LEARNING OF PHYSICS, BELIEFS AND ATTITUDES OF STUDENTS OF ENGINEERING, AN EDUCATIONAL INTERVENTION

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Abstract

Both, students and teachers have beliefs about physics and the nature of science itself, which could promote negative attitudes and contribute to the difficulty of their learning. Beliefs act as singularly powerful perceptual filters and create results, limiting beliefs usually revolve around the "cannot". The beliefs that we build based on our own or shared by the collective experience have an impact on learning, learning sciences, particularly physics could be a charming experience for some, while for others it can be terrifying. It has been seen that if students possess a deeper understanding of the process of science, instead of focusing exclusively on their results, they will have a greater ability to refute or resist common attitudes to the pseudoscience, becoming critical people who will be able to make decisions based on arguments.

To explore the beliefs of students about their learning and physics; It was designed the Colorado Learning Attitudes about Science Survey. This survey distinguishes between beliefs towards Physics on expert students and novices and identifies how these beliefs are greatly modified due to teaching-learning strategies designed and applied by the teacher. An educational intervention in a college physics course, was performed in order to know if the proposed education strategy changed beliefs towards Physics. The test was applied at the beginning and at the end of the instruction, the results of the analysis indicate that students reported a profile of responses Pro and in accordance with the opinions of experts in most of the categories measured by the instrument after the lesson, especially in problem solving and confidence to solve these problems ensuring that they could find a suitable way on how to solve problems although not being able to find the solution easily, they seek different ways to propose alternative solutions, which favors not only conceptual learning, but the development of Metacognitive of higher-order skills to deal with and solve a lot easier those things that they do not know and how to find the information and the search for errors. This paper describes both, teaching methods and changes in beliefs in the various categories that are measured with the instrument, which have had an impact on attitudes towards the usefulness of physics and its use in engineering.

Keywords: Attitude about Science, Educational intervention, Students beliefs, CLASS.

1 INTRODUCTION

The debate that in the last 30 years has arisen in the educational processes related to the sciences, is precisely, the utility that these have in the life of the students of higher education. Beyond education and accreditation, Sciences allow a better understanding of the world that the students have to face at the end of his career. The National Research Council [1] has developed a series of recommendations on the incorporation of skills for the use of the sciences that can be carried out by university students. These are: adaptability, social commitment and communication skills, problem-solving skills non-routine, self-knowledge and self-development and finally critical thinking. To develop scientific skills in the university students [2], there are established four strategies that exist to develop the concept of utility of the sciences:

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To understand science. Requires that integrate different fields of science, and are considered to be the social aspects of how the sciences are acquired, understand and apply in everyday life. It is a question of the students recognizing the interdependence that involves the concepts of the nature of the science and the scientific models.

To do science. Requires the students to participate in real-life scenarios of science. The investigation processes in the classroom, provide sufficient tools to adapt their scientific knowledge in real world conditions outside of the classroom; that is to say, transfer their theoretical conceptions in practice.

To communicate science. Requires an understanding of the scientific terms and the way in which they can be interpreted in other spheres of life. Includes the internalization of terminology to share with other audiences their experiences of scientific learning. The popularization of science is also part of this capacity.

Conscience in/for science. Requires coping skills and social commitment beyond the schooling. Possess a conscious thought of the impact of our actions as human beings.

The beliefs toward science and its usefulness to the students are a determining factor in the learning process, the favorable attitudes toward science and toward the scientific discipline of study, contribute to the learning. [3],[4],[5],[6],[7],[8],[9],[10],[11],[12][13]. Precisely in order to explore these beliefs, the design of a class (Colorado Learning attitudes about science Survey), an instrument that has been validated and developed at the University of Colorado by the draft Phet (Physics Education Technology) and the research group on physics teaching PER@C (Physics Education Research Group at Colorado).

The instrument was developed based on three surveys known Maryland physics Expectations Survey [14], the views on the Survey Science (VASS) [15], and beliefs epistemological evaluation on the Physical Sciences [16]. CLASS was developed with statements as clear and concise possible, consists of 42 questions with a Likert-type scale (agreement - disagreement). The statements make a measurement in 8 categories: connection with the real world, personal interests, internalization of the physical, conceptual connections, understanding and application of concepts, general troubleshooting, security in the solution of problems and sophistication of the solution of problems. Each category consists of between four and eight sentences that define a specific way of thinking [17]. In the current version of the survey (version 3), six statements do not yet have a response "expert" and are not included in the analysis.

The authors recommend that the test to be applied before and after the instruction and an analysis of factors [17]. It is possible to identify and classify to the students who come to a way of thinking specifies, either as experts or beginners, the results may contribute to evaluate a method of instruction as it has been seen that the beliefs of students toward science and toward the nature of science affect their learning [3]. Although recently it has been proposed by a group of researchers that the instrument CLASS presents problems in the validation and propose an abridged version of categories, another group of researchers have defended the categories originally proposed by Adams and his colleagues, arguing that the instrument was validated not only from the application of statistical methods, but the results were contrasted with the interviews with hundreds of students who participated in the study [18]. For this work is using version 3 of the class that has been widely accepted by researchers in science education throughout the world in the past 10 years.

2 THE EDUCATIONAL STRATEGY

In the approach to science, technology and society (CTS), the student is to be understood as a social being, product, and protagonist of multiple social interactions in which involves throughout their school life and non-formal where knowledge cultural are rebuilt with the contribution of the other members of the academic community from collaborative work, in order to understand and propose solutions to problems of context based on science. Promote the appreciation of the structure and mechanisms of the natural sciences and social sciences is one of the main objectives of this approach.

The Recursive Model of Science education (REC) whose characteristics are described in table 2 has been proposed to develop didactic sequences considering the current interests of the University for Purposes of construction of scientific contents immersed in real problems for this build and rebuild your learning and appreciation about the contents of the sciences of nature [20]. It is believed that as the students identify aspects relevant to the discipline, it is easy to learn and solve problems in a manner closer to as scientists do.

Table 2. Components of the Model REC for the development of didactic sequences in the science class university.

Authors	Suarez-Rodríguez, Mora-Ley, Ramírez - Díaz, 2015
Educational Level	College
Model	Recursive model of teaching of the Sciences (REC)
Oriented to:	Oriented to the contextualization of academic content in such a way that pupils can go by linking the science, technology and society as a whole synergistic knowledge.
Didactic components	Socio-techno-scientific and didactic analysis.
Consider	Current interests of the pupils Social context in addition to the education context learning. Beliefs and teaching Mediation Metacognition Explicitation of the students Experimental work. Construction of explanations Confrontation of ideas of the students Consolidation: application of the built models
Approach	CTS, nature of science and the nature of the teaching-learning
Discipline	Sciences

Source: own

In this work you want to know the impact that has instruction on beliefs about the physical and the utility of science. This sequence didactics considers as academic content central the fall of the bodies, this didactic sequence considers as academic content central the fall of the bodies, within the components of the academic content is considered important that the students identify the variables present in the fall and when it is considered as free fall both qualitatively and quantitatively. This didactic sequence considered for each academic content to work the application of a teaching strategy, in this case has taken the seminar Socratic inquiry as a strategy for the introduction of this physical situation, the planning described in table 3.

Table 3. Planning Scheme of class considering the components of the Model Recursive science education.

Didactic sequence: Fall of the bodies.	Session: Conceptual evaluation on the present variables in the free fall.	Subject: Fall free
Taxonomy level SOLO: Expanded abstract. Uses a general principle and abstract product from your analysis and you can generalize to other contexts. Able to make assumptions based on general principles. [19].	Objetives: Identify the variables present in the fall of the bodies. Propose alternative methods for the calculation of the speed of falling bodies.	Cognitive skills: critical thinking. Beliefs and Attitudes: Recognition of the utility of science and physics.
Resource: Critical reading: A jump of faith of Daniel Michaels, published by Dow Jones Newswire original source. Forms part of the anthology of readings in the field of physics, authorship own.		Group: PHYSICS for engineering.

Description of the strategy	What does the teacher do?	What does the student do?	Complementary notes
Contextualization and recognition of previous ideas.	The question appears: Can a man jump of a balloon to 40 km high and survive? What happens with the speed of the parachutist during the fall? What characteristics must the wardrobe of the parachutist have and why?	Explains what you know or believe about the subject. Analyzes with regard to the questions, and your experience. Record your answer in the manual without share it at this time with other students.	Manual: Anthology of readings on the subject of physics, reading number 6, page 36. Own authorship.
Management of learning materials.	Requests the student to start reading.	The student will read the document individually.	
Verification of reading comprehension.	Ask the student's response to section 1.	Later will give answers to the questions of reading comprehension.	Section 1 consists of 10 questions to be evaluated with F or V with which the level of understanding about reading student is identified.
Confrontation of ideas of the students	Make questions or activities that allows you to recognize what the activity students expect and what they already know.	In plenary session the students will present their answers to check the level of understanding group and clarify doubts.	According to the answers be defined words that are not understood by the students. With the help of Professor in order to ensure that the text has been explored and understood.
Work with the text	In an individual way or collective help to the students to interrogate the text, question it and especially they understand it.	Responding to question 1 of section 2 of the reading. "Determine whether the article is true based on the results and issue an own conclusion based on their results displayed in reading".	Students will share their position through arguments that will sustain with the data displayed in the article.
Metacognition	Write questions that will help students to develop their arguments and understanding of the text (this can be done in groups or in round table).	The learner is asked to answer questions 3 and 4 individually. 3. Perform calculations on the speed achieved by the skydiver to each of the distances mentioned in the article by applying the model to free fall. 4. Contrast the results found for you with those reported in the article, would justify these similarities and/or differences. The free fall believes q despise the resistance of the air is desirable in this case? Justify.	Subsequently will meet in small groups where they will share their results and reach an agreement sidewalk of the individual responses.

Experimental and conceptual formalization. Construction of explanations	Moderates the presentation on other questions that are open or that are generated during the discussions. Focusing on the question of what we learned?	Will respond to the activity 5. 5. Prepare a Power Point presentation where you submit calculations and comparison with the results of their group, also try to explain the results if necessary investigate the causes of the differences between them and report them. Use equations that describe the movement, make graphs and compare the results.	Each collaborative team will appoint a representative who will expose the presentation with their results to the group. Appoint a moderator to monitor activity and a rapporteur which makes Group annotations. Which will be recording in a table on the Board.
Socialization of the work	Professor formalized expected learning students have acquired as a result of the activity of class. The teacher initiated a reflection using the results proposed by students and used calculations and obtained errors to give the results related to the mathematical model.	Students will participate by responding to questions or defending its position raised above, as well as developing the group conclusions from the results.	
Consolidation. Application of constructed models: applications to similar problems.	Professor exposes that the difference between results obtained by the students is due to a variable that affects the fall has not been considered, and students asked to develop a proposal with the relevant calculations which explanation to this variability.	Subsequent to the intervention of professor students will propose new variables to explain this fact, by teams will present their results, giving continuity to the Power Point presentation.	During the work in the classroom may use different materials for consultation to obtain the information needed for the development of their proposals.
Consolidation. Application of the models constructed: applications for transfer to other contexts.	Based on the question of what happens if the jump is performed from the surface of the water at the bottom of an abyss? Moderates a discussion about what you can do from now. Professor exposes that the difference between results obtained by the students is due to a variable that affects the fall has not been considered, and students asked to develop a proposal with the relevant calculations which explanation to this variability.	After the intervention of the teacher the students propose new variables to explain this fact, teams presented their results, giving continuity to the presentation Power Point.	During the work in the classroom may use materials in book, text book, go to the library to obtain the information needed for the development of their proposals.
Evaluation strategy	Evaluates individual participation with evidence left in the manual. And a header indicating the level of performance by teams. Students will make a vote using remote controls at the end of each exhibition to promote the evaluation between peers and to facilitate the capture of responses.		

Evaluation Criteria	The realized calculations will be valued, and the proposals that give explanation the difference of the results calculated with those reported in the article, as well as the graphic description of the movement and the quality of their exposure.
Work in other academic settings	Conduct a search that sustain the arguments.
Notes of the teacher	Students will be expected to consider that the differences are due to the decrease in the strength of gravity under away from the earth, for this shall calculate the variation of the acceleration due to gravity, prior research on how to do it. Some will award to the effects of the force of air resistance and in the same way they would seek out the way to calculate, it is possible that some students understand the concept of speed terminal and integrate their explanations. This way of dealing with a problem of free fall will encourage reflection on the causes of the movement and effects of resistive forces on speed. Which will contribute to the conceptualization of the dynamics.

Source: Own.

3 METODOLOGY

Once applied the REC model in the construction of the teaching sequence were designed activities and materials that make up the strategy. To learn about the beliefs applies the CLASS, the students had a time of 45 minutes following the indications to answer. The instrument was applied to 17 college students, all of the participants in the study ended up responding in one less than that time period and all answered correctly the response of both the pre and post test security. After the pre-test agreement intervention strategy applied to table 2 activities and at the end of the application of the teaching sequence, applied the pos-test. According to the results the students' interviews were conducted in order to obtain more information.

4 RESULTS

The data were analyzed using an analysis of factors proposed by the research group at the University of Colorado [17], the results of the analysis indicate that the students reported a profile of responses favorable and in line with the views of experts in the majority of the categories after the instruction, especially in problem solving and the confidence to solve them, which presents a more favorable exchange rate, approaching the views of the experts as shown in Figure 2 by ensuring that they can find a proper way of how to solve physical problems in spite of not being able to find the solution easily, are looking for different ways to propose alternative solutions, which favors not only the conceptual learning but, the development of metacognitive skills of higher order to confront and solve more easily those things that don't know and how to look for information and the search for the errors.

In the categories that are more in disagreement with the experts continue to think that physics cannot be explained without mathematics, although his vision remains wrong, has changed with the instruction. Have travelled to consider that the problems were resolved by applying a mathematical formula to obtain a requested value to consider that they can represent physical phenomena through mathematical modeling, for example the student S03FISCARHS13H argument in the initial interview "the physical problems are resolved with a formula that we have to choose which gives us the professor", in the final interview explains that "all physical phenomena can be expressed with the mathematical models and can be resolved using calculation".

The conceptual error that is seen in the arguments end may be due to the fact that during the investigation gave emphasis to the calculation as a tool. This leads to the thought of integrating in subsequent courses a problematic situation that requires other mathematical tools and to further explore this concept and its involvement in the learning of physics.

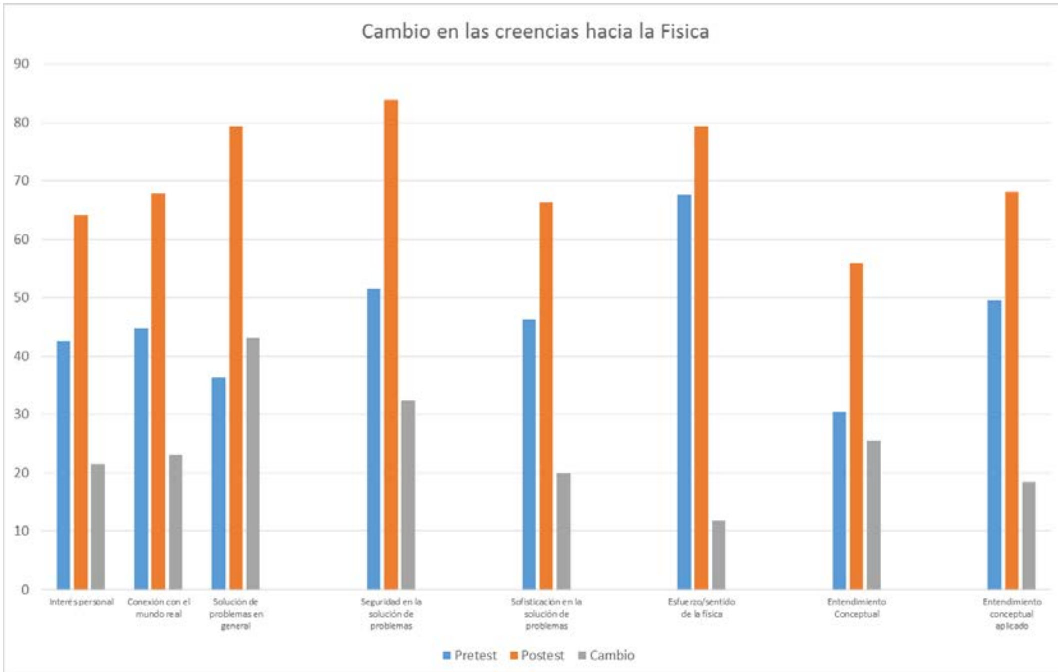

Figure 2. Percentage of responses related to beliefs towards Physics according to experts in each category by group. Source. Own elaboration.

In Figure 3 shows clearly how students passed to take views against those of the experts to have views more suited to this. The importance of this result lies in that the CLASS believes that this change is related to the instruction. (Voltaire, 2009), what evidence to a large extent that the activities included in the sequence didactics have positively influenced the beliefs toward the physics of the students.

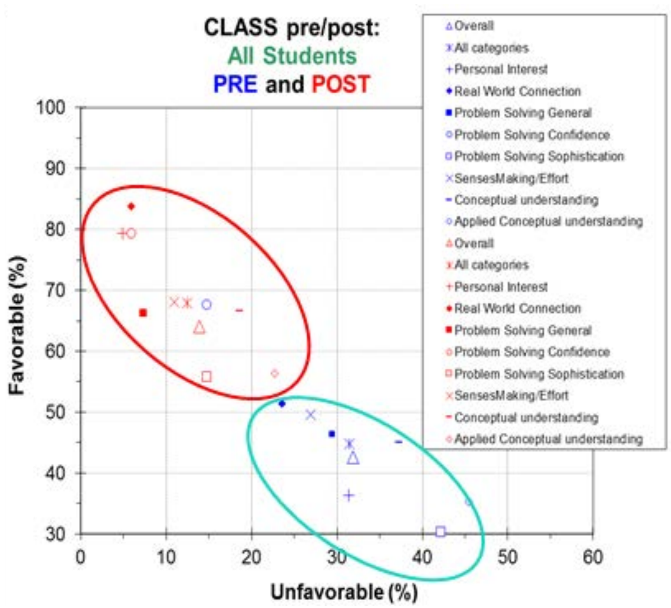

Figure 3. Change in the beliefs toward physics in the students, the chart shows in red the results of the post-test and in blue for the pretest. Source: own.

In Figure 4 (A) you can see the percentage of students that have favorable public statements in both the pretest and the posttest, this transition evidence that students have changed their statements as novices approaching more from that of the experts. Figure 4 shows the transition of disagree with or beginners. Below are analyzed by category the results.

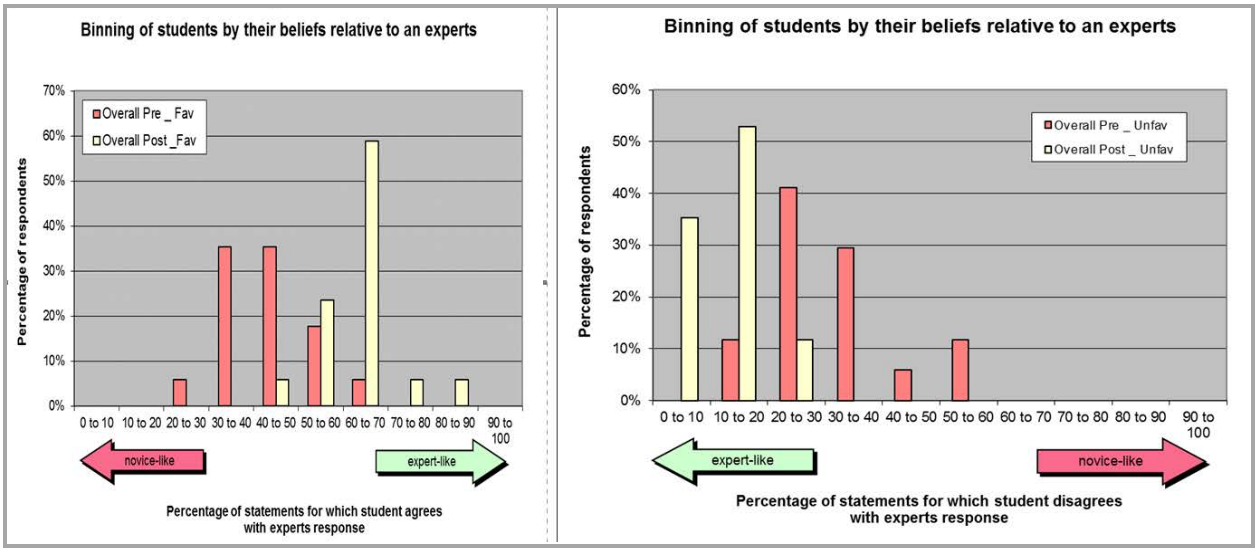

Figure 4. Comparison of students in the pre and post test in terms of beliefs toward the physical. Figure A shows the transition of the views coming from novices to experts, in Figure B in disagreement with the newbies. Source: own

✦ <u>*Personal Interest.*</u>

In this category are investigating whether the respondents see a connection with the study of physics. In the students found a statistically significant increase in their favorable responses to this category, out of a 36.3 per cent in the profile of pre-instruction to 79.4 % in the profile following the instruction. When asked "I think in the physics experiment in everyday life" [Question # 3], only 8% gave an answer that is contrary to the opinion of experts". In all the questions in this category, there is a transition to the opinion of the experts in what we can infer that the students realized that the ideas learned in class and the skills are useful in daily life in addition to that changed his perspective toward the solution of physical problems as evidenced by the change of 50% in relation to question 12.

✦ <u>*Connection to the real world.*</u>

Asking the students if they think that the ideas learned in a class of physics are relevant and useful in a wide variety of real-world settings. The favorable responses percentage after the instruction and the positive changes in their responses in this category is the 32.4 % reveal that the course Introduction to Physics was successful in demonstrating the link between physics and their real-world experiences. Students reported that "think about their personal experiences and relate to the topic being discussed" [Question 37] since 71% said they agree with the experts. The biggest change is presented in the statement 30, which recognize the skills they need to learn physics and can be used to solve problems outside the classroom, this result together with the statements of question 11 on the issue of the recognition of the work that you have to do to achieve a goal evidence that students have had significant advances in their metacognitive skills.

General problems solution. he results of this category are asked the students how they perceive the role of mathematical formulas to express relationships between physical quantities, have had a considerable change recital at the end of the statement that mathematics can be useful in the interpretation of the problems, recognize that some parts of the equations represent characteristics of the phenomena in particular, they recognize that to understand the physics is necessary to work in spite of not getting the solutions in a first attempt. Although on the other hand recognize that not all individuals have the capacity to learn physics, to ask them why they argue that in order to learn physics you need to know various that we are easy to learn if you are not working hard.

✦ *Confidence in the solution of problems.*

Test if students are able to find a way to solve problems in physics, especially when they are difficult to resolve and are stuck in the initial proposal to address the problem. It is noted that students do not leave to deal with a problem to find difficulties in the solution, but rather pose different proposals and recognize the importance of listening to the ideas of their peers which favors the collaborative learning.

✦ *The sophistication in the solution of problems.*

Determines whether students are able to apply a method used to solve a problem of physics with other related to the problem or situation. They have changed their position since it considered that can solve a problem of physics at the end of the instruction.

5 CONCLUSIONS

The transition from the beliefs of students from beginner to expert has allowed us to recognize that the educational intervention has encouraged the development of critical thinking that has led to the identification of problems, development of alternative responses to the solution of problems. The activities proposed in the sequence didactics have contributed to visualize the physical as an alternative solution of problems and understanding of the real world, and this thinking is useful for students' address the problems of engineering with a justification theorize. The individual activities promote the assimilation of the contents and group activities encourage team work, the valuation of the proposals of others, respect for the diversity of ideas and tolerance, characteristics considered important for scientific development. It is expected that the change beliefs toward physics and toward the usefulness of science impact in the development of future for engineering students.

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