

“Softsciences”: a Portuguese project on computers for learning basic sciences

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ABSTRACT

We present the «Softsciences» project, a common action undertaken by the Portuguese Physical, Chemical and Mathematical Societies since 1991. Its goal is creating, producing and distributing software for learning Science and Mathematics, at the middle and high school levels. We describe some products we have made and our future plans, for both off- and on-line edition. Experiences like ours promoting a synergy of secondary and tertiary schools to produce discipline-based computational materials are effective means for improving science education.

Keywords: Software, Education, Basic sciences, Physics and Chemistry.

1. WHAT IS?

Relatively small and less developed countries like Portugal offer an interesting ground for observing the dissemination of computers in education.

The Portuguese Physical, Chemical and Mathematical Societies have set up in 1991 a common action for creating, producing and distributing software for learning Science and Mathematics, especially at the middle and high schools levels. The action was called "Softsciences", with the obvious intention of making somewhat "softer" the learning of the so-called "hard" sciences but without making concessions on the rigor side. The Ministry for Education and the recent Ministry for Science and Technology have been supporting our program. The action started from the conclusions of the First Portuguese Meeting on "Computers for Chemistry and Physics Teaching", at the University of Coimbra, which gathered in 1990 leading international experts (Edward Redish - Maryland, Joshua Schwartz - Harvard, and Daniel Cabrol - Nice, France) and hundreds of teachers. That meeting has benefited from the presence of since then, more than twenty educational programs on Physics, Chemistry and Mathematics have been produced and widely distributed in schools.

In our opinion, some of the most interesting applications of computer in science teaching have been developed for college teaching, mainly for freshmen [1] and [2]. Trying to follow the spirit of those initiatives we invested in producing software for secondary schools where needs in adequate computer-based materials are well-known.

The pedagogic and scientific quality of the programs has been assured by peer review. All of them are in agreement with the more recent curricula, although some have a somewhat broader scope, trying for instance to develop the layman's interest in science and to increase the popular understanding of science. Around a dozen university and high school teachers and many students strove to work in the project.

In 1997 all programs were brought together in a CD-ROM, under the suggestive name "Omniscience 97". As a bonus, a multimedia program was included ("Periodic Table Multimedia") as well as Web pages with abundant teaching and learning resources on Sciences and Mathematics. "Omniscience" has a home page with the web address: <http://www.fis.uc.pt/~softc/omni98>, through which new materials are being offered. A copy of the CD-ROM was given to all (around 1500) Portuguese middle and high schools.

2. GUIDELINES

Our main goal is helping pupils and teachers to learn and teach science in a heuristic and even funny way (one of the authors has written a book entitled "The Fun of Physics", which was a national best seller [3]). We think that, notwithstanding the controversy on replacing real by virtual environments, some problems may acquire a new type of understanding from convenient computer simulations. One good example is our program "Relative" on relative motion: We have on the screen two frames, one fixed and one moving (for instance, a car with a ball) and we observed at the same time object motion in the two frames of reference (Figure 1).



Figure 1 - The program "Relative".

On the other hand, we are aware that computers in science teaching are not the solution to main pedagogical problems, in particular they are not the elixir to educational success [4]. Anyway, the contribution of computational strategies to a new and more effective science teaching [5] can not nowadays be forgotten in curricula development and implementation ([6], [7] and [8]).

3. TYPE OF PROGRAMS

We think that, notwithstanding the controversy on partially replacing real by virtual learning environments, some problems may acquire a new type of understanding from adequate computer simulations and multimedia tools ([9]).

The traditional classification of educational programs into distinct "types" is no more useful. Each of our programs may have, for example, a simulation character but also a database content, tutorial aspects, play elements, etc. Whenever possible, we have tried to combine these different forms and functions although most of the programs are simulations.

University students programmed almost all software. That justifies the non-professional presentation of some of them. The interface of our first programs (made six years ago for MS-DOS using languages as Pascal, Basic, etc.) is naturally more poor than the modern ones (using Borland C++, Visual Basic and Delphi). Pedagogic arguments and scientific accuracy are essential ingredients in our software development and testing, since we consider them to be more important than, for instance, design. The oldest programs, in spite of their poor interface, keep interesting and are still being demanded and used by many schools. That interest may also be explained by the lack of up-to-date hardware by schools. On the other hand, the most recent productions (e. g. the "Multimedia Periodic Table" - Figure 2) are Windows-based and have a commercial competitive look.

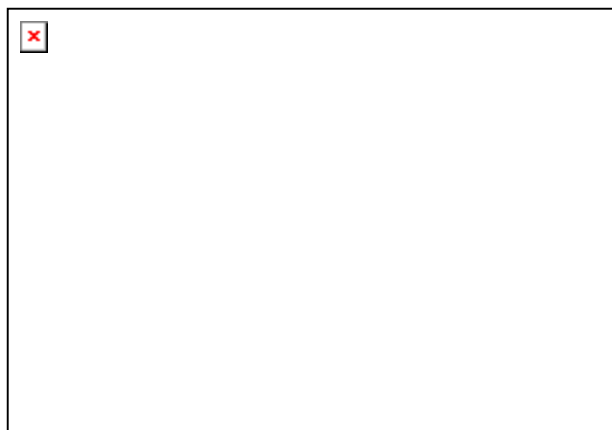


Figure 2 - The program "Multimedia Periodic Table".

4. THE IMPORTANCE OF MANUALS

All programs are presented with a manual, which contains not only technical specifications and instructions, but also educational suggestions for exploring the program addressing the needs of both teachers and pupils. In some cases, ancillary materials (e.g., biographies, curiosities, and related topics) are enclosed.

The need for good pedagogical quality in designing software for science learning is generally recognized [10]. We know, from our own experience on software production and evaluation, how bad the effect of using a fancy computer program may be when its learning content is deficient or inadequate. For instance, one of our goals in software design has been to reduce the "speed" of many pupils when using computers. For that, user's protocols suitable to step-by-step learning have proved to be useful. Our latest programs contain a «guidebook» with questions and challenges and we have just finished a generic tool to build on-line exploration manuals.

5. TOGETHER WITH SCHOOLS

The "Softsciences" project was born in an university environment, promoted by faculty with interest in new forms of teaching and learning. Its software titles, however, are almost exclusively intended for middle and high schools. Some of the programs are related to M. Sc. theses on Science Teaching with computers, written up by high school teachers (that is the case e.g. of "Relative"). Two Ph. D. theses on Science Teaching are also under way (on "Chemical Equilibrium" and on "Virtual Water"). All our programs are co-authored by high school teachers.

This kind of collaboration is not always easy (the main difficulties are geographic spreading and time availability). But we try to keep that alliance since we think that it is the answer to the real necessities of schools. Besides the involvement of undergraduate and graduate students, we have tried, with no big success so far, to involve in software development senior high school pupils (we have organized two «National Science Software Contests» with limited participation).

6. SOFTWARE DISTRIBUTION

Portugal has had in the eighties a national program for promoting computers in schools (project «Minerva»). This program was well thought and has been referred abroad to as a model [11]. In the real life of schools, however, there were no long-term effects especially in terms of dissemination and application of educational programs inside classrooms. The production of software was indeed supported but there is no report of extensive and fruitful use of them. "Minerva" finished in 1992 and only in 1997 a new program has been established: it was named "Nonius", from the Latin name of the XVIIth century Portuguese mathematician Pedro Nunes [12]. This program does not seem to be amplifying significantly the efforts, like our own, already going on in the field.

In face of the school needs, we have elected pragmatism as our keyword. We wanted to make it easy for the pedagogical community to acquire and use our programs. We have been sending to all Portuguese secondary schools a catalogue with the available program title. Mail order has been working from the Portuguese Physical Society offices and a presence has been assured at many national Science Education meetings.

7. SHORT DESCRIPTION OF THE PROGRAMS

In the following we present a short description of some of our programs
(see <http://nautilus.fis.uc.pt/~softc> for more information):

- "Kepler", simulations of planetary systems with one star and one planet, two stars and one planet and one star and two planets.
- "Le Chat", graphic illustrations of chemical equilibrium. The demonstration version of the latter may be downloaded in http://nautilus.fis.uc.pt/~wwwqui/equilibrio/port/eqq_lechat2.html.
- "Millikan", a simulation of a famous experiment: that done by Robert Millikan to measure the electronic charge. The English beta demonstration program may be downloaded in http://www.fis.uc.pt/~spf/soft_c/soft09_i.htm (Figure 3).



Figure 3 - English version of "Millikan".

- "Relative", a program on object motion in different, inertial or accelerated reference frames (Figure 1). It is easy to provide different scenarios from postcards.
- "Energy", a strategy game which allows for the management of Earth's energy resources during the next 150 years.
- "Periodic Table", a very complete database containing information about the chemical elements. A English version of our periodic table in is available on-line (Figure 4) (<http://nautilus.fis.uc.pt/st2.5/>).



Figure 4 - English version of periodic table on-line.

- "Throw!", a simulation of javelin motion under the forces of gravity and air resistance.
- "Zero", a powerful tool to help teachers creating and correcting multiple choice tests. We think that this kind of programs is adequate to attract teachers to the use of new technologies.

- "Angles", a program for learning elementary trigonometry, by explicit examples.

8. PROJECTS IN THE WEB

The potential of the Internet for teaching and learning is enormous [13]. Recently, the Portuguese Ministry for Science and Technology has finished an action for placing Internet connected computer at the library of every Portuguese middle and high school.

We are already providing educational contents that are available on line to schools and homes. A lot of information on "Softsciences" (<http://nautilus.fis.uc.pt/~softc/isoft>) is in the Web. Everything is written in Portuguese to make life easier to Portuguese teachers and pupils, but we are translating into English some of the material. The oldest programs may be free downloaded. We have developed, as a framework for our materials, the "Omniscience" homepage, which is connected to the above-mentioned CD-ROM. It encompasses all our software titles and educational materials (<http://nautilus.fis.uc.pt/~softc/omni98>).

A part of "Omniscience" is called "READ Sciences" (http://www.fis.uc.pt/Read_c/Read_c.html): it includes science resources (e. g., receipts of science experiments, a database with almost all Portuguese books on popular science, lists of the best science videos, etc.). The educational impact of this project is noticeable not only in Portugal but also in Brazil. Another of our pages is "Nonius" (<http://www.mat.uc.pt/~jaimecs/>), offers not only a lot of links to the math educational world but also many items of our own. Our most recent feature are educational resource Web pages for Chemistry and Physics. (<http://nautilus.fis.uc.pt/~wwwqui>).

9. FUTURE

The project "Softsciences" is currently finally new versions of "Le Chat", "Zero" and "Multimedia Periodic Table - in English". We are shipping the CD-ROM «Omniscience 98», an updated version of the previous disc. We would like to increase our international exchange and, in that context, we have been in the Ibero-American Meeting on Computers for Science in Brazil in 1998 (www.penta.ufrgs.br/ribie98).

We keep improving and increasing our Internet pages. In the future, more attention will be paid to the Internet in software design (for instance, programs being developed will include direct links to the Web to load new example files).

At the present we are working more and more for the Web. One of the most recent projects is called «Molecularium»: this is a set of molecular simulations for teaching Physics and Chemistry to pupils from the 8th grade to college (an example is available in <http://nautilus.fis.uc.pt/~cec/molecularium/solidovapor/iodo.html>, Figure 5) [14].



Figure 5 – An example of the «Molecularium», iodine sublimation on line.

These simulations refer to thermodynamical concepts (pressure and temperature), physical states of matter aggregation (solids, liquids and gases) and transitions between them. They are going to be linked in a coherent way to stereoscopic video images of real objects (see <http://www.science.widener.edu/molecule3d/>), in order to smooth the transition from the macroscopic to the microscopic worlds.

Another project we are working in is “Virtual Water”, a virtual reality program which is a multidisciplinary work involving computational simulation of physical and chemical systems, computer graphics, and science education [15]. The focus here is on 3D visualisation in quantum mechanics and molecular dynamics.

We have a Competence Center to provide formation and support to teachers and, at one time, new opportunities to respond to them. This is giving us a better contact with school problems and needs.

The feedback we have received allow us to conclude that the reception of our programs has been very good. More pupils are being attracted to science with the aid of the computer and by other means. They are having new forms of interactions with their teachers and peers, in the same classroom or far away in the planet. They are entering the realm of science and getting engaged to it!

10. HOW TO GET THE PROGRAMS?

Our CD-ROM (Portuguese version only) is available from the following addresses:

Mail: "Softciências", Departamento de Física da Universidade de Coimbra, 3000 Coimbra, Portugal.

Phone: 351.239.410600

Fax: 351.239.829158

Internet: <http://nautilus.fis.uc.pt/~softc>

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