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## ABSTRACT

One of the main points in the development of Educational Software is how to trap, and keep, student's attention. This is a major problem because, unlike the classroom where students are supervised and controlled by teachers, on their computers, at home, they are free to use the software or simply close it and do anything else. The common solution to this problem has been the development of very showy materials, where students are presented to sounds, animations, and sophisticated interactions. Nevertheless, at the Centre of Applied Science and Technological Development we think that this approach might belie some important problems and that other factor must be reviewed and taken into account in order to create good-quality educational software. In this paper we introduce an approach that is based on a study of students, and the identification complete of their beliefs about physics. These beliefs are then used in the development of our software. We present the obtained results; as well as future works perspectives.

**KEYWORDS:** Educational software, Distance learning, User centred design, User analysis.

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## 1. INTRODUCTION

Educational Software (ES) is intended to help students with their learning by supplying them the materials, examples, exercises, tasks, etc. that might help them to create and organize their own knowledge. In order to work fine, educational materials need to be attractive and attainable for students, so they can catch their attention and lead them to a true understanding of the exposed concepts [1]. In this sense, computers appeared to be a great media because, as we have used to hear for many years, they seemed to encourage and motivate learners to study, and this, apparently based on the only pleasure of using them [2-4]. Unfortunately time passes, and today one should not forget that computers are not any longer new and strange artefacts for students. Moreover, at present they are rather seen as game devices, than workstations. In this new context, why would students use such a joyful artefact for studying?

A new generation of ES producers seem to have an answer to this question: Students won't do it. What we need in this *twitch-speed* era -they say- is to develop ES that behaves and looks like games, so we can efficiently capture student's attention and, as a by-pass product of their interaction with it, teach them something [5]. Indeed, one can observe how nowadays virtually every ES privileges environments where animations, sounds, and sophisticated interactions, are presented to students.

At the Centre of Applied Sciences and Technological Development we think of this approach as an interesting solution, that nevertheless requires some reflections:

- a) Showy materials might encourage a passive participation of students, as they are mainly treated as spectators.
- b) Interactions that demand *twitch-speed* reactions (very quick reactions) can hardly help students in the development of deep analytical thoughts, or in the construction of complex semantic nets. Actually they rather encourage a trial and error strategy.
- c) All these elaborated materials and interactions might distract students from the main part of the software: the contents of the course.

The risk of ignoring these potential problems is that the final software might become a game (even a successful one), that teaches nothing.

At the Centre of Applied Sciences and Technological Development we are working on a different approach, based on the analysis of students, and a *“role-playing”* strategy. The term *“role-playing”* is taken from the video-games culture, and is used to refer to those games where the user becomes one of the characters, immerse in the virtual environment. As we will explain later, this is a technique that we use intensively in our approach, mainly because it gives to the user the feeling of being part of the system, capable of deciding the course of the action, and not only a passive observer. And this, even when actions are not of *twitch-speed* kind.

For what it concerns the analysis of students, the goal is to study what is their conceptualization and understanding about a particular discipline, this time physics. From this analysis, one can obtain the beliefs that students have constructed from their everyday experiences, and how they relate these beliefs with the theory studied at school. We were particularly interested in the adaptations that learners make to the learned concepts, in order to integrate them to the rest of their previous knowledge (or beliefs).

This analysis allows us to integrate in the system evidences that are against these identified beliefs, obliging the student's to doubt about their own previous ideas and conclusions. Now, this is the core aspect of our approach; because if one can succeed on making the learner hesitate, the problem of urging him/her to learn something is almost solved: the learner will ask for an explanation to his/her doubts, becoming an active participant, rather than a passive observer that must bear the explanations of the teacher.

The confronting evidences might be of several kinds: photographs, videos, graphs (simulations do not always work well under this strategy, because students seem to keep in mind that they can be manipulated), etc. Yet we have found that the most compelling ones are when we put this evidences as questions in the mouse of virtual classmates. These experiences, and the approach followed in the implementation of a Physics Tutorial is described in the following sections.

## 2. WORK WITH STUDENTS

The work started at the Centre of Applied Sciences and Technological Development with twelve non-directed interviews [6], each one with duration of ninety minutes. For these interviews we invited nine high school students, grouped in three different teams (see Fig. 1). The students were invited to speak freely and to explain some of the most basic and fundamental concepts in physics (e.g. movement, velocity, acceleration, etc.).



*Figure 1. Extracts of the videos recorded during the interviews with students. In these pictures each team is trying to explain what movement it is.*

Surprisingly, the explanations obtained in these interviews were far beyond these limited subjects, as student's incorporated in their answers other concepts and theories, every time more complicated and without any apparent coherence. All this mess of concepts and disordered explanations were then analyzed, trying to establish a categorized list of beliefs and confusions shown by the students in these sessions. The result was a list of concepts where students show misunderstandings, categorized by topics. An excerpt of this list (for the topic of movement) is shown in the following table.

TABLE 1 TOPIC: MOVEMENT
<ul style="list-style-type: none"> <li>• Movement and force: Displacement of a body when a force is applied to it; etc.</li> <li>• Movement related with the change of place: To change of place is to make movement; etc.</li> <li>• Movement related with size and weight: The things that are bigger move faster; a body moves depending on the force that is applied to it, and its weight; etc.</li> <li>• Movement related with change of position: it is possible to change the position of a body, without changing it of place; etc.</li> <li>• Movement and displacement: to move and to displace are not the same thing; etc.</li> <li>• Movement and perception: movement is any reaction that one can perceive; etc.</li> </ul>

With this list settled and organized, the next question we had to face was: Which is the best way of using this information? This is presented in the following section.

### 3. INTEGRATION OF THE MATERIAL TO AN EDUCATION SOFTWARE

The first obvious choice to use this material was to write the obtained list in the form of a FAQ list. Nevertheless, a FAQ list seemed to us as an out-of context tool, too isolated from the rest of the material. This is why, we preferred to use it in three different ways:

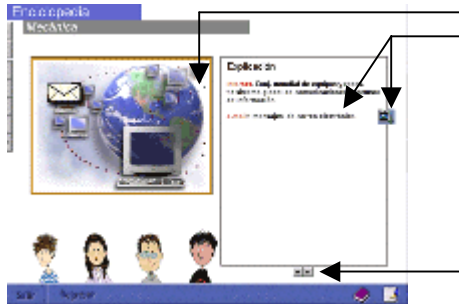
- 1) *Definition of the theoretical material:* the theoretical material of the software was specified so it answers or gives explicit explanations to some of the identified problems;
- 2) *Definition of examples and media selection:* examples and exercises were specified using particular medias in each case, so they show things that we know are against the students' identified beliefs;
- 3) *Definition of virtual classmates that present, at the end of an explanation, the rest of the beliefs that we have identified on the students:* four virtual classmates were included in the software. Their role is to present to the user (the student), their "own" questions about the reviewed topic. The user can then select one of these questions and have this classmate to ask it to the system.



Figure 2. Virtual classmates

#### 4. THE PHYSICS TUTORIAL

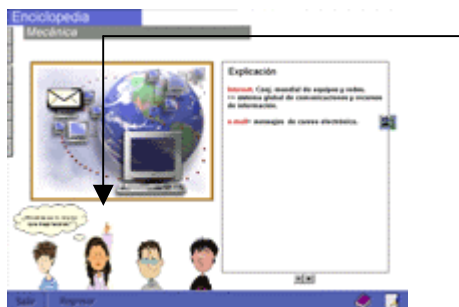
In this section, the third strategy is detailed. We show how the questions are presented, how students can interact with their virtual classmates, and how does answers are presented. First of all, students must select the topic that will be explained by the system. This is done from a main menu. Once the topic is selected, the system presents to the student the following screen.



The topic is presented using two windows:

1. One for an animated explanation; and
2. A second window that summarize the main points of the explanation in text mode. For each main point, this window might also include links to other related sections in the tutor.

The explanation of the system can be paused at any moment using the Pause/Play button. In contrast with other systems, the students do not control the repetition of the explanation based on the elapsed time, but on the main points written down by the system (they select one and the system restarts from that point).



When the presentation of the topic has finished, the virtual mates present their "own" doubts or questions to the student. The student decides if any of the questions is interesting to him by clicking on the mate that presents it.

The virtual mate interrogates the student if he/she should ask the teacher (the system) for an answer, or if the student himself/herself wants to try to answer the question.

In case the student chooses the answer of the system, the corresponding material is presented to her/him in the same way that the first presentation, but this time the classmates do not present any more questions.



When the student chooses to answer by himself/herself to the question, he/she is presented to a quiz (a game?) that must be solved in order to reach the right answer. In this figure, the student must help to "Morita" the flea to pull the cart carrying food. This exercise should help students to separate the concept of force, from the concept of movement. These exercises are not rated, so students do not get any grades from them. They only are able to solve it, or not.

## 5. RESULTS AND CONCLUSIONS

At the present moment, the module described in this paper is in its final stage. The goal is to develop a skeleton that allows us to integrate new doubts, commentaries, exercises, etc. without recompiling the program. These technical aspects have not been mentioned in this paper, as they have no real relevance to the subject we wanted to deal with: a more compelling approach to catch and keep students attention.

We have made a first evaluation of the module described in this paper with five high-school students [7]. Some of the results obtained from these evaluation sessions are shown in the following charts: students seem to like this technique since almost in every case they asked to answer to their virtual classmate, and every time they asked for more questions, etc.

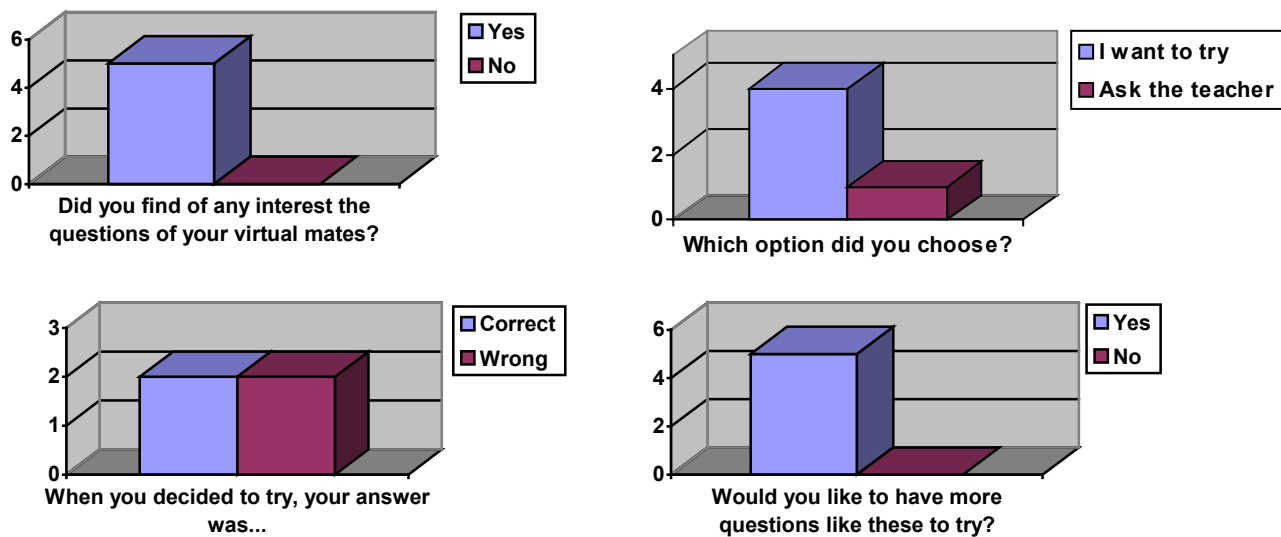


Figure 3. Evaluations with students of the approach

Nevertheless, the most important and encouraging event is not in these statistics, but in the fact that, while using the system, the students acted as if they were themselves the ones that were asking questions, and not the virtual classmates, as in a role-playing game.

Even if these results are to be confirmed with a larger population, we believe this is a very promising approach, as it does not base neither on the complexity of the interactions, nor on the speed on which they happen. On the other hand, it encourages the participation of the students, definitely catches their attention and, what is most important, changes their attitudes from passive ones to active ones, which are demanding new knowledge.

## 6. REFERENCES

- [1] Squires, D., & Preece, J. Predicting quality in educational software: Evaluating for learning, usability and the synergy between them. *Interacting with computers*, 11(3), 467-483 (1999).
- [2] Beichner, R. J. Multimedia editing to promote science learning. *Journal of Educational Multimedia and Hypermedia*, 3, 55-70 (1994).
- [3] Bork, A. M. Effective computer use in physics education. *American Journal of Physics*, 43(1), 81-88 (1975).
- [4] Guillies, A. D., Sinclair, B. D., & Swithenby, S. J. Feeling physics: computer packages for building concepts and understanding. *Physics Education*, 31(6), 362-368 (1996).
- [5] Prensky, M. *Digital Game-Based Learning*. New York: Mc-Graw Hill. (2000).
- [6] Rubin, J. *Handbook of Usability Testing* (1 ed.). New York: John Wiley & Sons, Inc. (1994).
- [7] Gálvez Cruz, D. C. *Modelado de las dudas de los alumnos y su integración en software educativo*. M.C. Thesis, UNAM, México D.F. (2001).

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