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EDUCATIONAL SOFTWARE APPLIED IN TEACHING AND ASSESSING PHYSICS IN HIGH SCHOOLS

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Abstract: This paper stands as an argument for employing educational software in teaching and evaluating Physics skills and knowledge in high-schools. The authors' main goal is to pinpoint and focus on strategies of teaching Physics through the use of modern means, namely educational software. This paper presents a number of educational software: The Science of Music, Mechanical Oscillations, Fluid Mechanics and Special Relativity. The usage of interactive teaching tools provides continuous feedback and enhances the teaching and learning processes.

Key words: oscillations educational software, science of music educational software, special relativity educational software, interactive teaching and learning process, physics.

1. INTRODUCTION

In an active and interactive teaching and learning process, the student is no longer a passive receiver of knowledge processed and spread by the teacher. Contrarily, the student becomes an active person which, guided by teachers, discover and scrutinize new knowledge territories. The main goal in an active and interactive teaching-learning process must be to help the students to discover the pleasure of inquiry and learning, which leads to increase confidence in their forces. The usage of modern technologies and educational software is a must of the modern educational process [1]. We will make our point making an appeal to a number of specific educational software, among which The Science of Music, Mechanical Oscillations, Fluid Mechanics and Special Relativity, all made in "Tudor Vianu" National High School of Computer Science, Bucharest, as a result of a very good collaboration between teachers and students.

There is considerable evidence to suggest that a move towards pedagogies involving full interaction, collective reflection and the development of consensual knowledge would lead to improved learning and attainment [2, 3, 4]. However,

imposed external guidance is leading teachers to focus on superficial features of interactive teaching such as pace and structure rather than deeper aspects of the pedagogy.

2. THE ADVANTAGES OF EDUCATIONAL SOFTWARE USAGE

Use of computers and software ICT tools in classrooms and laboratories, provide much more effective and efficient environments in teaching and learning, making physics– science easier to understand. The advantages of using simulation software in conjunction with classroom teaching are well known. It is generally acceptable that the use of interactive teaching tools, which provide instant feedback to the student's inputs, improve and accelerate the learning process. The use of simulation and ICT tools secondary education is not a new concept [5, 6]. However, the traditional teaching methodology used in secondary education is based mainly on oral speech and use of blackboard.

In line with a number of researchers in ICT education [7, 8, 9], teaching approaches that are based on the understanding of software principles for problem solving involve three major components:

1) It is important to generate understanding using situated examples, visualizations, and dialogues. By using situated examples, the teacher should enable the students to understand the software problem. The principles of the software are then explained through visualizations. Finally, the teacher gives the right sequence of software instructions showing the main implementation steps of the problem solving process.

2) Students use software principles to construct solutions to the problem through involvement in realistic task-based activities. The goal is for students to construct their knowledge and to work at their own pace from their prerequisites. The teacher works as a mentor and guide of learning rather than as a transmitter of knowledge.

3) Students get the opportunity to raise questions regarding the specific problem solving process or more general problems related to software use. Students might for example discuss how the software could be used in similar situations. The teacher can then provide supplementary information.

The advantages offered by the educational software include unconventional tests allowing for an optimal feedback, user-friendly working environments, individual and/or team work, stimulation of the creativity and of the competition spirit by pursue of different modules, visual support which gives rapid understanding of even the most subtle and complex scientific themes. For a more intense involvement of each student into the learning process, the educational software provides animation and the possibility to replay. This kind of activities

allow the student to learn by playing, by varying different parameters and quantities in a rigorous, mathematical way, because mathematics, creativity, logic, and originality are all needed to improve technology [10].

3. EDUCATIONAL SOFTWARE DEVELOPED IN "TUDOR VIANU" NATIONAL HIGH SCHOOL OF COMPUTER SCIENCE AND LINKS BETWEEN DIFFERENT FIELDS OF SCIENCES

On the one hand, the computers offer the power to perform computation that is very long. The computers' graphic capabilities make them useful in designing devices and in simulating complicated processes [11]. On the other hand, science content must be embedded in a variety of curriculum patterns that are developmentally appropriate, interesting and relevant to student's lives. The program of study in science should connect to other school subject. The curriculum must put more emphasis on connecting science to other subjects, such mathematics, chemistry, biology, even music, less emphasis on treating science as a subject isolated from other school subjects.

The modern science curriculum should be coordinated with the mathematics curriculum in order to enhance the student's usage and understanding of mathematics in the study of science [12].

3.1. OSCILLATIONS EDUCATIONAL SOFTWARE

Regarding the above statements, we will provide an example of links between physics and mathematics, using the "Oscillations" educational software, as it is shown in Fig. 1 [13]. It is designed for students studying this mechanics phenomenon, with the intent to present them with an analogous mathematical model and with a broader view on oscillations extended to optical and heat phenomena. The software conveys information on harmonic oscillatory motion, including phasor diagrams, energy, the superposition of parallel oscillations having the same or different frequency, the superposition of perpendicular oscillation having the same or different frequency, and examples of oscillatory motion, chosen from all the fields of classical physics: optics, electricity, mechanics, and thermodynamics. This educational software is entirely interactive. It's main plus is the quality of simulations, which includes the actual oscillator which accurately moves according to the parameters specified by the student. Beside the oscillator there is a real-time graph illustrating the physical quantities which characterize the motion. For a better understanding of the phenomenon, the simulation can be paused at any moment. The student can easily correlate between physical parameters, having the liberty to compose his or her own representation, thus involving him or her into the learning process, an optimal possibility for the student to learn while playing, by varying parameters in a rigorous, mathematical way.

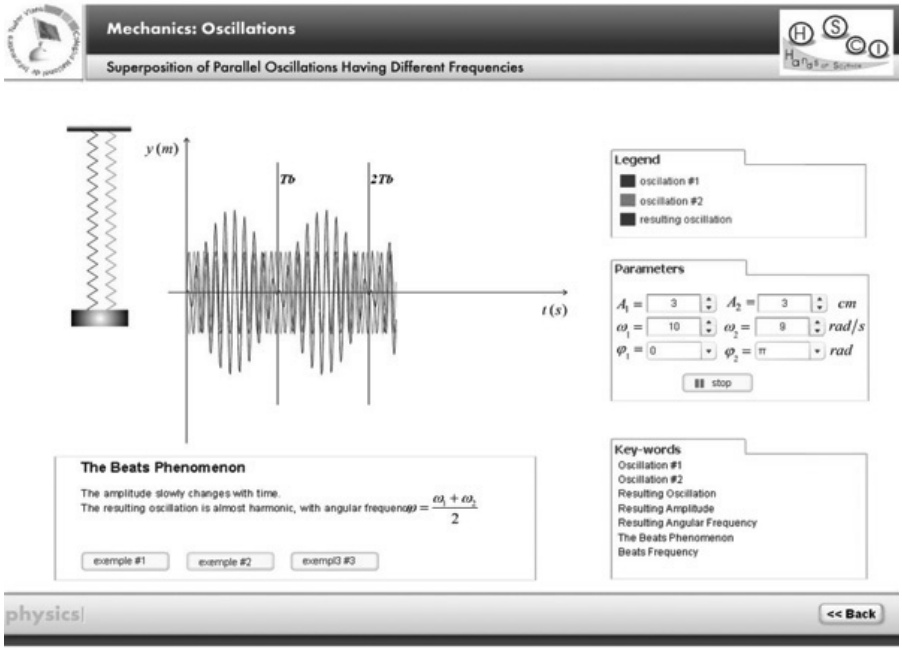

Fig. 1 – A screenshot from the Oscillations educational software.

3.2. SCIENCE OF MUSIC EDUCATIONAL SOFTWARE

Science of Music is an educational software which offers a journey in the world of music guided by the laws of physics, thus managing to observe the regularities that appear. The starting point for this project was a passage from a book written by the well-known physicist Richard Feynman, "The Character of Physical lows". After reading what Feynman said, the idea of showing how harmonies recorded by our senses can be translated into mathematical equation came to us.

The application is designed for those who study physics, music, or both, and it's useful also as an auxiliary material for student class preparation. It is structured so that the user fully understands the mathematical laws and practical applications of physics in music. It is divided in six sections: theory, piano, guitar, other instruments, game and test. The Theory section is divided in two types of lessons: a „classical lesson" which consists of mathematical demonstrations and physical laws, and an „unconventional lesson" which presents the link between physics and music in a funny way.

The visual support enables the understanding and fast connection between the physical and musical phenomena. Many hours of explanations are reduced to a few minutes, as it is shown in Fig. 2 [14, 15].

The application is entirely interactive, being attractive even for those who are not really interested by any of the two subjects.

The software contents a virtual piano and a virtual guitar. It enables the user to interact with this kind of musical instruments. He or she can see how the musical notes are distributed on the piano, hear them while playing the piano and understand the science behind both the physics and the music [16].

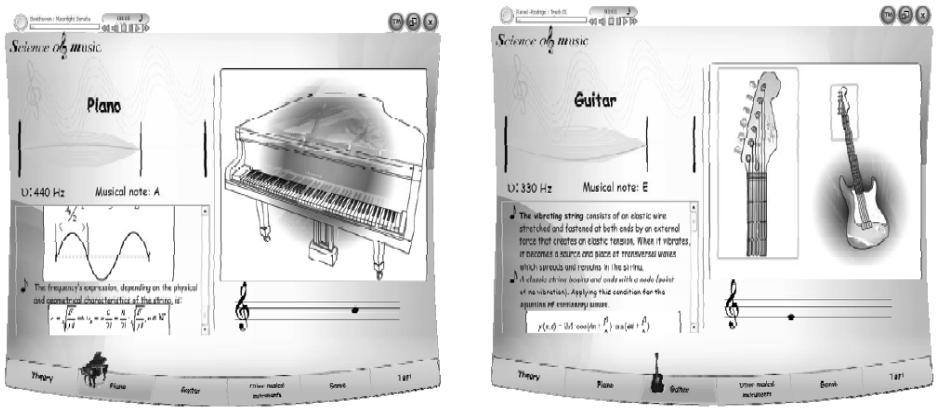

Fig. 2 – Two screenshots from the Science of Music educational software.

3.3. FLUID MECHANICS EDUCATIONAL SOFTWARE

In the 9-12 grades, the students can understand better the working to the circulatory system of the human body, using, for instance, the Fluid Mechanics educational software. This entirely interactive program contains such notions as hydrostatic pressure, Pascal's Law, Archimedes's Law, Poiseuille's Law and Bernoulli's Law. The most attractive part of the project, in our opinion, is the real life applications: the Magnus Effect, as it is shown in Fig. 3, the Coanda Effect, the aerodynamics notions, and the human circulatory system presented as a game.

The software is useful for those who study biology and/or physics. Its main objectives are:

• revealing mathematical regularities behind the dynamics of flowing phenomena;

• acquiring interdisciplinary transfers in the study of fluids and biology;

• developing a proper use of formal languages (mathematics, physics and biology);

• establishing connections between various specific physical quantities, mathematical expressions and theoretical biological notions;

• investigating pattern and symmetries present in the real world but visible only with the eyes "of the mind", namely physical laws [16].

Fig. 3 – A screenshot from the Fluid Mechanics educational software.

3.4. SPECIAL RELATIVITY EDUCATIONAL SOFTWARE

The educational software allows the investigation, in the virtual lab, of some physics phenomena that "contradict" our human perceptions. For example, The Special Relativity software presents a sensible and revolutionary physics subject in an attractive, accessible, yet rigorous manner. Just like everybody, the students are amazed when they find out which the real laws that govern our universe are, and especially what implications they have. This entirely interactive application makes it easier for them to familiarize with the phenomena in Einstein's relativity. Many hours of explanations are condensed into a few minutes of activity. The visual support offers a rapid understanding of this phenomenon. This way of learning has a big advantage: the flexibility, the fact that each student can set his or her own pace of study.

Each lesson is divided in three sections, as it is shown in Fig. 4:

• Learn: displays the Physical laws that explain the specific experiment; it contains mathematical explanations and definitions for all the concepts involved in that lesson.

• Play: instantiates the theory by enabling the user to play and discover the phenomenon behind the mathematical laws.

• Test: contains single-choice questions based on the concepts presented in that lesson.

Fig. 4 – Two screenshots from the Special Relativity educational software.

The first lesson presents the most interesting effects that occur at high speeds (comparable with the speed of light), according to Einstein's Special Relativity Theory. These effects are: the contraction of lengths and the time dilation, as it is shown in Fig. 5. The lesson's sections enable the student to fully understand the phenomena by learning, playing and testing his knowledge.

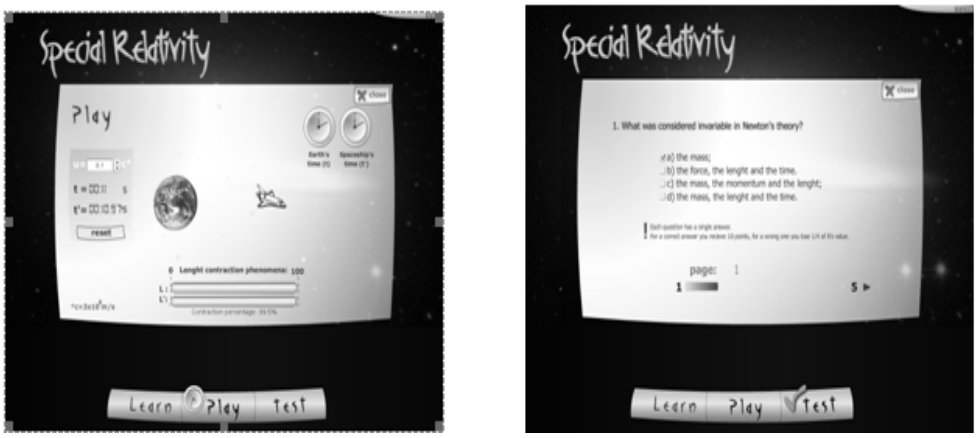

Fig. 5 – Special Relativity educational software: shrinking lengths and stretching durations.

The Play section shows length and time information for the experiment as the student selects different shuttle speeds. It also presents an animation of the high speed's effects.

The second lesson presents the effects that occur at high speeds (comparable with the speed of light), on geometric figures. At high speeds, according to Einstein's Special Relativity Theory, a length contraction occurs, on the direction of movement. The lesson's sections enable the student to fully understand the phenomena by learning, playing and testing his knowledge, as it is shown in Fig. 6.

Fig. 6 – Special Relativity educational software: relativistic effects on geometric figures.

The Play section enables the student to see the effects of different speeds on a cube or a sphere. The animation makes it easy to understand and visualize the phenomena.

The third lesson presents the effects that occur at high speeds (comparable with the speed of light), in particle accelerators. By accelerating particles at speeds close to the speed of light, their mass increases, this resulting in an increase of their trajectory radius. The lesson's sections enable the student to fully understand the phenomena by learning, playing and testing his knowledge.

The Play section enables the student to select different speeds for the particle and the animation makes it easy to understand and visualize the effects on mass and trajectory.

The forth lesson presents the light cone concept and, as an exemplification, the Sun's death. Einstein's Special Relativity Theory states that two individual events are separated by quadriintervals, which are represented by a light cone. The lesson's sections enable the student to fully understand the phenomena by learning, playing and testing his knowledge.

The Play section enables the student see, by selecting each planet of the solar system, the time it takes to witness the Sun's death (the time it takes to enter its light cone) as it is shown in Fig. 7.

Fig. 7 – Special Relativity educational software: light cones and the Sun's death.

4. CONCLUSIONS

By using educational software, the student is provided with sequences, which can be lesson stages, tests, and so on. Through these sequences, he or she can access information (libraries, internet), can receive a mark, or can contact other students who work in the same environment.

The teacher who has access to educational software can choose certain lesson stages which are in accordance with topics from the school curriculum, but he/she can also create sequences based on the feedback received from a certain group of students, or on the strategies that he/she uses.

The greatest advantage is represented by the opportunity to receive feedback from all the students in the class who, in their turn, can work independently according to their level or abilities; thus, the educational process can be shaped directly on the group of students the teacher is working with, the flexibility and adaptability of the educational teaching content being a necessary conditions in order to improve the learning results.

We propose this type of lesson based on interactive conveyance of information, and developing motivation and interactive learning skills. The student will learn by reading, discovering and solving numerous reasoning exercises which make reference to theoretical Physics concepts. Navigating through lessons is easy and intuitive. Each lesson contains a help section specific to that particular lesson.

The main teaching advantage of these lessons is represented by the fact that they implement a well-thought teaching methodology resorting to an interactive working strategy, the taught subject being presented in a varied way with the help of specific programming techniques. These techniques appeal to and trigger specific skills of the student, which enable him/her to learn more easily. Among these skills one can mention discovering, exploratory observation, demonstration, modeling, thus the students having to deal with a variety of questions and tasks for those who are learning.

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