage is induced in the coil, exactly as in the AC generator. But, before reaching the load, the induced voltage is transformed into a DC voltage by the collector (Fig. 4), which works as a mechanical rectifier. The contact segments of the collector move to a different brush each half turn of the loop, keeping a unidirectional current flowing through the electrical load of the circuit [1].

The rotation speed has to be well determined so that the final result is the expected one. As stated before, the rotation speed influences the induced voltage amplitude and frequency.

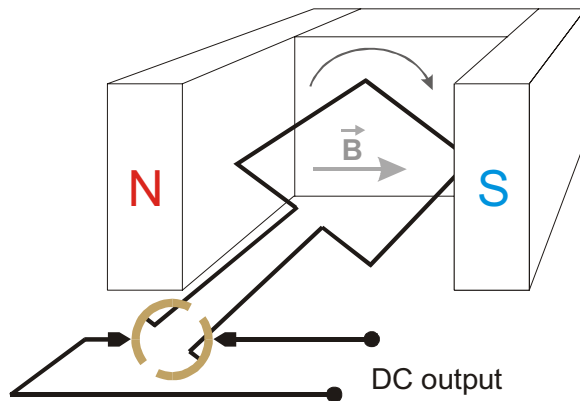


Figure 3. DC generator.

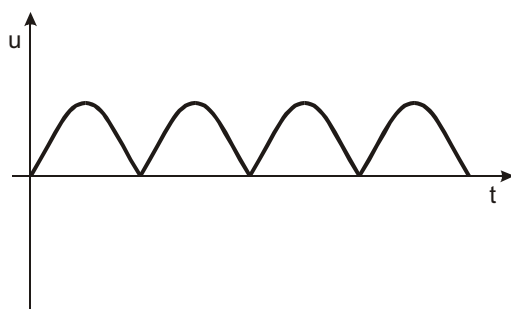


Figure 4. DC generator output.

4. Generator' description

Instead of a simple loop, an iron core coil with 1241 turns of 0,16mm² varnished copper wire was used. The iron core and its windings are shown in Fig. 5.

The magnetic field used to induce a voltage between the coil terminals was provided by a

“U” shaped strong permanent magnet, shown in Fig. 6.

The most challenging part to build was a contact rings and collector unit (Fig. 7). It was made of three printed circuit board disks, coaxially mounted on the rotating axis.

The two smaller disks were kept with their entire conductive layer and were intended to supply the generated AC voltage. The conductive layer of the larger disk was cut into two halves, in order to implement the collector, which mechanically rectifies the generated AC voltage.



Figure 5. Coil with iron core.



Figure 6. Permanent magnet used to induce a voltage in the coil.

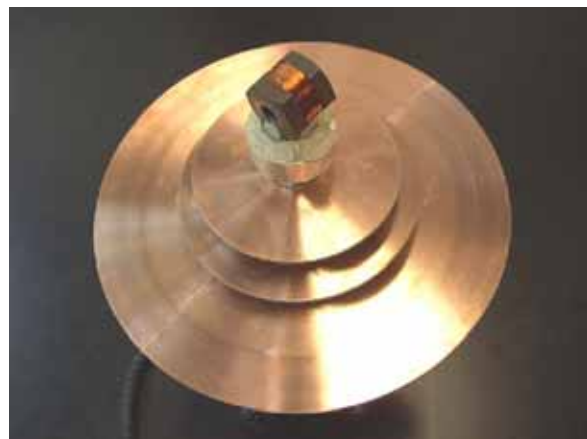


Figure 7. Three coaxial printed circuit board disks with coil on top.

Fig. 8 and Fig. 9 illustrate how the rings and collector unit was built in a more comprehensive way.

In Fig. 8, a cross-section of this unit is shown, revealing how electrical connections were made: one terminal of the coil was connected to one of the smaller disks and to one of the halves of the larger disk (collector); the other terminal was connected to the other smaller disk and to the other half of the larger one.

Fig. 9 shows a panoramic view of the assembly and the generator outputs responsible for supplying alternating or direct current to an electrical load. In order to make the generator operate properly, the DC output brushes positions must be displaced by 180° from each other. The AC output brushes may be placed anywhere on the respective disks.

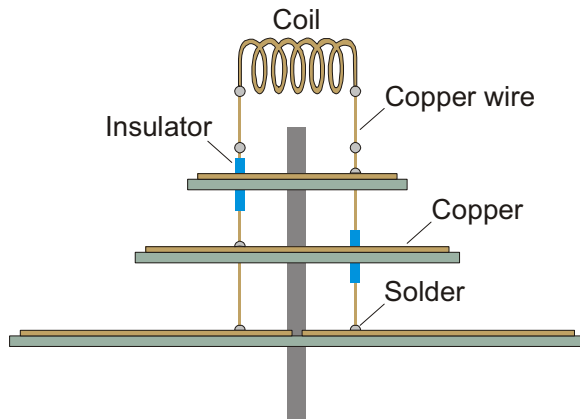


Figure 8. Connecting the coil to the three coaxial printed circuit board disks.

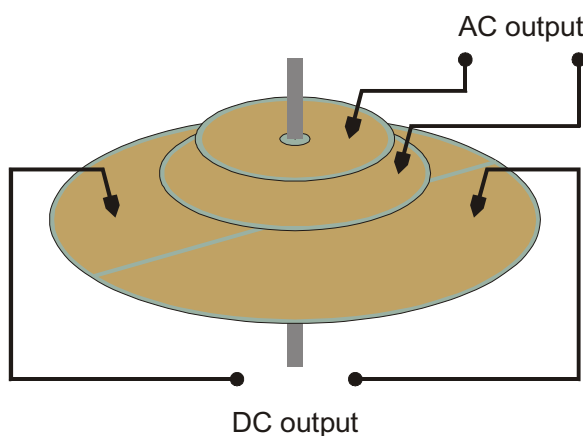


Figure 9. Outputs of the generator.

5. Results

The energy efficiency of this generator was not possible to determine. Although electrical

power could be easily measured, some sort of mechanical power meter was needed and it was not available. There are always mechanical and electrical power losses in the process of transforming mechanical energy into electric energy. Mechanical losses may be reduced by lubricating friction points.

The generator was put to rotate at 3000RPM; the measured induced voltage was 1,2V peak-to-peak, with a 50Hz frequency.

6. Conclusions

Spinning a wire loop within a uniform magnetic field in a convenient fashion induces a voltage between the loop terminals. Rotation speed influences the induced voltage amplitude and frequency. If an electrical load is connected to the loop terminals, a current will be established in the circuit.

The current generated by a basic electrical generator is alternating current. If the generator is intended to supply direct current, it must have a device working as a mechanical rectifier: the collector.

A device capable of generating both AC voltage and DC voltage has been presented. A coil attached to a shaft spins within the magnetic field of a "U" shaped magnet. Three conveniently designed conductive disks allow the electrical load of the generator to be fed either with alternating current or direct current.

This device is very useful to illustrate the principles of electrical energy generation. It also shows the main similarities and differences between AC and DC generators: the working principle is the same for both machines, but the AC generator has contact rings and the DC generator has a collector.

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Perennial Value of Great Physics Laboratory Equipment Collections

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Abstract. *The education in Mathematics, Physics and, Chemistry has been basic for the training of Romanian higher technical staff during all its history in Bucharest, even since "Princely Academy of St. SAVA" (1694). The first Physics and Chemistry experimental laboratory equipment was bought in 1833 and the first Physics Laboratory was active in 1850. For the new campus (Polizu street) of the „National School of Bridges and Roads”, built between the years 1884-6, it had been ordered, to E. DUCRETET scientific equipment company in Paris, a full collection of Physics laboratory equipment (867 pieces, later on developed), intended for course demonstrations and students' laboratory work. The collection was honoured at 1885' Anvers International Exhibition. It played an important role in the development of Bucharest Polytechnics. Today, there are being exhibited in the UPB Museum 17 devices of the initial DUCRETET collection, found by the first author, some of them being also used to teach Experimental Physics to classes of pupils.*

Keywords. Interactive museum, DUCRETET collection, repertory of museums, repertory of collections, competitions for scientific archaeology, scientific equipment restoration.

1. Introduction

The basic sciences education has been fundamental for the training of higher technical staff along all its history in Bucharest [1, 2, 3, 4], even since "Princely Academy of St. SAVA" (1694, Greek language¹) and the first Romanian "Higher Technical School" (1818²).

At the "St. SAVA College" (1832), one of the four offered curricula was in "Exact

Sciences".

The first experimental laboratory equipment for Physics and Chemistry was bought in 1833 and the first Physics Laboratory (called as that) was operational in 1850.

The higher technical education in Bucharest was reorganized many times. Since 1991, the official name of Bucharest Polytechnics has been the University "POLITEHNICA" in Bucharest (UPB)

2. The Museum

In the new campus (Polizu street) of the „National School of Bridges and Roads" (SNPS), campus designed by the French architects Lecomte de Nouy and Bernard Cassien and build between 1884-6, it was reserved a large room (called **MUSEUM**), close to the main amphitheatre, in the building A, for the equipment for the experimental demonstrations during courses and laboratory activities of "élèves".

A full collection of Physics laboratory equipment was ordered, by the Director of SNPS, Prof. Gheorghe DUCA, to the internationally renowned Eugène DUCRETET scientific equipment company in Paris (35, rue des Feuillantines, that time).



Figure 1. Mail envelope to commemorate the 75 anniversary of the 1898 wireless connection Tour Eiffel – Panthéon.

¹ Analogue to Latin language in Western Europe

² This autumn is to be celebrated the 190th anniversary of starting engineering education in Romanian language, in Bucharest.

Eugène DUCRETET (1844-1915), in spite of being a self made man, produced new devices for leading physicists of his time, became an active member of the French Physics Society (more than 30 papers published) and a patent holder (especially in radio communications), a gold medallist of and finally an organizer of universal exhibitions [5, 6, 7].

In November 1897, E. DUCRETET conducted the first experiments on wireless communications between his workshops (street Claude Bernard, Paris) and PANTHEON (400m).

On November 5, 1898, a fully operational equipment was publicly tested under the supervision of the “*Academie de Sciences*” in Paris, the Academy member MASCART confirming the success of the experiments of wireless communications between the 3rd platform of Tour Eiffel and the Panthéon (see Fig. 1) [8]. One year later, DUCRETET equipped the Russian Navy with its equipment (the system “POPOV-DUCRETET”).

The MUSEUM, founded in 1886, was continuously developed, including collections of „POLITEHNICA” achievements.

Some of its exhibits have been exposed at world exhibitions , f. e. at the 1900 Exhibition in Paris was exhibited the model of the bridge build over Danube, at Cernavoda, bridge designed and built, by competition, by Prof. Anghel SALIGNY (one of the participants at that competition being Gustave EIFFEL!).



Figure 2. The found pieces from DUCRETET Collection, at the re-opening of the Museum, on December 3, 2003

During a visit in the Museum, on June 3, 1904, the King Charles I st of Romania accepted that one of his hands be irradiated by a, just

arrived, Radium source, and examined the resultant radiography.

Since its beginning, the MUSEUM was the nursery of new experimental courses which started with the documentation abroad of the Director of the Museum, the acquisition of experimental equipment for teaching and for the practical work of the students, in the new emerging fields. Later on, followed new curricula and eventually, new departments, for instance the “Electrical Engineering”, after comprehensive documentation visits in Western Europe.

The MUSEUM was reorganized as the INDUSTRIAL MUSEUM OF THE „POLYTECHNIC SCHOOL”, in 1927, the Museum’s collections being developed by acquisitions, by exhibits produced in the Museum workshop or donated by professors or industrial companies.



Figure 3. The original Catalogue (1886) of DUCRETET' Bucharest Collection.

The MUSEUM disappeared from documents in 1948, during the soviet’s imposed reform of education in the country. Nevertheless, a part of the DUCRETET Collection has been preserved in the Department of Physics, for experimental demonstrations during experimental courses, until 1960’.

The Museum has been re-opened on December 3, 2003, during Prof. Ioan DUMITRACHE rectorship, on the celebration of the anniversary of 185 years from the first higher technical courses taught in Bucharest, in Romanian language.

There have been exhibited 14 pieces of the DUCRETET collection, pieces found in the Department of Physics of the University “POLITEHNICA” in Bucharest (UPB).

3. The initial DUCRETET Collection

This DUCRETET collection, firstly made out of 867 pieces (the catalogue of which has been found), was exhibited, before to arrive in Bucharest, at the 1885 International Exhibition of Anvers, where received the "Honour Diploma".

The Collection started to be used in Bucharest, since 1886, when the new POLIZU campus was ready.

The Catalogue (Fig. 3, actually an Inventory, mentioning quantities and values) shows that the DUCRETET Collection was structured in the sections:

A 001-148 - Measuring devices and Mechanics
B 149 – 235 - Statical electricity
C 236 – 254 - Magnetism
D 255 – 414 - Heat
E 415 – 493 - Acoustics
F 494 – 709 - Optics
G 713 – 863 - Dynamical Electricity
H 864 – 881 - Telegraphy, Telephony, Photophony.

For a couple of years, following the initial acquisition, there had been ordered to DUCRETET Co., every year, about 20 new laboratory items illustrating newly discovered phenomena (radio, Roentgen rays, radioactivity a. s. o.).

The King CAROL I of Romania honoured Eugene DUCRETET with the title of „Officier de l'instruction publique, de la Couronne de Roumanie”.

By its size, its variety, its actuality, its quality, the high precision of its components made up to date and its reliability, (many of them even today working!), this collection of lab equipment has been unique in Romania and probably, very rare in the world.

The existence of such a Collection imposed the founding in the Department of Physics of the POLYTECHNICS of Bucharest of a mechanical and electrical workshop, initially for maintenance and repairs but lately for building new didactic and research equipment, later on multiplied by specialized companies.

Since the arriving of the DUCRETET collection (1886), the courses of Physics taught to engineering students (freshmen, sophomore and juniors) were experimental ones, until 1960' when a communist reform transformed Physics taught in Polytechnics in a theoretical discipline offered to seniors, only. Since then, the

destruction of the collection was very fast, it being considered financially totally depreciated and disappearing from records.

During its existence, working components of the collection were exhibited at different National Exhibitions.



Figure 4 The telescope of a goniometer (F 539)

The DUCRETET collection was used, since 1890, by the commission empowered to issue recognition and equivalency certificates for the engineering diplomas obtained abroad, commission hosted by Bucharest National School of Bridges and Roads.

The Collection was used for research especially interdisciplinary, training of school teachers, of gifted students attending scientific conferences at POLITEHNICA and of Romanian participants in international Olympiads, as models for didactic equipment built by local and other Balkan companies and research institutes.

The Collection has been a source of progress along all its history.

4. The DUCRETET devices existing in the Museum

The Museum has been re-opened on December 3, 2003 (as "Museum of UPB"), in the old POLIZU campus, but in the building M.

There have been found and exhibited the **Catalogue** (Fig. 3) of the Museum of the

National School of Bridges and Roads in Bucharest, opened in 1886 describing the components of DUCRETET Collection and 14 pieces of the initial DUCRETET collection, all in state of operation, starting with a genuine metre-etalon and its metrological certificate issued in Sevres.

Three more devices have been found, also by the first author, this year.

A dozen of pieces have been found, some in regular use, in student's laboratories (f. e. FRESNEL LENS - Fig.5, ASTRONOMICAL Lunette) but many pieces have been lost, under legal and administrative official coverage of "depreciation".



Figure 5. Large RUHMKORFF's induction coil for 35 cm sparks (G 825)



Figure 6. FRESNEL's lens (F 557)

Table 1 List of DUCRETET exhibits in the Museum of UPB

Code	Name	Cost (RO LEI, 1885)
	Scoala Nationala de Poduri si Sosele; CATALOGUL MUSEULUI; 1886	
A 003	Metre etalon (Ag in brass) with, centimetre, certificate and box	140
A 018	7 ivory spheres to study collisions (recently found)	70
E 432	LISSAJOUS' optical comparison device with electrical excitation	140
F 502	Correcting prism with support	70
F 504	Variable rectangular diaphragm	30
F 505	Set of interchangeable diaphragms	12
F 539	Telescope (recently found; from BABINET's goniometer ?)	375
F 557	FRESNEL's lens (stepped)	300
F 558	Empty prism (for Carbon Sulphide) annex to the goniometer	50
F 617	MUELLER's device for studying fluorescence (with prism and lens)	220
F 645	Astronomical telescope with searcher with tripod	300
F 660	Aplanetic objective (recently found)	115
F 666	Table for polishing glass	42
F 690	BERTIN's set to study polarisation (FRESNEL's arrangement)	35
F 707	Newton's device to generate interference rings	50
G 825	Large RUHMKORFF's coil for 35 cm sparks	1250
G 843	FARADAY's device to study the rotation of the plane of polarization	950



Figure 7. The electromagnet (G 843) used in FARADAY's experiment to study the rotation of the polarization plane. Also, pole heads for other uses.

5. Activities of the Museum of UPB

In the "POLITEHNICA" Museum, where the remains of the DUCRETET Collection are

preserved now, some pieces of the Collection are used for live experimental demonstrations offered to classes of school pupils. Occasionally, some pieces are displayed at HSCI events, in schools.

The Museum of University "POLITEHNICA" plays today an important role in Informal Science Education, in developing Science literacy and in Civic education of its visitors, the Museum officers going to schools and exhibiting at different conferences, contributing to make Physics more appealing and socially relevant to young generations and not only.

6. Conclusion and suggestions for further work

A large number of collections of physics laboratory equipment with great scientific and historical value exist all over the world in museums universities and research institutions. Its scientific and pedagogical value should be explored by universities schools and educators.

We suggest the Hands-on Science Network, with the contribution of pupils, students, teachers, professors, museums and equipment companies, to organise and keep:

- a *repertory of museums of sciences* open to live classes,
- a *repertory* of remains of valuable laboratory *collections*, particularly of those having received important prizes along their history, and to organize, periodically,
- *contests* of pupils and students for finding and

restoring old pieces of physics' laboratory equipment.

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Electronic Resources in Patient Education: Issues and Solutions

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Abstract. *Management of electronic resources has become a critical function for successful patient education. The aim of our project is to promote relevant life style changes in the city of Lviv and the nearby region by direct provision of health care consumer educational services that focus on education of patient and caregiving families in the proper ways of modifying life style to improve cardiovascular health conditions. By accessing the most current sources of health information through access to the Internet; development and dissemination of current information for health care providers and educational materials for the general public on cardiovascular disease and lifestyle modification, improvements in both primary and secondary prevention of cardiovascular disease could be achieved..*

Keywords. Public health, health care, literacy, electronic health information, Internet, patient education, computer network, consumer health information.

1. Introduction

Health literacy is a public health goal for the 21st century. More than ever, the public health employs information technology to promote health and aid in health care – or what can be called eHealth. Health information is obtained

from different contexts including electronic resources such as the World Wide Web and other technologies that now play an increasing role in consumer health. To benefit from electronic health resources, people should be able to use them to their optimal level that requires eHealth literacy which combines “basic reading and writing skills, working knowledge of computers, a basic understanding of science, and an appreciation of the social context that mediates how online health information is produced, transmitted, and received...” [1].

Until 2004, no formal programs in Ukraine existed to provide healthcare education to sick/disabled people and their caregivers to assist in coping with cardiovascular disease and needed lifestyle changes related to this health problem. To overcome the long-term consequences of the lack of such a program, the project “Educating Health Care Consumers to Prevent Heart Disease” was conjointly developed and implemented to introduce formal patient and family cardiovascular health education, disseminate printed instructional/reference materials regarding cardiovascular disease, and take advantage of group learning opportunities and patient-to-patient peer support. The project focuses on integrating information literacy into patient education, accessing the most current sources of health information through access to the Internet and explaining how to interpret

numerical consumer health information. This healthcare project was made possible by a grant from the Bureau of Educational and Cultural Affairs of the United States Department of State (ECA) through a program administered by International Research & Exchanges Board (IREX).

2. Access barriers to consumer health information

Health care in recent years puts greater emphasis on the active and informed consumer that has led to understanding that both access to and adequate comprehension of health information is still a problem. A report from the US Institute of Medicine entitled "Health Literacy: A Prescription to End Confusion" considered the relationship between health and literacy and showed that those with limited literacy skills have less knowledge of disease management and health promoting behaviors, report poorer health status, and are less likely to use preventive services than those with average or above average literacy skills [2].

2.1. eHealth Literacy Model

According to C. Norman and H. Skinner [3] eHealth literacy is comprised of six core skills, or literacies:

- traditional literacy,
- health literacy,
- information literacy,
- scientific literacy,
- media literacy, and
- computer literacy.

The authors use the metaphor of a lily to describe that the petals (literacies) feed the pistil (eHealth literacy), and the pistil overlaps the petals, tying them together. Within the lily model, the six literacies are organized into two central types: analytic (traditional, media, information) and context-specific (computer, scientific, health) [3].

The eHealth Literacy Scale (eHEALS) has been developed to provide a general estimate of consumer eHealth literacy skills for a wide range of populations and contexts. The eHEALS is a self-report tool that can be used by a health professional. It is "an 8-item measure of eHealth literacy developed to measure

consumers' combined knowledge, comfort, and perceived skills at finding, evaluating, and applying electronic health information to health problems" [3].

2.2. Professional and consumer language

Apparently, consumers and healthcare professional speak and think about health-related concepts differently. This vocabulary gap is becoming a more important problem as consumers increasingly explore eHealth resources for their own. Thus, professional language is a barrier to eHealth literacy. Consumers are prefer using a combination of "everyday language", technical terms (no matter if they understand or don't understand those terms) and various explanatory models, all influenced by many contributing factors.

What could be a bridge or crosswalk between consumer expressions and professional terms to aid information communication and retrieval? To address this problem, a concept of a consumer health vocabulary (CHV) was introduced, and "CHV is refers to a collection of expressions, concepts, attitudes, and beliefs observed to be used by most members of a consumer discourse group to communicate about health-related issues..." [4]. Although developing an open-access draft "first-generation" CHV has been reported [4], we had to solve our specific local problem related to the Ukrainian speaking audience and to develop a Ukrainian CHV to be used by consumers in a variety of situations:

- Face-to face communication between patients and physicians,
- Comprehension of information on diagnoses, lab results, personal risk factors, prescribed drugs,
- Submission personal health data in-person and through electronic media,
- Formulation of information retrieval queries to biomedical databases and other information systems that is also a problem to professionals [5, 6].

There are several types of professional terms that are difficult for lay comprehension:

- Difficult general language words which have the same meanings in the professional language (for example, intermittent),

- Medical terms requiring the subject knowledge to understand (for example, diastolic or angina),
- General language words which have different meanings in the professional language (for example, negative (not good) means “absence of a disease condition”).

2.3. Why studies are contradictory

Consumers look for simple certain data to help them being healthy. The problem is that single studies rarely provide such certainty. Instead, contradictory studies appear in the media almost weekly. The general public is becoming increasingly skeptical about advice on health and asks why researchers can't get it right the first time.

The IFIC Review explains the nature of the scientific process which is “a road of discovery”, but “not necessarily a straight line”. It is “characterized by cycles of revisions, conjectures, assertions, and contradictions... In addition, although such cycles often frustrate nonscientists and can contribute to increasing public skepticism about advice on food and health, it is important to understand that science is evolutionary, not revolutionary... Because scientific research explores the unknown, uncertainty is an unavoidable part of current investigations. Only through repeated research and analyses do certainties emerge” [7].

Everybody will agree that consumers read health-related literature to get answers. However the results section of a study provides “data” instead, and these data should be properly interpreted to become answers.

2.4. Understanding numerical data in consumer health materials

Much consumer health information regarding disease or treatment risks and benefits is essentially quantitative in nature that makes it difficult to understand to consumers because the interpretation of this type of information requires significant quantitative skill.

Consumers choosing between health care alternatives need to understand the likelihood of both the negative outcomes (risks) and the positive outcomes (benefits) associated with the available options to make informed choices between them. For example: a women making decisions about hormone replacement therapy to

treat menopausal symptoms must understand and weigh the reduced risk of osteoporosis, cardiovascular disease, colorectal cancer, and Alzheimer's disease against the increased risk of breast cancer, myocardial infarction, cerebrovascular disease, and thromboembolic disease [8]. Even fractions and proportions used to present risks and benefits are challenging for the average person. Furthermore, even highly educated people have difficulty performing the quantitative operations that are commonly required in the interpretation of likelihood (for example, converting from percentages to proportions and vice versa). This shows that “the understanding of information regarding risks and benefits proves challenging for many, if not all, people” [8].

However there is an evidence that “the format in which likelihood is presented—verbal, numeric, or visual—influences understanding” [8]. Below is a brief summary of recommended formats.

- **Verbal format.** Verbal labels be used only to describe probabilities that are unknown or vague. The meaning of a verbal label changes with the outcome being described, particularly if the outcomes range from very low-probability events to higher-probability events. As a result, verbal labels should not be used to describe multiple likelihoods in a single communication. For example, for low-probability risks a 1% chance is labeled high, but when verbal labels are used in a more general context (for example, to describe the likelihood of a false positive test result), a 10% chance is considered a small possibility. The interpretation of these two labels in a single communication presents difficulty for the information consumer that, increases the level of misunderstanding.
- **Numerical format.** Numerical format of probability are better when likelihood can be precisely specified (for example, the likelihood of medication side effects can be precisely specified on the basis of clinical trial results). For numerical representations, frequency format (for example, 5 times out of 100) is most preferred, followed by percent (e.g., 5%). Probability format (like 0.05) is not

recommended as being most difficult for consumers to understand. When frequency format is used to present multiple risks, the size of the comparison group should be held constant (for example, 1 in 100, 5 in 100, and 20 in 100, but not 1 in 100, 1 in 20, and 2 in 10).

- **Visual format.** Pictographs showing frequency representations of likelihood tend to be the easiest format to understand. The only disadvantage is that they take up a large amount of space, particularly in comparison to numerical representations and, thus, may be inappropriate when there are many likelihoods to be communicated or when presenting very low probability events.

3. Educating health care consumers in Ukraine to prevent heart disease

Cardiovascular disease is recognized to be one of the most prevalent world health problems and is of considerable concern in Ukraine. According to the data from the Regional Medical Information & Analytical Center in the city of Lviv, cardiovascular disease is known as the primary cause of death for 62 % of those who died in Ukraine during the year 2007. At present, 10.3 persons from every 1000 of the Ukrainian population die from cardiovascular disease. Overall, cardiovascular morbidity in Ukraine has increased by 9.36 % in comparison with the year 2003. Morbidity of cardiovascular origin not only causes a deterioration of health status and shortened life expectancy but also has increased the rates of related disability, which has negatively affected the quality of life for people in Ukraine.

3.1. Patient education project

Although patients in Ukraine get adequate medical treatment they remain at high risk of continued cardiovascular sequelae because the medical treatment provided is not adequately reinforced by relevant modifications of patient life style in such areas as diet, exercise, smoking cessation, and reduction of alcohol consumption, for example. Most cardiovascular patients have poor knowledge of how to change their behavior using disease specific lifestyle modification in the outpatient rehabilitation period, and

moreover, they seldom are educated to understand that lifestyle modification is a life long commitment toward maintaining or improving their own health.

The aim of our project was to promote relevant life style changes in the city of Lviv, Ukraine and the nearby region by direct provision of health care consumer educational services that focused on educating patient and caregiving families in the proper ways of modifying life style to improve cardiovascular health conditions. By accessing the most current sources of health information through access to the Internet; development and dissemination of current information for health care providers and educational materials for the general public on cardiovascular disease and lifestyle modification, improvements in both primary and secondary prevention of cardiovascular disease were achieved. Additionally, health professionals, social workers and caregivers were trained to provide outreach educational programs about cardiovascular disease prevention in the community at large.

3.2. Patient education program and educational materials

Classes for patients and other health consumers on modification of life style, disease management and social rehabilitation were conducted once a week. Educational presentations to healthcare/socialwork professionals on the design and provision of educational programs about heart disease prevention were conducted once a month. Workshops for socialwork/healthcare professionals and interested community groups in the general public about heart disease and related issues were conducted once a month in Lviv Regional Cardiology Center.

A series of consumer pamphlets titled "Learning Ways to Protect Your Cardiovascular Health" was published and distributed to a selected target audience and mailed to regional health and academic libraries, hospitals and cardiology centers in Ukraine. Additionally, patient handouts are available from the <http://www.ukrcardio.org> website. Initially this series was planned to include 5 pamphlets. However, physicians from Lviv Railway Hospital and specialists from the Ukrainian-American Birth Defects Program provided so much additional material on vital related topics

that this information was formatted as three more pamphlets and included in the printed educational series. As a result, the final printed educational series now consists of 8 pamphlets on the following topics:

- Blood Pressure Notebook
- Ischemic Disease
- Eye Conditions in Hypertension Patients
- Birth Heart Defects. Hypertension in Pregnancy.
- Diabetes in Hypertension Patients.
- Hypertension
- Complementary and Alternative Therapy: Diet and Exercises
- Complementary and Alternative Therapy: Herbal Therapy and Hirudotherapy.

Pamphlets and patient handouts were discussed at patient meetings and at Ternopil Medical Library in particular. The educational program, based on a 5-step strategy was developed and improved according to opinions expressed by physicians from Lviv Regional Cardiology Center and Lviv Railway Hospital:

- 1 - what is a disease and risk factors;
- 2 - what warning signs are;
- 3 - what diagnostics techniques are used;
- 4 - what drugs are administered and why;
- 5 - lifestyle to follow.

3.3. Project evaluation

Questionnaires and evaluation forms were completed by health care professionals and consumers so that the researchers could learn of beliefs and attitudes towards the patient education system and materials developed during the project.

Our analysis of questionnaires and evaluation forms (completed by 162 patients, 43 physicians and nurses, 36 librarians and information specialists, and 23 administrators) shows that overall participant attitude has been positive regarding the educational program on cardiovascular health.

All respondents considered attending patient classes to have been a very useful adjunct to the drug therapy.

All participating physicians reported that they recommended the pamphlets and handouts to their patients.

Several physicians and information specialists (12 people) joined the project team to present patient classes and develop the pamphlets.

A focus group of patients (20 people) demonstrated an improved level of cholesterol, weight and exercise activity and better understanding of risk factors related to lifestyle (diet and smoking).

3.4. Patients' attitude

A brief review of the project evaluation questionnaires indicates that:

- (1) all patients know a normal blood pressure level, but only 20 % patients know a normal cholesterol level;
- (2) respondents highly rated the utility of the educational pamphlets (4.9 score out of a 5 point scale), but they are slightly less positive about the comprehensibility of the pamphlets that were developed (4.1 score out of a 5 point scale);
- (3) healthcare professionals indicated that a formal patient education system makes their work less time-consuming and more effective provided that patient learning groups are kept small in size, otherwise patients indicated that they prefer speaking to a doctor individually during a healthcare visit.

4. Conclusions

Implementing improvements will be the aim of our continued effort after initial project completion to include the development of additional more focused educational materials and improvements to the delivery of the educational program itself based on the questionnaire recommendations noted above. We think that the educational project could be improved if in future:

- (1) a cholesterol-related class would be added to the program;
- (2) pamphlets would be peer-reviewed for readability and comprehension;
- (3) training in understanding and interpreting health-related numerical information would be added to the program;
- (4) patient groups should be limited to 5-7 persons instead of the typical 12-15 members attending each class during the initial project.

Attending the patient classes has become very popular among the patients in Lviv Regional Cardiology Center but it remains important to keep each class size small for improved communication.

Both Ukrainian health care professionals and consumers have responded positively to the idea of continuing these patient education services. The increasing number of participants in this project is further evidence that the initial conjoint cardiovascular project we have described has dealt with important topical and meaningful health issues and concerns of both the healthcare provider and the consumer populations in Ukraine.

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