Revision of prerequisites: ICT tools

Albert Gras-Marti (agm@ua.es), **Julio V. Santos**, **Mario Pardo, Joan A. Miralles, Adolfo Celdran**, **Marisa Cano-Villalba**

Departament de Fisica Aplicada, Universitat d'Alacant,

E-03690 Sant Vicent, Alacant, Spain

Abstract

This is a report on the use of ICT tools to encourage subject matter revision of prerequisites for Science students. As part of a program of Teaching Networks at our University, we have developed a project to help students of Introductory Physics with the prerequisites in Physics and Mathematics (for Chemistry and Biology majors). We use a digital platform to provide periodically tests which the students must take before certain deadlines. Both multiple choice and open answer questions are posted. Encouraging results of the project in terms of students' learning and prospects for the future are discussed.

Keywords: Internet Physics education

1. Introduction

In teaching undergraduate Physics one finds routinely that the students do not seem to know, or have forgotten, very basic concepts, definitions, formulae, etc., of Physics and Mathematics. This lack of basic knowledge has certainly been addressed in previous High School or even undergraduate courses, and is necessary for a good understanding of the current subject. This situation cannot be dealt with some extra material put into the regular lectures, due to rather dense syllabi. And the process of updating and catching up with a previous knowledge base has to develop during the semester(s) that the course lasts. This project aims to bridge this gap. We have undertaken a research program that takes pedagogical advantage of Information and Communication Technologies (ICT) in our teaching-learning environment as tools to encourage subject-matter revision and updating of prerequisites in Physics and Mathematics.

The project was prompted by a newly introduced scheme in the University of Alacant that set up a number of Research and Training Teaching Networks (RTTN) on Campus. An RTTN is a community of University teaching staff (usually with 5 to 10 members) set up for the analysis, reflection and discussion of some aspects of their teaching and tutorial practices, with the objective of improving the quality of student's learning (Day, 2002). There are many examples of the use of computers in education (Linn, 1998). Inspiration for the project came also from a web site with a pre-diagnosis test of Mathematics for Physics students (Forinash, 2002). Recent articles on ICT issues in Education have recently appeared in AEQ: Burkle and Sayed (2002) and León-Rojas et al. (2002).

The following section deals with the project background, in terms of students' needs. Sect.3 describes the project, and results and analysis are given in Sect.4. We finish up with some conclusions and a few proposals for future action.

2. Students' background

We decided to set up an RTTN in order to address various problems detected over the years while teaching Physics for students majoring in Chemistry or Biology. First, students' failure rate in many courses, including ours, is exceedingly large (the percentage of passes is usually below 30%). We are also aware of the limited impact of traditional teaching practices on students' understanding and mastery of the subject matter. In fact, Santos Benito et al. (1996 and 2003) analyzed the scope of student's knowledge some time after a course is over. Even for simple basic questions they find a dismal percentage of correct answers (typically between 10 and 30%) over a wide spectrum of fields of elementary Physics, both for Medical students and for students majoring in Chemistry, Optics or Teacher education.

Furthermore, our lecturing is still adjusting to the ever-reducing number of lecturing hours that recent curricular reforms have left for teaching Physics service courses. The available classroom time for Physics in the Chemistry degree, for instance, is only one-third of what it was 10 years ago. So, we have to focus on the wide-ranging contents that the syllabus determines, and have no time to go through a systematic revision of prior basic knowledge that the students should have in order to adequately follow the subject matter.

The limited knowledge base in Mathematics and Physics of students entering the University is another worry. A sizable fraction (30-50%) of first-year students have not chosen to study Physics in the upper High-School years. And even those students taking up the University entrance exams that did have Science in High School do not reach, on average, a pass in Chemistry, Physics or Mathematics (Canals and Hernandis, 2001). Still, the averaging in the grading procedure, where all subjects taken up in High School are included, allow students to start a scientific degree.

So, our students enter the University courses, effectively, with very limited or non existent background of Physics and Mathematics, and the usual teaching habits for undergraduates do not cater for their needs. This, combined with other factors (like student lack of motivation, poor work habits, etc.) results in an intolerable failure rate and in poor overall learning.

3. The project

We hypothesized whether students could improve their grades (and, more importantly, their mastery of the materials covered), if we devised a procedure that required students to study specific extra materials and then take some tests, in an easily accessed system via Internet. Thus, the project addressed three main questions:

1. *Can one use ICT tools to encourage the study of prerequisites in Physics and Mathematics and thereby improve students' performance?*
2. *Do students recall sufficiently basic theory and practice of previous undergraduate courses?*
3. *Are specially designed extra activities (studying guides and testing of prerequisites) capable of motivating students more and lead to better learning outcomes and to more positive attitudes towards our subjects?*

The project is an example of an Action Research in the classroom (AR-home, 2002). Research actions, although lacking the formal structure, the duration and the more widespread objectives of a research project, may have a large impact in terms of improved teaching practices. The aim of the project is to orient students so they may refresh the prerequisites (foundations) which are needed for a given subject. These prerequisites are not included in the syllabus for the subject matter. We use a digital platform in order to provide tests periodically which the students must take before a corresponding deadline. Prior to that, hand-outs are delivered with the contents of the test, and the references where the corresponding matter may be recalled (or studied!). A test is taken every other week (7 tests in all), so students have sufficient study time prior to each test. Some results derived from the literature in Physics Education Research are taken into account in designing these tests. In particular, special attention is paid to the well-researched students' misconceptions in introductory Physics (for example, Furio and Guisasola, 2001).

We have used the Micro Campus (MC), a teaching-oriented platform developed at our University. It is an Internet-based service that complements teaching and administration. It aims at influencing the quality of teaching by enriching the relations among teachers and students, and overcoming time/space limitations.

The platform includes typical administration and teaching options: one may obtain class enrolment lists, post notices for the class, answer tutorial questions, set up and moderate discussion lists and chats, etc. Two of the more interesting options of the MC as a teaching/learning tool, the Tutorials and Frequent Doubts, have been described elsewhere (Gras-Marti and Cano-Villalba, 2001) and were the basis for part of the present work. In this project we are interested in the MC option of taking tests. Three different kinds of tests are implemented in its present configuration: 1) multiple choice test, where the lecturer has flexibility in the number of answers and grading per question; 2) open answer tests, where students must respond concisely to questions; 3) material-forwarding tests, a dedicated FTP facility designed to submit essays, graphics, and other student-generated material. The first two types of tests have been used here. The MC implements time-constraints for the duration of the tests (a message is sent when only 5 minutes are left) and the possibility that each student has only one opportunity to take each test.

The complexity and importance of tests in the teaching/learning process is stressed in the Physics Education research literature (Alonso-Sanchez et al., 1995), and we know that changing a single element of this process is certainly not sufficient to have long lasting effects. So this prerequisites-testing project is just one more tool that should be incorporated fully into the syllabus and used as a lever towards achieving improved learning.

Three groups in the Chemistry degree were involved, namely, two in Physics I (first-year course, 115 students) and one in Applied Physics (second-year course, 45 students). Students participation was voluntary but they received (extra) credit towards their final grades. The two first-year groups were taught by different lecturers. This allows for cross-checking. For second-year students we wished to check also how much of the material covered when they were first-year students they still knew (or remembered easily, after some refreshing), and which is necessary for the present course.

We have also included occasionally some questions about material outside the announced plan for a test. This served two purposes: to check the degree of long-term learning of some basic concepts, and to check whether students were studying regularly the subject matter discussed during the lectures. One interesting extension of the project, that we had not anticipated, was to put up tests similar to the final exams. We prepared four sets of these tests for first-year students.

So, we have been able to investigate a variety of teaching/learning scenarios:

- Prerequisites for first-year Physics (recall from High-School Physics).
- Prerequisites for second-year Physics (recall from their first-year Physics).
- Degree of regular study of the current subject (unannounced questioning).
- Final-exam models.

4. Results

Students' participation was reasonable. Eighty percent of first-year students, and 65% of second-year students have voluntarily participated at some point in the testing project; participation increased as weeks passed (except at the end of the semester).

We distributed a Lickert-scale questionnaire asking the students for their opinion about the use of the MC as a teaching complement. Each question was marked between 0 and 10 points (10 = a lot). Some questions and the corresponding average of students' answers are as follows: *Interest of the activities performed during the project (7.9); Do you think that the MC testing scheme helps in the teaching/learning process? (8.0); Should we increase the amount of tests? (7.5); Would you like to have these kinds of tests in other subjects? (8.5)*. So, the overall degree of satisfaction of the students with the project is rather high. Note also that students would rather have this scheme implemented in other subjects also.

Student's opinions about the testing procedure were also obtained via interviews and questionnaires. These clearly show that students can be motivated by the use of TIC, they adapt readily to the new rhythm of the classes, and they feel that time devoted to the testing project is well spent and profitable. Here are some specific comments: "The pros are many because I prefer to use the computer while I am learning..."; "One point in favor of testing in the MC is that attention *must* be kept at all times during the test..."; "...it is the first time that prerequisites for a subject are taken care of explicitly".

A bonus of the MC platform used for testing is that after each deadline is over students have a number of tests available, with the corresponding correct answers, that they may look up during the preparation for final exams. This was repeatedly stressed by the students in the polls conducted.

To the question “What are the advantages of the project?”, students responses were: “It is a different way of learning”; “It is a more interactive process: the results of our multiple-choice test are known immediately, as well as the correct answers”; “The scheme forces us to study Physics and Mathematics more regularly”; “It helps a lot in understanding a difficult subject like Physics, which many of us do not particularly enjoy.”

To the question “What are the disadvantages of the project?” one student replied: “We had to work harder! In some cases, and due to our heavy load in laboratory sessions during the semester, we had difficulties in appropriately preparing for the test”. Obviously, the project meant extra efforts for the students in an already overloaded syllabus.

According to the students’ opinions, there are various “pluses” of taking tests on the computer: “Students’ concentration increases, and the urge to look around when trying to get inspiration during the exam diminishes”; “A student may start each part of the exam at his/her own pace”. For others, however, the experience was “...very stressful, specially because I do not type quickly enough”.

The basic deficiencies in the students’ scientific and mathematical background, mentioned in Sect.2, are easily observable in the prerequisites tests. For instance, many of the students’ answers (often over 50%) were wrong about very basic mathematical formulae (like the areas and volumes of simple geometrical figures) or operations (like simple derivatives). The same holds for elementary concepts in Physics. However, a repetition of some of these questions, in latter tests, yielded more correct answers.

In general, the results obtained by the students on the different tests performed along the project were rather low on average (below 50%). There were, of course, the occasional students who consistently did well in all the tests, but they accounted for less than 10% of the total ensemble.

We have also tested the quality of second-year students’ recall of topics studied the previous year. Second-year students took, in some cases, the same tests as first-year students, with questions covering first-year Physics. In comparing the results, the second-year students did clearly better (up to 50% better) than their first-year counterparts. However, the overall grades achieved by second-year students were far from ideal (the average grade was 60%, even though rather basic questions were tested).

We have checked the effect of prerequisite testing on students’ performance in the final exams. Eighty percent of the students who had taken more than 4 tests passed the finals, whereas only 10% of those who took none or a few tests passed. Of course, students’ motivation and attitude towards the subject have an effect here. Clearly, those students who did better in the sample tests for finals did well also in the final exams.

Also, in comparing this years' final results with last years', when the prerequisites tests were not implemented, the average class marks increased by more than 30%, and the distribution of grades noticeably increased.

5. Conclusions

Encouraging students to study prerequisites for a given subject can be done using ICT tools and makes an impact in their learning. This project has been positively evaluated both by teachers and by students and the quantitative results are encouraging. We have obtained a good amount of information about our students, both with regards to their knowledge of prerequisites in Physics and Mathematics, and the knowledge acquired during the course. The increased teacher-student interaction is also a rewarding experience that is facilitated by the use of ICT tools. After this year's experience with the project, we are convinced that the scheme may be adequately expanded to address even those students who have *not* taken enough Physics courses before entering the University.

Furthermore, the need has emerged to reorganize the syllabi and integrate more efficiently the contents and the time-table with the options brought about by the MC platform (tests, tutorials, FAQ-lists, etc.). One may also open up the scope of this project to try and show in some detail more connections between the subject matter they study in Physics and the implications for the subjects they are majoring in. This can be easily done via the tests. We would then expect students' appreciation and motivation towards our Physics courses to further increase.

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References

Alonso-Sanchez, M., Gil-Perez, D., Martinez-Torregrosa, J. (1995). Evaluation activities coherent with teaching physics as guided research, *Revista Enseñanza Fisica (Argentina)* 8, 5-20.

AR-home (2002). Action Research Home web site, http://www.scu.edu.au/schools/gcm/ar/arhome.html (accessed 1-6-02).

Burkle, M. and Sayed, Y. (2002). Integrating ICT in Higher Education: ITESM. *Academic Exchange Quaterly* 6 (3) article 2057-1w.

Canals, A., and Hernandis, V. (2001). *Numerus clausus* and student failure in Chemistry degree, Curie Digital 2001, 2, 38-40, in http://www.curiedigital.net (accessed 15-3-02).

Day, C. (2002). http://www.nottingham.ac.uk/education/staff/cday.htm (accessed 14-4-02).

Forinash, K. (2002). "Math Review - Algebra - Trig: A quiz/review of math you need to know P201/P202", http://physics.ius.edu/cgi-bin/quiztest.cgi?mathreview (accessed 11-6-02).

Furio, C. and Guisasola, J. (1998). Difficulties in learning the concept of fields, *Science Education* 82, 511-526.

Gras-Marti, A., Cano-Villalba, M. (2001). *The virtual campus as a teaching tool*, International Conference Physics Teacher Education Beyond 2000, R. Pinto, S. Surinach, Elsevier, Paris (ISBN 2-84299-312-8), 717-718.

Leon-Rojas, J.M., Masero-Vargas, V., Morales-Morgado, M.M. (2002). ICT-based Borderless Combination of Alternative and Augmentative Communication Systems. *Academic Exchange Quaterly* Fall 2002, 6 (3) 85-90.

Linn, M.C. (1998). *Educational Technology*, Handbook of Science Education, Kluwer Academic Publishers, New York, 265-420.

Santos Benito, J.V. and Gras-Marti, A. (2003). Physics knowledge among University students-Influence of Education reform. *Revista Electronica Enseñanza Ciencias (to appear)*.

Santos Benito, J.V., Martínez Miguel, A., Giner Caturla, J.J. (1996). Profile of physics students entering the University *(unpublished)*.

agm@ua.es

Mailing address: A. Gras-Marti, DFA-Ciencies, E-03080 University Alacant, Spain

Albert Gras-Marti: Full Professor Applied Physics. Research career: Atomic Collisions in Solids, Physics Education.

Julio Santos: Professor Applied Physics. Research in Physics Education; author of textbooks in Optics, Applied Physics.

Mario Pardo: Professor Applied Physics. Main research in Optics. Ex-vice-rector of student affairs.

Joan Miralles: Full Professor Applied Physics. Research in theoretical Astrophysics, author of textbooks in Astronomy, Basic Physics.

Adolfo Celdran: Professor Applied Physics. He worked in video for education, director of Media Workshop. He writes poetry, songs.

Marisa Cano-Villalba collaborates in educational research in the Department. Interests: use of computers in education, health issues.