

Interactive Tutorial for Training Physics Students in Their First Year at University

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Abstract: This paper describes the application of new technology to solve a specific problem that is present in all levels of the learning process. We refer to the lack of knowledge related to previous courses. This is specially important in the first year at university and requires an imaginative solution using all tools available. We propose an interactive tutorial as the best solution to this problem. It allows the individual treatment and can be used as much time as the user needs. The effectiveness of the tutorial depends on the appropriate diagnostic of the problems the user has, and on an attractive way to solve these problems. The tutorial is structured in different levels and a fictional character conducts the user through the tutorial.

Key words: New technology applied to education, tutorials, interactive learning.

1. Introduction

In our daily experience as physics teachers in the first Technical Industrial Engineering course we have verified two facts in relation to the level of knowledge that students have when they arrive at University.

- A. In many cases students have such a lack of basic knowledge that they can not understand the new concepts.
- B. Every student has his own problems, depending on their previous history, and it is very difficult to find them.

Fact A is related to the fact that, in the first year of university, students come from different previous studies. Some of them have followed several physics courses and have a good level, especially in mechanics; others have only had one physics course, three years before, and do not remember the basic concepts. However, the most important problem we find is the low level in mathematics. They do not understand what a vector means or how to solve an equations system or a differential equation of first degree with constant coefficients.

Computers are now a common instrument that is present in all the aspects of our life. At first the scientist saw in them a valuable tool for solving calculus problems. Later, the increase of their numerical and graphical abilities made them essential as much in research as in the professional work in the scientific and technological field. Internet has opened a window to the communications systems and all society has entered in the computer world.

In this context, teachers have the opportunity of taking advantage of the pedagogical possibilities of the new technology[1,2,3]. A well designed program will attract the attention of the student and will have a motivating effect over the new generations of young people that are used to the multimedia systems. The interactive tutorials are part of a wider experience that affects our teaching methodology. We have performed some changes in evaluation by approaching the continuous evaluation system, unusual at university level. We try to establish connections between theory and reality by showing experiments in lectures similar to those included in the Mechanical Universe video tapes[4]. We try to obtain the maximum benefit of computers by using simulation programs, PowerPoint presentations, 3D animations, distance learning, forum, world wide web sites, ...

We think that the learning process is very complex and there is not a only one solution to give the key to solve all the problems related to it. In every level of the teaching process there are some topics that present special difficulties and require an especial effort from the part of the teacher. Besides, we also find some problems related to the deficiency of his basic knowledge that make it difficult to progress in the present level. This is specially important in the first year of university because the students come from different previous studies. In the present work we analyse the way which the interactive tutorials can lead to the adaptation of the student to the new media, when they start at the university.

2. Problem to solve

First of all to say that we are not trying to perform a standard physics course because the aim of the work is to discover the subjects students had to know but they do not know. This is an old problem and the institution we

belong to has tried solutions of a different nature like extra courses (previous or during the normal course) or books written specially for this target. The problem that special courses present is that teachers have to solve many problems in a short period of time, and on the other hand, students can not have a personalised treatment because the variety of problems and the variety of students is enormous. The dearest benefit these courses is that they allow students to establish a first contact with the University making the new media more familiar for them. The books or material for study present a similar problem. Without a guide, the student can not find where their problems are and still less are able to solve them. In general the student has the sensation that there is not a good relation between the invested time and the obtained result.

The new technology opens a new field of applications in education through interactivity and non linearity that favours a learning by individual discovery. The tutorial course provides individual treatment in two different ways: the selection of the content and the time necessary to reach the level the user wants to. If navigation through the program is well designed the user is able to pass quickly through the topics he knows and find his own lack of knowledge. The tutorial allows the use of different tools like text, diagrams, graphs, photographs, video, 3D animation, test, that results in a rich material of study it. Is for these reasons we think that the tutorial could provide the best solution to this problem.

The first thing to do is to define the object of the program: for whom it is directed, for what it is necessary, when and for how long it is going to be used, what is the subject matter to treat and how deep it will be treated.

The program is directed at students in the first year of university that have difficulties to following the normal rhythm of the physics classes due to problems related to previous courses. Although the subject is related to high school we can not forget that users will be university students.

As the tutorial is a complementary material of work for students with problems, we have to design the program in such way that it must appear, at the same time, attractive and effective for the user. It is important that the program quickly detects where the difficulties the user has are and direct him to the method to solve it. The tutorial may also have some extra element that could be interesting for the user.

From our point of view, students should have their first contact with the program before starting at university, if it is possible. Specially for students that come from professional training and know they are going to have problems in physics and mathematics. They would start working as soon as possible getting an overview of the course and fixing the diagnostic of their situation. The time and the topics on which he works depend on each student, although is advisable that they solve the problems related to the previous courses as soon as possible. In any case they have the tutorial available as long as they need and there will probably be some students that will need to work with the tutorial along the first year.

As the goal of the program is to solve the difficulties that students have in relation to previous courses, the content of the tutorial works on a reduced number of topics related to the basic concepts in physics such as system of units, escalar and vectorial magnitudes, Newton's laws and electricity, all of them at a basic level.

Every topic is treated in different levels and at the same time the user is progressing in the knowledge of physics, the program shows him other items related to university such like sport facilities, the library, computer rooms and so on. The aim of this is to get the new student familiar with the university environment.

3. The program

The course is introduced by a fictional character that accompanies the user, guides him in the learning process and shows him some interesting things related to university.

We have divided the tutorial into five topics:

1. Physical magnitudes and international system of units.
2. Vectorial magnitudes.
3. Movement in one and two dimensions.
4. Newton's laws.
5. Basic principles on electricity.

Every topic consists of a part of theory where the subject it treats is explained, a glossary of terms related to the topic, a test that determines the level of knowledge of the user and solves exercises in order to practice.

The test and the exercises are structured in three levels. When the student starts working on a subject, he has to answer a general test that indicates the level of knowledge that the student has at that moment. Then, he works on the adequate level trying to improve his knowledge and acquiring new ones. If he needs some help he can accede to

the theory part or consult exercises of a lower level through hypertext. When he thinks, or the fictional character indicates him that he has learned enough, he can try doing the test of the corresponding level. Depending on the number of correct answers, the program shows him whether he advances to the next level (or to the next topic if he has finished this one) or if he should continue with more practice.

The general test consists of 15 questions, 5 in each level, obtained aleatory from a wide test bank. The student passes the level if he gets a score of more than three in the corresponding level. The test of each level is composed of 10 aleatory questions from the corresponding test bank. Some of the questions are conceptual, while others are related to the practice. Some of them can be answered immediately, while others require some calculus. In the test, the questions can be of different types: multiple choice, true or false, to join by arrows, to classify items, to put words or phrases in order, to arrange objects, to fill in the blank. This allows us to choose the best way to fit to the type of question and give variety to the product trying to avoid boring the user. From time to time, the fictional character sends messages of congratulation trying to keep the attention of the user and encouraging him to continue with the work.

The solved exercises are very similar to those presented in the test. All of them are related to some part of the theory of the unit that can be consulted at any time through hypertext. Every exercise is solved in two ways, abbreviated and longer, depending on the user in every moment. Our recommendation is that the user tries to do the exercise by himself in a notebook and then checks his answer, short or long depending on his needs.

Every topic of the tutorial is structured at different levels. Depending on the level the user has when he starts and on the level he wants to obtain at the end, he will follow his own way through the program. We do not think that all the users have to reach the highest level in every topic, because we have selected the material of work thinking in users that could have different interest and we would like to satisfy all of them.

Just as important as the scientific aspect, is the emotional one. This is the target of the fictional character that sends messages to the user not only guiding him through the learning process but encouraging him to continue and giving him a prize when he gets a new level. As users are students in their first year at university, they are not confident with the media that surround them and they usually show insecure behaviour. Then, the reward the tutorial offers to users is to show them university facilities like sports installations, the cantina, the library, computer rooms, laboratories, web pages. As soon as the student gets familiar with the new situation, he can obtain better academic results. This part of the tutorial is presented in a very attractive way, by using video and 3D animations.

4. How to evaluate the results

At this moment the tutorial needs to be tested before it is used in a generalised form. In the first stage it has been checked by physics and mathematics teachers. The next step is to give the program to some selected students in order to try it again. When the program passes all the tests it can be distributed to the students. Our intention is to analyse how the new material affects the results of the users.

Jiménez [5] proposes that multimedia programs would be effective for the transmission of information but they would not be so good when we try to teach concepts. Although we are sure that the interactive tutorial is the best way to solve the problem of the lack of knowledge related to previous courses, it will be very useful to measure the effect of the program on the conceptualisation. Hestenes et al. [6] have designed a test in order to evaluate the effectiveness of instruction. They call it the Force Concept Inventory, and it consists of 30 multiple choice questions about the most basic concepts in Newtonian mechanics. This test allows one to measure the gain (differences between the results of a pre-test and a post-test) that a group of students reaches following a teaching method. For this purpose we will compare the gain obtained in the test by the users group with the control group that have not used the tutorial. It is very important to be sure that the groups are similar with respect to other variables. The test will be done during the first university year because we want to know how the use of the tutorial (related to previous courses) affects the apprenticeship of physics in the first year at university.

We also want to point out that Spain is in the process of changing its educational system. The age of obligatory school has changed from fourteen to sixteen and many changes have been done in every subject. Only some experimental groups of students have arrived at university level at this moment and the general group will get to university in two years from now. We think that the specific problems they will present could be different although the program is designed to be open enough to help these new requests. Then we will have to check the results again.

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