Analysis of the relationship between previous ideas about the physics concepts and a poor student's performance in classroom (FECS'14)

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Abstract. - *This paper exposes the relationship between common misconceptions of the physics of movement in the classroom and the serial of previous ideas developed by engineering students along their life with the forced consequence of failed notes and further problems with lectures related with those topics.*
This paper shows the results of a research developed into the Technological Institute of Queretaro in order to identify typical misconceptions about the bodies' behavior in static and dynamic conditions which could produce problems to develop models of our environment. With the obtained information a software system is developed in order to conduct a serial of computer experiments that confronts the student´s ideas with physics laws in order to force cognitive conflict within the student, leading it to the building of new concepts and a better understanding of the lecture.

Keywords: previous ideas, physics, cognitive models

1 Introduction

Desertion and low notes are typical problems that several countries around the world experiment continuously in their day by day educative process. These conditions are normally evaluated as a way to identify the economical amount of resources that every year the country loses for this concept and are the basis to plan strategies oriented to improve the activity into and out of the classroom.

A lot of students experiments certain level of afraid when a lecture of mathematics must be coursed, and in a low number of cases of study, the student considers self-sufficient or with the competence to solve properly a math exercise.
A different condition is identified when the topic of study is the physics, since a large number of students in their own opinion consider this basic science easier than math and with a higher dominion of the topics related to the discipline. Nonetheless this point of view from the students, the rate of failing is close to the 50% of students in all engineering programs [1].
This condition is the result several factors acting simultaneously including large number of lectures per day, the cultural influence of mass communication media, a lack of criteria to discern the quality of information that the individual can find in the internet lots of misconceptions learned along the student´s life. All these can be conditions that could lead a student toward low performance in classroom or to fail a course, because they are not able to establish logical connections between the learned theory and their real life experiences.
In the particular situation of physics lectures three elements are common: a low level in math, a low development of abilities to establish connections between theoretical concepts and real life situations [2] and previous ideas about a topic that act as an inhibitor of the learning process [3].

In order to identify what kind of wrong previous ideas our students of engineering have, it was applied the “Force Concept Inventory” (FCI), it is a test with multiple options developed in 1992 whose main objective is to evaluate if the student is capable to do a right answer in physics problems nonetheless the great quantity of failed concepts learnt for the individuals along their entire lives.

2 Misconceptions detection

2.1 Structure of the test

The first step was to apply a serial of tests to students of computer engineering with 10 questions selected from the “Force Concept Inventory” [4], about the bodies´ movement understanding.
The test is designed explaining a possible situation of a body under movement and the student must think about the logical answer that could join the situation with the information and experiences that previously the student has obtained.
Every one of the questions contain the description of one of such situations, most of the times a picture that shows several options to describe the behavior of the body and a total of 5 options to choose one of them as the right answer.
The next example can explain the nature of the questions and the level of misunderstanding about the topic in physics.

“A canon ball is launched at 0 degrees. What option can describe the movement of the ball mass after it is out of the canon?”

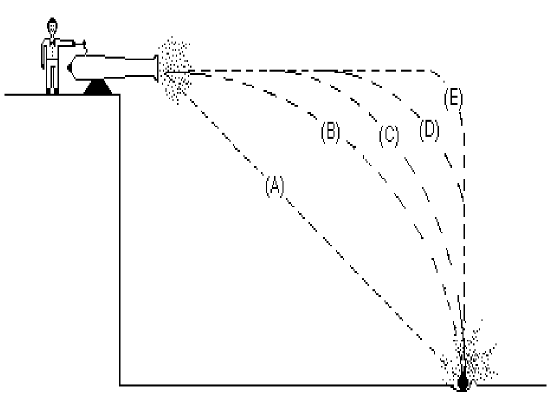

Figure 1 Question example

With the following results

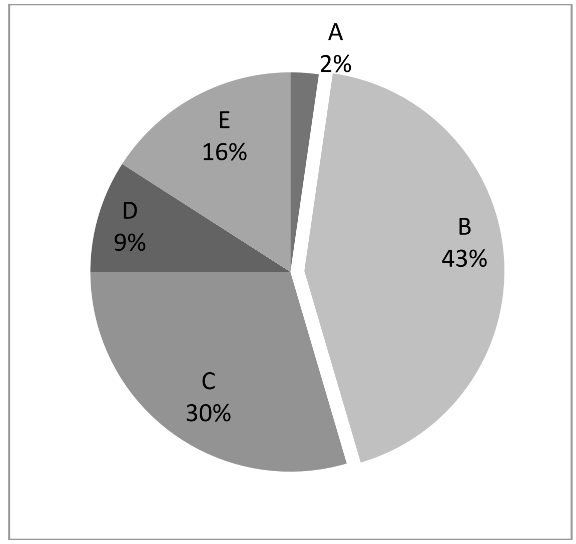

Figure 2 Question number 4 selections

The graphic shows the number of students (43 %) that chose the correct option (B), it corresponds to one parabolic movement given that the combination of movement vectors along x axis with constant velocity and the vector along Y axis with accelerated conditions because the action of the gravity.
It is important to check the high number of students that chose option E nonetheless the impossibility of such movement condition. This number of responses can suggest that there are several involved factors that lead the student to consider as valid possibilities those that normally in the real life are not considered as a typical response of a system.

2.2 Validating proposal

At this point it was necessary to validate if the previous ideas can influence the mental procedures of one individual to consider possible movement conditions that the serial of experiences in our life have shown that are not valid.
Another question from the FCI requests the movement behavior of a body that is dropped from an airplane in flight. The 5 options show different combination of movement but only option D is correct.
The next 2 figures define the quest conditions and the percentage of students that selected it. The

result show several difficulties for the individuals to understand the behavior of bodies under movement.

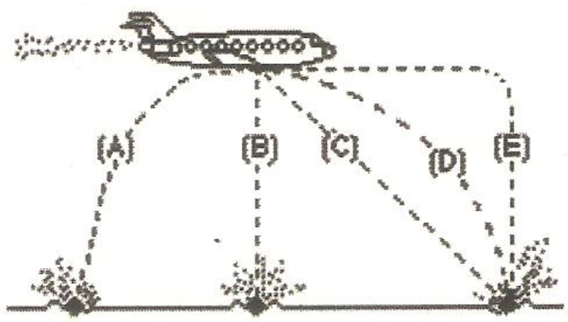

Figure 3. Dropped body movement

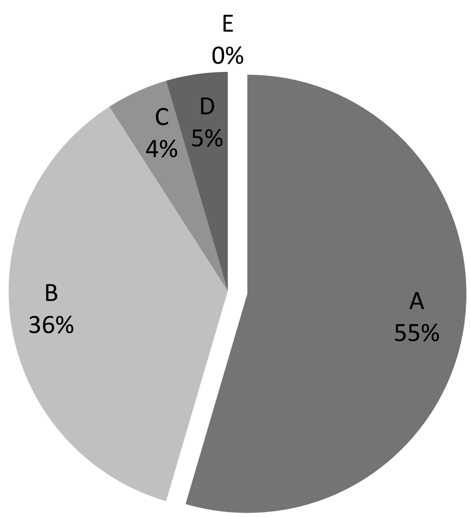

Figure 4 Plane question results. This test was made to students that have not studied the formal physics course

With this information it is obvious that a large number of students have troubles to establish proper connections with a proposed condition and the physics laws.

2.2.1 Knowledge in physics

Another hypothesis formulated to define the potential reason of this kind of mistakes is that most of the students in second semester have not matriculated the course of physics and it can be one reason of the obtained results.
Again, the same test was applied to different groups of students of computing engineering but now with the difference that they had completed and covered the conditions to validate the lecture. This condition should improve the number of right answers in the same test, because of the serial of experiences and academic resources applied into and out of the classroom.
The next graph shows the result of the plane question with students that had approved the physics course:

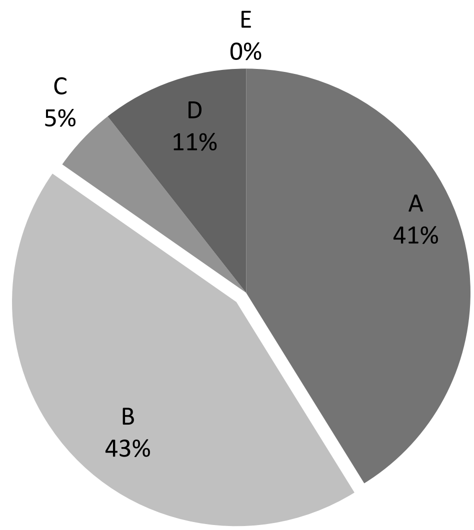

Figure 5 Plane question and results with students of higher levels after the physics course

It means that the impact of the lectures in the understanding of physics laws is poor, because only 11% of students concluded that D was the right option in comparison with the original 5%, and the number of students that selected option B increased in a7%.
The total test let us to conclude that, the information provided in a typical program of physics is not enough to change the understanding level of the topic and it is sure that this condition will affect the performance of the student in consecutive courses given that serial of mistakes that the individual is carrying on.
In order to identify the more important reasons of this condition a secondary research was done. It was found that most of the students that were wrong in the first study have a great influence of the concepts and situations that the mass media such as TV, video games and movies show.

Figure 6 The roadrunner® illustrates the impossible cartoon physics

2.2.2 Applying software and hardware to develop experiments

Most misconceptions about physics are about science in general, but these are most obvious in the case of physics, because of all the sciences it is the most foreign to most people, because it seems to relate the least to everyday events. In fact, the opposite is true, since physics applies to everything, while the other sciences are more specialized. Physics school experiments play a crucial role in motivation of students in physics education; these experiments form a crucial element in effective cognitive motivational teaching techniques.

One of the most cheap and powerful tools available today for measuring results in an experiment is the Arduino® board, a cheap readily available microprocessor board designed right from the start to let non-engineers make use of computer-control for projects. According to the official web site (www.arduino.cc), "Arduino® is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software."

The advantages to guide a test and experiments under Arduino® platform is the possibility to validate the behavior of a body under movement applying sensors that can measure the variables that are being studied, and at same time the student interacts with electronic systems increasing by this way the point of view and synergetic behavior of the future engineers.

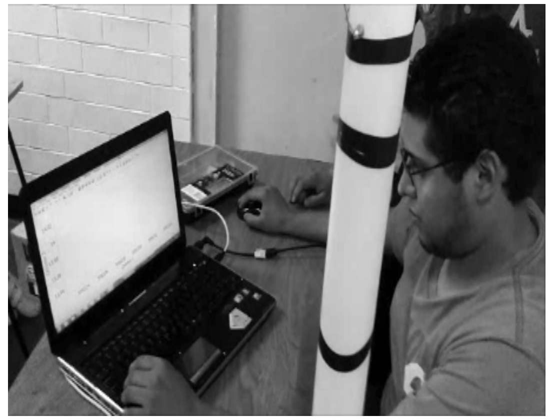

Figure 7 Programming the Arduino board

Arduino® can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. This can be used to make a powerful recipe for engaged learning: Show students how to command actions in the physical world – make lights blink, sounds sound, motors move, robots roam, sensors sense. Combine this concrete act of control over physical objects activity with the abstract power of programming – show students how to make those lights blink in response to the sounds, make the sensors guide the motors.

Figure 8 Free fall systems

The students at the Technological Institute of Querétaro designed and implemented several experiments to show the behavior of a free falling object, using basic sensors to send the signal to an Arduino board in order to measure the speed of a body under the acceleration of gravity. They programmed the required software to make sense of these data, and proceeded to draw conclusions after comparing these results with their previous ideas about this phenomenon, which often led them to a cognitive conflict.

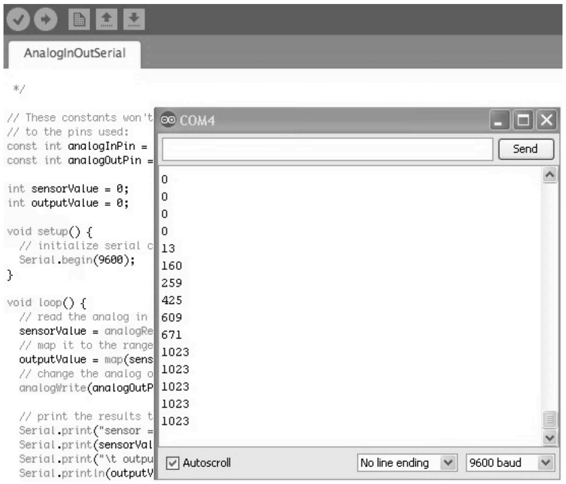

Figure 9 Source code based upon the Wiring programming framework for Arduino, and obtained data from the free fall experiment

2.2.3 Obtained results

The obtained results with the tool were totally satisfactory. All the groups of students were involved in the solution of an engineering problem that required the development of a serial of abilities and competences, not only in physics, because it was required to practice with sensors, programing and to understand the ways to stablish the interface with a computer to get the results of the experiment.
After this experience the group (not the same than the original data) was requested to answer the test and the graph can show us the difference when a tool able to validate or refuse our ideas and concepts is applied.

This result tell us than it is possible to improve the level of understanding in a topic if the proper didactictools are applied.

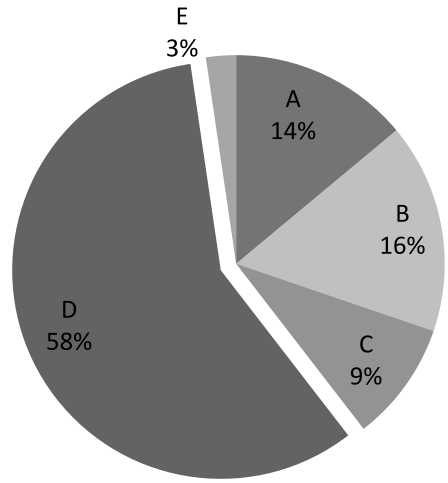

Figure 10 Number of right answer D, after applying the Arduino board.

3 Conclusions

This time is plenty of electronic resources that allow the students to get information about all kind of topics; unfortunately, more information does not mean more understanding of the topics to the students.
It is important to the teacher into the classroom to adapt the new technologies with the learning process looking for a way to improve the performance of the students

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