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#### Abstract

Today's society demands school education to follow the changing processes and the new possibilities given by Information and Communication Technologies (ICT). If on one hand, we believe that ICT are attractive and their use in teaching can offer advantages and motivate students, on the other hand it is our understanding that, if not properly framed, they can cause dispersion and disorientation in class. Developing tools and materials to guide, stimulate and support learning is a field of most importance. To involve teachers in this process is crucial, as we are reflecting on and investigating within a research work including the conception, implementation and evaluation of a pedagogical device to improve the teaching of Physics (Mechanics) in secondary schools with the aid of ICT. This pedagogical device combines two digital educational resources - the Digital Board (DB) and a computer simulator using the open source visual programming language VPython - along with an activity guide supporting teaching and learning processes. The use of the device in classroom explores the interactive features of computer simulations, together with their presentation and manipulation using the DB by the teacher and the students themselves in front of the whole class. Exploring the device in a class of 11th grade, we collected data through students' observation, audio and video records, students' tests and inquiries and teacher's interviews and reports. Preliminary results show better students' outcomes and a more effective learning of physical concepts, based on interaction, motivation, involvement in learning processes and development of critical thinking. The active involvement of the teacher in all stages of this experiment was an added value and we could perceive a paradigm shift regarding the use of the technologies in her teaching conceptions and practices.

Keywords: digital board; computational simulations; teaching and learning physics.

# 1. Context

Physics is often taught with some abstraction degree, more focused on solving quantitative rather than qualitative problems. For this reason, many consider it a difficult and unattractive subject. Concept learning is one of the main objectives of Physics education and also one of the greatest challenges to teachers, since students arrive with different previous / prior knowledge based on daily observations, which is often different from scientific knowledge, called preconceptions [1], conceptual models that students use to interpret the day-to-day observed phenomena and have to be considered for the learning of a Physics content [2] and demands consistent and differentiated strategies of formal education. Learning Physics requires students involved in their knowledge construction process investigating, testing hypotheses, modifying or validating them, simulating phenomena, applying concepts in problem solving, learning how to interpret daily life phenomena with Physics' laws, theories and concepts. Therefore, teaching processes must be motivating, awakening students' curiosity, making them active learners. The aid of digital educational resources for this purpose is highlighted in this Computational simulators-play an important role in supporting Physics' concepts learning [3-5]. Their use in classroom aims to improve teachers' instructional potential, to motivate students and to engage them in highly active and interactive tasks. From these, it is possible to create environments in which students learn through exploration, where they feel free to choose the data collection and analysis processes, experiencing new experimental situations in which they can test hypotheses, identify cause and effect relations and exercise decision making. The analysis of the collected data, as well as being motivating for the student by the interaction with the computer, is also an educational element that allows the establishment of situations where the students are allowed to

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make mistakes and learn from them, try again and become aware of their learning. They are also very useful to achieve a meaningful learning, namely, bridging the previous knowledge and the learning of new physical concepts, helping in the development of scientific understanding of concepts. In this research a computer simulator is used in classroom combined with another technological tool, in this case a Digital Board (DB). Several authors [6-9] emphasize the benefits of using the DB in classroom, thanks to its interactive and collaborative potential, the possibility to edit and to insert text, images, graphics and spreadsheets in real time. Other benefits are related to visualization, recording and sharing possibilities. The justification for using the DB rather than a simple image projector is related to how the simulator can be explored together with this tool. Using the DB, with a pen, also called *ActivPen*, or even with the touch of a finger on the screen, the teacher can interact with the simulator in front of the class, that is, in the board, providing real-time motion observations. This is difficult to perform when working only with an image projector. Also, DB tools can be added to the simulation, increasing interactive teaching.

International Conference

# 2. Methodology

This study examined how the combination of these two technological tools could enhance interaction in classroom and the management of didactic processes for Physics' learning regarding Mechanics contents. The study was conducted in a class of 12 11<sup>th</sup> grade students from Avelar Brotero Secondary School in Coimbra, Portugal, with the collaboration of the respective Physics Chemistry teacher. It involved the adaptation of the simulator to the context, the assessment and testing of the pedagogical device and an exploratory analysis of the processes and results. The data collection used an observation grid, audio and video records, teachers' interview and students' inquiry and tests. The theme selection and the determination of simulator features had the collaboration of the teacher. She explained the main students' difficulties observed throughout her teaching practice and the contents in which they are most visible. This collaboration took place through nine extra-class meetings. The study focused in particular on accelerated motion, with emphasis on the association of real motion with its description regarding position/time and speed/time graphs in the inclined plane, which is one of the contents that the group presented most inadequate preconceptions. Supported by the work sessions and informal teacher interviews a test version of the simulator was programmed using a Vphyton programming language, after analysis of other Physics simulators available on the internet. The aim was to program a simple simulator in Portuguese language, that simulates the movement of a sphere in the inclined plane, specific to the objectives to be achieved, with great potential for Mechanics teaching and learning. A resource that can be used by teachers and students, facilitating teaching work and useful for knowledge construction, since it was planned according to the main conceptual difficulties of students on motion in the inclined plane.





Fig. 1. Simulator screen.



#### The tasks to be performed during the intervention were then defined. This process was carried out with the participation of the teacher, taking into account the characteristics of the students. It should be emphasized the importance of teacher's participation, present at all stages, from planning to executing and evaluating. The researcher observed the group at two moments before the intervention. The next step was the collection of pre-intervention data. An audio recorded teacher interview was conducted. A script was previously prepared to assist the researcher in the process and the interview lasted 40 minutes. Data was also collected from the students through a test that lasted 15 minutes. This instrument sought to investigate students' knowledge before and after the intervention/gain of knowledge. Simultaneously and meeting her needs we developed a teacher training component regarding the use of the DB tools and the simulator. This component lasted 6 hours, distributed in three meetings. First, the work focused on the DB, then on the built simulator. Finally, both tools were combined. The intervention occurred during a class period, taking 3 hours. The teacher was supported and could follow the activity script. The class begins with an activity to be solved, projected on the DB screen. The teacher questioned the class about the resolution and a student take notes on the DB Flipchart, with the considerations raised by the class. Then the simulator was opened and the proposed activity was simulated to validate or not the hypotheses raised by the class. In another proposed activity, the simulation was performed first, without making visible the graphic representation of the motion, and the group should jointly decide how this representation would look. The notes were again made on the Flipchart and then validated on the simulator. Several activities were developed in the intervention, and all of them involved students' collaboration.

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Fig.2. Intervention process

# 3. Results

This experience evidenced a great acceptance of the teacher and the class towards working with the proposed pedagogical device. At all stages, the teacher was very open to dialogue and motivated to use the tools. We also observed students' enthusiasm about being able to make use of these resources for their own knowledge construction, with awareness of the process and positive attitudes about the DB use, since it was not necessary to stop the simulation and go to the front of the simulator to make comments, questions and observations. The work on the simulator with the DB enabled this real-time interaction. As for the simulator, the advantages of its use for this content were observed, allowing to teach some concepts that were previously difficult to understand by the students, overcoming the limitation of visualization of the motions using only the blackboard and the manual, as reported by the teacher in the interview. The work was also facilitated regarding existing preconceptions, hypotheses testing and the validation of previously constructed knowledge. Because it is a simulator built with an easy-to-use, simple and yet attractive interface, it became evident that both students and the teacher felt comfortable and motivated to use it. As for the analysis of the



students' tests, a great conceptual evolution was observed. Many of the preconceptions presented in the pre-test were replaced by scientific concepts in the post-test. When analysing the teacher interviews (pre and post intervention), it was observed great satisfaction on working with the combination of the two technological resources. It should be highlighted that the teacher reported in the pre-interview that she believed that she could teach better the students without them. This opinion was completed reversed in the post interview, in which the teacher assumes the importance of the use of these resources for the students' learning and emphasizes that she will start using them in her lessons.

International Conference

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