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NEW METHODOLOGY TO IMPROVE THE LEARNING PROCESS OF ELECTROSTATICS

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Abstract. *This work is part of a research project whose main objective is to understand the impact that the use of Information and Communication Technology (ICT) has on the teaching and learning process on the subject of Physics. We will show that, with the use of a storm simulator, physics students improve their learning process; on one hand they understand storm phenomenon, and on the other hand, they assimilate better electrostatics ideas. Computer technology is a positive supplement to bridge the gap between education and the technological world in which we live. Computer-assisted technologies at the university offer students a great access to information, an eager motivation to learn, a jump-start on marketable job skills and an enhanced quality of class work.*
Keywords: Virtual laboratory, Technologies, Education, Teaching, Physics, Learning

1. **Introduction.** Education serves as a window through which our imagination and curiosity can take flight into the unknown and enhance our creativity, and the use of computer technology in education plays a big role in helping students to achieve their full development potential. Given the role that education plays in preparing students to go into the world, it seems clear that there should be a connection between the world and the classroom. Education in all the areas of knowledge was benefited by the developed technologies with the creation of new areas in which teachers and students can have new visual ways of the subjective concepts of study. The space which is created with the help of classrooms and virtual laboratories allows students to develop their own educational competencies according to the level they are in teaching within the area of science. It requires stages of practical formation in certain specific zones that help to consolidate theoretical learning.

Realization is usually developed in laboratories in which different human and material resources are involved. In many occasions it is necessary a great economic expenditure that education centers cannot usually afford. Also the setting up of machinery and mechanism to put practical sessions into force entails certain risks associated with the manipulation of them by people who are no experts.

To cover this necessity the adopted solution by some education centers, specially universities is the use of laboratories in which students complete their formation and do their investigation work which can improve or optimize the existing implantations. These laboratories, virtual laboratories are called simulators.

Several studies ('Cell phone video recording feature as a language learning tool' by Mr. N. A. Gromik, Qatar University) realized with students in Secondary Obligatory

Education and in several degrees demonstrate a change of attitude towards some subjects with the utilization of ICT (computer, scientific cinema, audio-visual tools), and also an improvement in the learning of these subjects. Analyzing the results in these studies, it is possible to verify that statistically significant differences are obtained in the average performance of the students, among the groups of students with whom it is implemented a strategy of education that uses ICT resources and another group, in which a boarding is realized from the traditional education.

Computers are important in education because they force us to reconsider how people learn, how they are empowered, and how is the nature of learning and how useful information is. We cannot avoid the presence of computers at university because they are forcing educators to re-evaluate teaching paradigm.

The main objective of this project is to show that the use of a simulator helps to improve the understanding of concepts related to subject of physics.

To achieve the objective we have mentioned above is necessary to follow these secondary objetives:

- To understand the impact of the use of the new technologies in the processes of the teaching and learning of the students in the subject of physics.
- To develop students' high-level computer skills and competence (student expertise) in ICT and in physics.
- To analyze the use of specific technological recourses as part of a strategy in teaching that helps to achieve learning.
- To determine if the use of external representation (images, animations, simulations and actual experiences) helps to understand the concepts of physics.

This paper is structured in 5 sections. The following analysis, which is done in Section 2, from our experience, demonstrates how the use of determined technical resources in a didactic unit, "Electrical Field", helps to improve the understanding of disciplinary concepts. Specially, in Section 3 we show the influence of external representation (images, animations, simulations) which has been used to register, analyze and explain the Electrical Field phenomena which are intended to improve the concepts of electrical load, electrical potential, thunder, lightning and beam. Section 4 includes the results we have achieved and conclusions are shown in Section 5. Section 6 deals with the future investigations.

2. **The System.** As we mentioned in Introduction, the main objective of this project is to show that the use of a simulator helps to improve the understanding of the disciplinary concepts in the subject of physics.

In a classroom or in a real laboratory, teachers cannot reproduce some important physics phenomena, but with a virtual laboratory (in this case, applets) they can [3].

In this work we centre on exposing a methodology that facilitates the students the follow-up of the didactic chosen unit. With the use of a storm simulation students can achieve the knowledge following their own way of learning, so departing from different levels it is possible to achieve the final claimed level.

The used simulator is a java applet where we can develop all the important concepts about Electrostatics (Electrical loads, potential difference, electrical field, Coulomb's law and electrization of the matter).

These concepts due to the fact that the ideas cannot be touched and it is not possible to represent them in classroom, it is very difficult for students to understand them.

The basic concepts of Electrostatic are shown in Figure 1.

The concepts we have shown with our storm simulator are

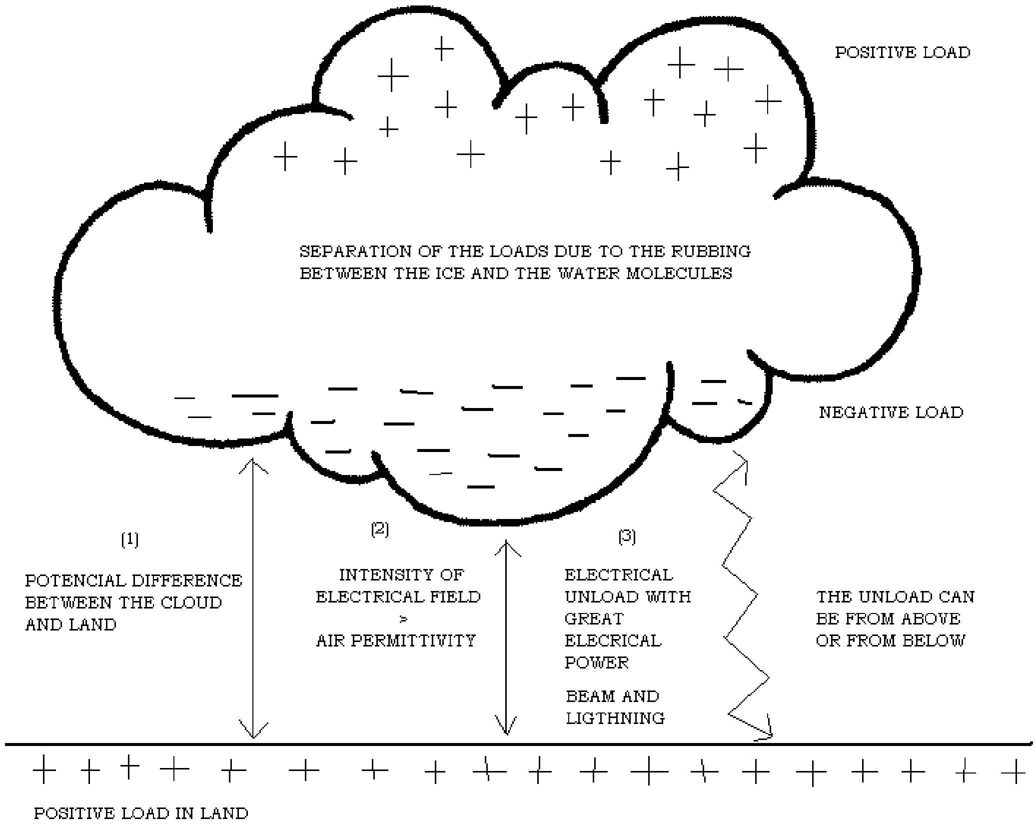

FIGURE 1. Developed concepts with the storm simulation

- An electrical storm is more commonly known as a thunder or lightning storm. An electrical storm may or may not present thunder, but lightning can still happen in the lack of thunder. It is created from the combination of atmospheric processes and dry air.
- Thunder is a direct result of lightning and it happens when clouds are separated and rejoined during an electrical storm. The friction created among different weather occurrences creates a build up of energy which results in an electrical storm.
- Lightning is a chaotic and dangerous aspect of weather. Lightning occurs most frequently during thunderstorms where lightning is created as a discharge of built up energy due to the separation of positive and negative charges which are generated inside the thunderstorm.
- A separation of electrical charge takes place due to the different rates of rising and falling within a thunderstorm. These collisions within the thunderstorm cause these particles to build up electric charge. As the thunderstorm grows, intense electrical fields can develop within it. Air, however, is a good insulator, and the electrical potential between clouds and ground must be of levels among ten to hundred of millions of volts before the insulating properties of the air break down and an ionized conductive channel is established for the current to flow between the two charges.

The simulator we have used, “Storm Simulator” has been developed with Java technology. The version of the JDK that we have used is the 1.6 (called Java SE 6.0).

The basic environment of the JDK’s Java that provides Sun is composed of tools in text mode, which are java, interpreter that executes programs in byte-code. javac, Java compiler that converts the code source into byte-code. javap, is a decompiler of byte-code

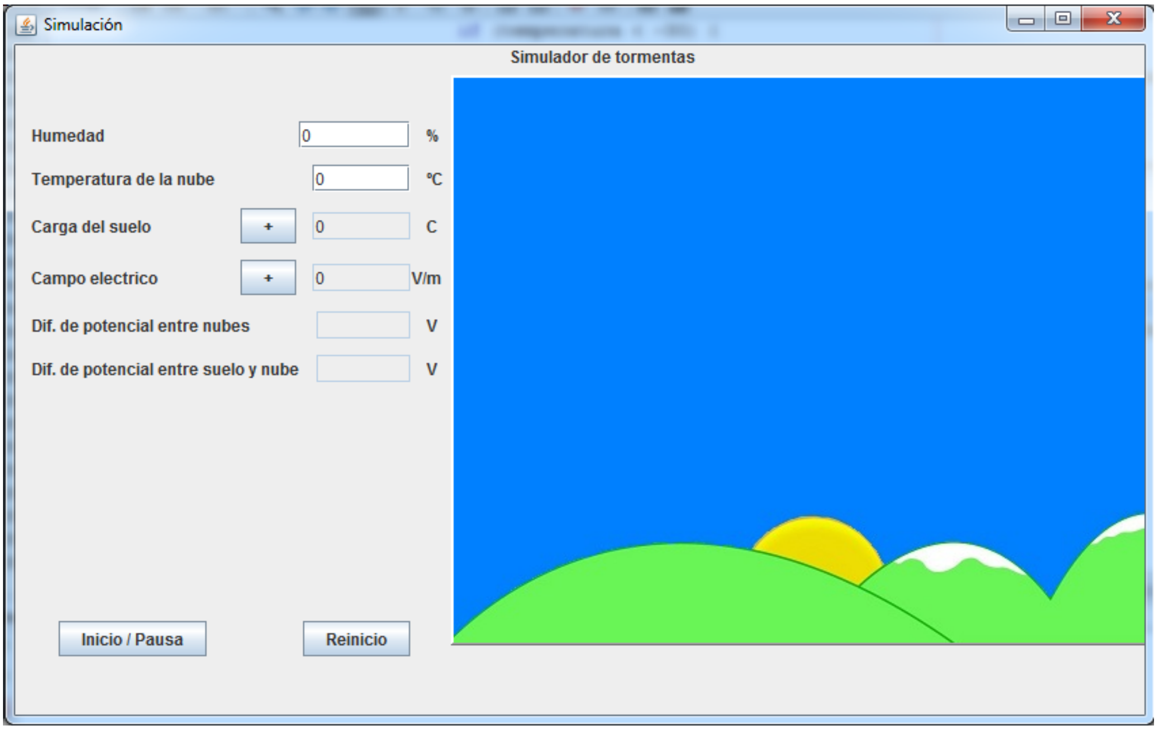

FIGURE 2. Electrical storm simulator

to code Java source. Javadoc, is an automatic generator of HTML documents from the code Java source. appletviewer, is an applet viewer.

The development environment we have used is NetBeans version 6. NetBeans is an open source platform that was born in 2000 as a project of Sun Microsystems.

The first screen of our storm simulator is shown in Figure 2. In this screen we can introduce values to the humidity, temperature ground electrical load and electric field which are magnitudes with initial value zero.

In this window we can see 2 parts: the left one with the data and the right one with an image. Once the data are introduced, we will be able to begin the simulation.

According to the introduced data, a succession of states from a sky without clouds until a sky with rays would be realized. After pressing beginning, the button would change its name to Following and the state will follow one another.

Once the values have been introduced, we click on start button, and this button changes its name and it becomes “Next” button.

In Figure 3, we show the tree of states which represents the different states of the process.

Our storm simulator is composed by 23 images, some of them are shown in Figures 4-7.

With this tool we can manage the academic objectives of the didactic unit, so students assimilate all these concepts while they use the simulator.

3. **The Experiment.** Physics is considered by most of the students as a difficult and abstract science. This difficulty is due to the fact that physics makes use of a scientific and mathematic language with unfamiliar terminology and the lack of interest of the students caused by the disconnection between physics as studied in the classroom and the phenomena which we observe outside it.

When the students are asked about this science they say it is an interesting subject but very difficult because there are lots of physical phenomena they cannot observe in their life and they cannot imagine them.

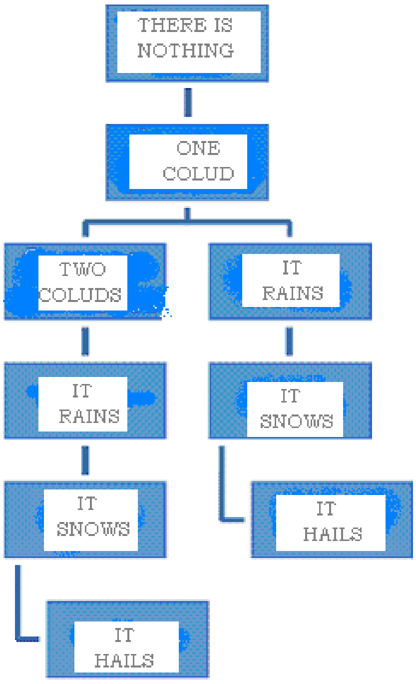

Figure 3. Tree of states

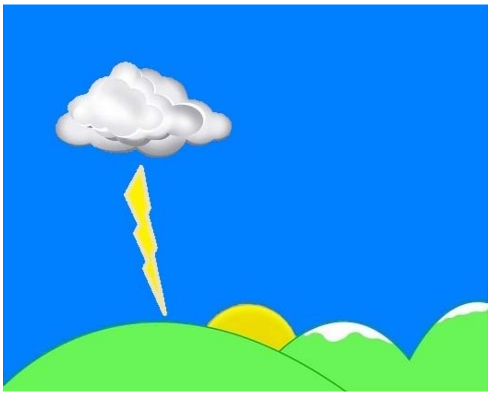

Figure 4. It snows with a cloud and ligthning.

Figure 5. It hails with a cloud and ligthning.

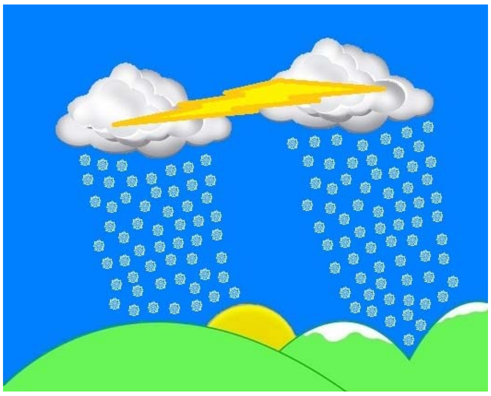

Figure 6. It hails with 2 clouds between both.

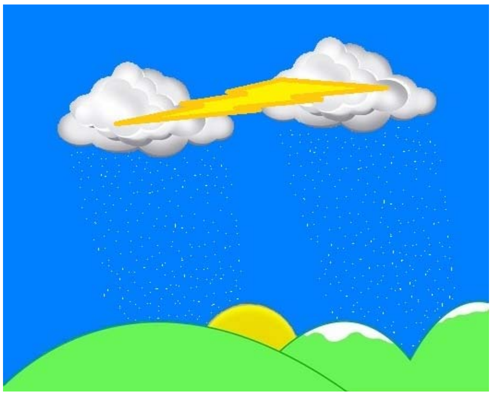

Figure 7. It rains between both.

In a classroom or in a real laboratory, teachers cannot reproduce some important physics phenomena, but with virtual laboratory (in this case, storm applet) they can.

This experience consists of:

- To analyze the use of certain technological recourses as part of strategy in teaching that allows achieving comprehensive learning.
- To determine if the use of external representation (images, animations, simulations and actual experiences) helps students to understand physical concepts.

All the students of this subject, who were in the third year of the degree of teaching, took part in the experience, they were 20: 18 students had never studied physics and 12 of them had not studied mathematics for several years and their ages were among 20 and 40 years old. Because of their lack of knowledge it was necessary to make explanations be slower and the teacher had to explain the didactic unit deeper.

The used methodology was the following:

- The first day, students were asked to make a written test of 10 questions, so the teacher could know the knowledge they had about these concepts. Students also made a questionnaire on their attitude towards sciences.
- The subject was explained for two weeks through magisterial classes. The teacher developed the didactic unit at the blackboard with several books. The students realized lots of exercises and they were asked to take a written test of 10 questions again.
- During the following week the electrical storm simulator was used. The teacher explained the students how to use the simulator, the parameters they had to manage and the concepts they were going to acquire. Finally, students made another test to evaluate their concepts and another questionnaire about their attitude toward physics.
- At this time we had 3 answered tests: previous, during and after experiment. And we were able to verify if the objective was reached and we could compare the results from the two previous texts done by students to check them with the use of the virtual laboratory. We were able to see a change in their attitude towards physics.
- Two months later, students made again a test of 10 questions with principal concepts about "Electric Field". We could observe students had not forgotten most or the concepts.

4. Results.

4.1. Academic results.

The results obtained in the 3 steps of the research are shown next.

As we mentioned above we could compare student's knowledge with the tests they were asked to make. In Figure 8 these results are shown.

The first column shows the result obtained by each student at the beginning of the investigation; the second column of the graphical shows the score of each student once the subject was explained and the last column shows the obtained results when the use of the simulator was ended.

Students got better results after using the simulator than after the class. There are 4 students who did not improve with the applets and only 2 students had worse results with the simulator than with the magisterial class.

We can see the evolution of each student, thanks to the use of the storm simulator.

Two months later students were asked to make another test as we wanted to know if they could remember the most important electric concepts. The results are shown in Figure 9.

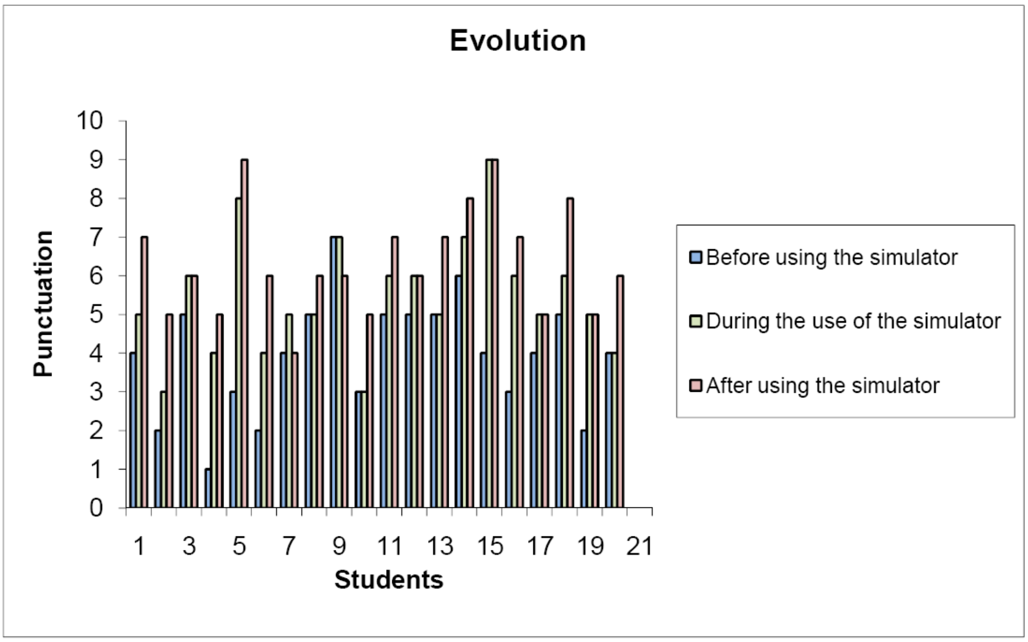

FIGURE 8. Results after each questionnaire

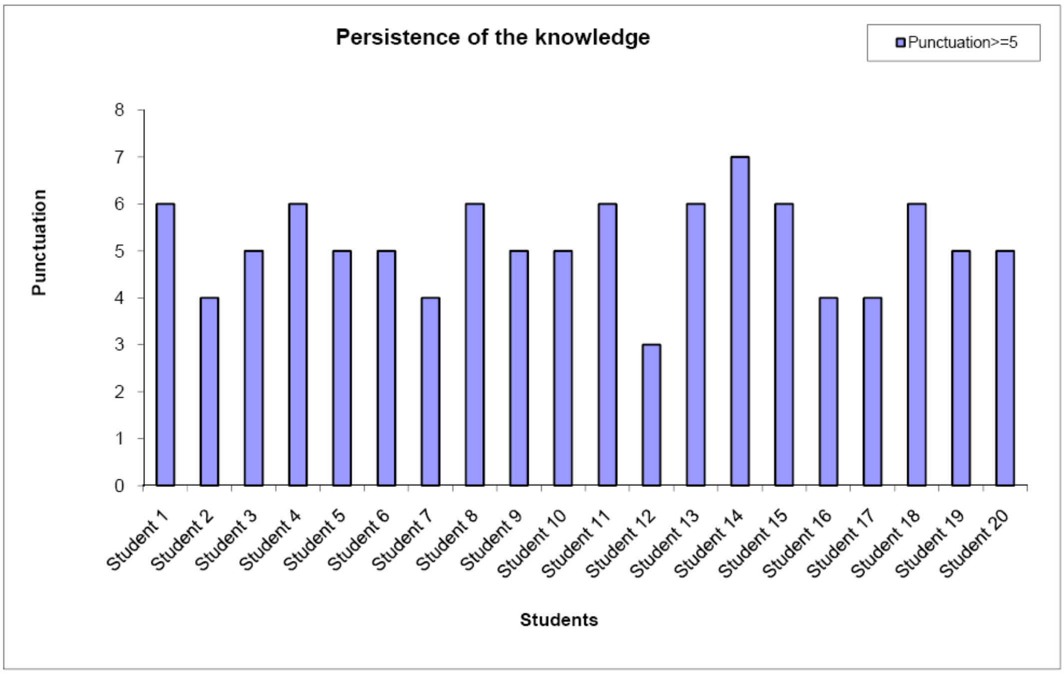

FIGURE 9. Results after 2 months

As we can see in Figure 9, two months later, 75% of the students obtained punctuation equal to or higher than 5; this means that with our storm simulator we obtain good results.

4.2. **Attitudinal results.** The interest of the students towards physics decreases progressively as they grow. Their innate curiosity and interest on science becomes in lack of interest, apathy, boredom and scholar failure at the beginning of secondary [5], a fact that worries nowadays [6].

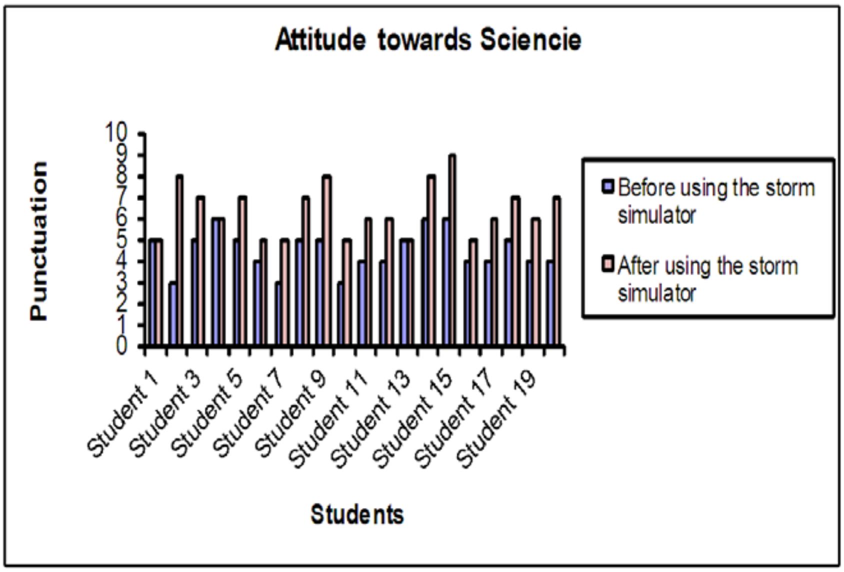

FIGURE 10. Results after 2 months

We wanted to know if using of ICT could improve their interest about science. The students not only answered tests about important concepts, but also about their attitude towards this science has changed. They were asked to answer 2 questionnaires, before and after using the storm simulator.

The first column shows the evaluation of each student towards science and the second one shows their attitude at the end of the research.

This graphic shows students did not like very much studying physics, in fact, they were not interested in it but, after using ICT, their interest towards physics changed.

5. Conclusions.

By analyzing the data of the completed experiences, significant statistical achievements in the performance of the students that took part in the experimental group are observed. An appreciable impact in the use of ICT for the understanding of the different didactic units is shown in Section 4.

This work has allowed us to know the impact that the use of new technologies has in the process of teaching and learning. It is shown that the application of technological resources to represent physical phenomena contributes to improving comprehensive learning of the physical concepts.

We believe that these results, which are shown in Section 4, are due to the students can see and handle a physical phenomenon that teachers cannot reproduce neither in class nor in a real laboratory. In such way they do not have to imagine the process. It is not a question of replacing the magisterial classes with ICT, but to complete them when it is possible.

The results show that, the use of a visual methodology helps to fix and support for a long time the acquired knowledge.

The inclusion of technology in educational centres allows a learning environment without erasing any of the key educational tools necessary to provide a quality learning environment. The increase of technology allows easier and more efficient access to learning materials and lesson plans and greatly increases the speed with which students can complete the same tasks. As long as teachers continue to teach and our students learn at classroom, learning environments will not be hindered by the influx of new technologies available to students and teachers alike.

Technology in the classroom is not just for students; teachers can use the technology to keep students' records, to evaluate their skills and to get and to plan lessons.

6. **Future Investigations.** This application was evaluated with students on campus classroom environments to explore physical simulations feasibility and to get valuable feedback from the potential users. Our experience with this project demonstrates that most learning pedagogies from constructive learning and conversation theories can be adapted for a mobile learning environment.

The key is to understand the strengths and weaknesses of a particular technology, while deploying good pedagogical practices to achieve specific learning goals.

In the future we may realize this experience with virtual students and with secondary school students.

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