Interest in Physics courses for Biological and Health Science students in High School

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Abstract. This work presents the electricity topic from a Physics course for Biological and Health Science students in High School. These students believe that Physics is not relevant to their future career or professional life. They consider themselves incapable of succeeding in the subject unless they learn by heart a lot of mathematical formulas and use them in the exam. In this way, we exposed the relation between Physics and Biological and Health Science, showing them the Electricity involved in biological phenomena. It has been observed how student's attitudes change depending on the examples and contexts used in class.

1. Introduction
In Mexico, the teaching and learning of science in High School, is a challenge for students and teachers, mainly because most of the students tend to consider science as something not related in his future daily work worsen by the tendency of many teachers to use traditional teaching methods, where the teacher is a transmitter of knowledge, and the student is a passive receiver.

In the case of Physics, and particular Electricity, teaching is further complicated due to the high degree of abstraction of the concepts involved and the use of mathematics as the natural language that allows describing in a few equations more than one phenomena that can be observed in nature and also in daily life. Furthermore, the teachers are faced with the learning problems that students have developed in their mathematics classes. It is undeniable the need to design and implement innovative teaching strategies in which new resources are used, such as the creation of appropriate learning environments, and tools like Information and Communication Technologies (ICT). In this way, meaningful learning is also available, but students are also motivated in scientific explanations of what they observe in their context, trying to connect to their interests.

In the specific case of Mexico City, in the last year of High School, students (approximately 17-18 years old) choose a curricular area. In this context, most "Physical-Mathematical" and "Life Science" students take a compulsory Physics course. Those courses must be different because of the approach, but in many cases, these two courses are almost the same, not considering the different interests of these populations [1]. In the last update of the curriculum, a clear differentiation between the examples and applications that should be presented for the Physical-Mathematical and Life Science areas is done; however, many teachers still do not take these suggestions into account. This work's importance lies in bringing to High School Education recommendations that appear in research, mainly related to Introductory Physics for Life Sciences at the University.
For the Biological and Health Sciences students, this is probably the last course of Physics in their academic life; this applies to those who want to get at the university in careers like biology, dentistry, medicine, nutrition, psychology, and others. In general, this group of students thinks that Physics is not necessary or useful for their careers and neither to their professional life, mostly because the examples used in Physics courses are related to Engineering and Physics [2]. This thinking provokes a generalized demotivation and that many of them just attend with the only goal to obtain a good grade, no matter if they learn something or not.

Most of Biological and Health Sciences students consider that they are not good at Physics because it is identified with solving algebra problems that do not need to be understood to obtain the right answer, so they are only interested in being promoted and so, they quickly forget anything related to this subject. We know that learning is achieved when the student wants to learn significatively, is interested, and the student thinks that is capable of learning and understanding the subject matter [3]. Therefore, the first thing that the teacher has to do is convince them of the usefulness of the subject and that they are qualified to learn it.

In this way, we propose a course in which Physics applied to Biological and Health Sciences is used to potentiate the emergence of significant learning. With this proposal, we hope to help students build relationships between Physics and their interests, allowing them to apply Physics to authentic examples of daily professional life [4]. It offers frequent opportunities for students to work, reflect, and establish specific connections between Life Sciences and the Physics they need to learn to become a better professional.

2. Proposal

In order to generate a genuine interest in the students, a more active class is proposed where the teacher is not the only speaker but a moderator that allows collaborative work and generate the discussion among peers, thus promoting meaningful learning based on experiences, allowing the student to see the precise relationship between Physics and their professional and personal interests.

In this work, the critical Physics topics are related to Biological and Health Sciences issues. This subject's schedule includes two sessions, by week, of two hours each, divided into theory and laboratory. Most of the laboratory sessions are used to introduce the topic and catch the interest of students.

We bet that the wrong attitude and low expectations toward Physics of this group of students may be changed if the teacher provides Physics examples that can be related to topics of interest in their career and shows high expectations in their learning. Therefore, the key to this work is based on contextualization and the communication of teacher expectations of student outcomes [5]. It is supposed that this may change their self-perception and positively modify their opinion towards the subject.

In the pedagogical context, the object of study of this problem should not be the transmission of knowledge or teaching but understanding. Several studies indicate the importance of using recreational activities and the emotional connection in the teaching of experimental sciences, given the nature of the teenager's brain development. Johan Huizinga [6] states that we learn better if we feel joy. According to this author, the game "permeates all human manifestations and their relations with the world, defines human behavior and development in social, cultural, emotional and of course, educational skills, all of them related to the construction of knowledge." On the other hand, Piaget and Vygotsky also pointed out the value of recreational activities in learning. For Piaget, the game facilitates the understanding of what has been assigned by adding a social meaning, while Vygotsky points out that the game is a tool that helps in the creation of the Next Development Zone.

If we want to understand the human being as a playful, biological, social and cultural subject, it is necessary to radically change the concept we have of education, closely linked to that of instruction, and introduce us rather to that of training, understanding of human development, where playful collective subjects must prevail and therefore knowledge. Assuming that the use of methodologies that include play can be very useful in the search for meaningful learning, in this work, some activities were implemented whose determination was motivating to the students while facilitating the comprehension of concepts that need high abstraction level [7].
To promote meaningful learning, we use situated learning, that is, to focus teaching on authentic educational practices that must be consistent, potentially meaningful and where the student should learn by participating in the same type of activities as experts in different fields of knowledge. If we consider a Vygotsky vision, learning implies that the symbols and signs of the culture and social group to which they belong are understood and internalized, and it is done when students appropriate cultural practices and tools and feel comfortable interacting with more experienced ones.

Some of the didactic strategies (based on experiential or situated learning) in this work to promote meaningful learning are:

i. Case analysis
ii. Practices located or on-site learning in real scenarios.
iii. Work in cooperative teams
iv. Exercises, demonstrations and simulations located

All of them are focused on the construction of knowledge through real contexts, on the development of reflexive and critical abilities and high-level thinking, and participation in the community's social practices.

2.1. Experimentation in Physics

In Physics subjects, experimentation can be an essential teaching resource that encourages learning. Through the experiment, the student is confronted with the physical phenomenon to be studied and motivated to generate a formalism. Qualitative and quantitative experimentation develops curiosity, leads to discussion, demands reflection, the realization of hypotheses, and a critical spirit; it develops the ability to analyze results and analyze correctly. Besides, it helps to develop the student's perception to relate to science and technology, although the peculiarities should not only be attributed to experimentation, but to research in general, where experimentation is fundamental but is not the only one.

However, despite the importance of implementing experimental activities in teaching Physics, theory and laboratory are usually separated in many courses. The laboratory is the ideal place for quantitative demonstration through experimentation, to clarify concepts, to verify or induce laws; it is the perfect space to learn to use knowledge in real situations. On the other hand, many times, the teacher's motivation to work with experimental activities disappears when he does not have access to the material, space or time to carry out an appropriate class.

It should be noted that experimental activities, when used correctly, are often a motivating and useful tool to positively orient students' approach to science. Through observation, students can be guided to the construction of simplified explanatory models, which, with the teacher's help, can bring it closer to the scientific model. This is most easily accomplished if theory and practice go hand in hand.

3. Work Description

From the very first moment, the teacher involved the students with questions about their everyday life in making connections between their conceptions of what is happening in nature and Physics concepts. During the discussion, the teacher takes note on the blackboard of the essential words that students used to explain the questions and the construction of the Physic concepts goes on by negotiating the meaning of them to approach the scientific concept. And at the end of the activity, each student writes in their own notebook the scientific concept and meaning seen in class.

As pointed above, it is well known that one of the best ways to learn is by playing, the laboratory is used to involved activities with emotional connection [6]. The teacher gives the students small challenges that let them discover why that is happening. This situation is given in the laboratory, with low-cost materials that can be seen in real life. After the student beat the challenge, they must make a Physic interpretation of what is happening. During the whole process, they are guided by the teacher.

The students work in small groups with a battery, a light bulb, and some cords to figure out how to make the light bulb on, in the beginning, they are very curious because they have never experienced something like that before, but they try to understand each component behavior and the way all work
together. After that, another challenge is to turn two light bulbs on with only one battery and the lower quantity of cords, and now the situation changes and challenges the students to think and work as a team with others. At the end of the class, we are able to deduce the theory behind those situations. It is clear that the parallel and series connection work differently and now we have a mathematical model to predict the way that happens. The teacher let the students generalize the use of this concept in real life and connect with medical devices and interaction between some animals like sharks and eels.

As homework, the students have to work with two PhET Simulations [8], using a computer, tablet or smartphone, the teacher gives them a guide with the activities they have to do in each simulation being free to modify everything they want and making observations of what is happening and compare with the real situation they saw in the laboratory. They can change all the variables, here the only recommendation is to change one at the time, observe what happens and write it down to discuss later. In the next class, the teacher discusses the final results with the students and help them with questions that may appear, connecting these final results with the phenomena and theory the students have done the class before.

Another activity that gave good results is a roll play call "Medical Symposium." This activity is led by Gamification theory, as part of the activity, students have to dress up as doctors using a white medical coat. The teacher gives them reading material related to the use of Electricity in the Medical environment in the class before the activity.

The Medical Symposium day they work in different cooperative teams, as specialists. The objective is to discuss with others the topic, define main ideas and make the information as easy as possible. After that, one member of each team now forms another team with members of different "specialties" the objective now is to explain a specific topic to the rest of the team and learn about others. At the end of the class, some volunteers explain the topics to the rest of the group [7]. After that, the student is capable of identifying the most critical Physical concepts and organize the ideas in a concept map, infographic or any other type of learning instrument as homework to post on Google Classroom.

4. Results
We applied two different exams, one pretest and at the end of our proposal, the posttest. Even though they are different, both ask for the same concepts and knowledge. In Figure 1 below we can see the gain in the use of concepts. In the pretest, the students' group get an average final score of 6.30, and in the posttest, the students' group get an average final score of 8.65. We worked with a group of 50 High School students between 17-18 years old, and each exam, pretest and posttest have 20 questions. The tool we used to apply the exams was a Google Formular with four answer options and a defined schedule to receive answers.

To promote motivation and focus students' interests, it was very suitable to use applications related to Life Sciences [9, 10,11]. The membrane potential was connected with the electric field and the number of ions present in each side of the membrane. Students were astonished when they realized that the potential difference was between positive charges. The nerve impulse was associated with Hodgkin and Huxley's mathematical model, where they made an analogy between membrane potential and a capacitor, and the active channels of sodium with variable resistors. The reading of the scientific article of Lamberti & Rodriguez [12] and the discussion of each figure in it, produced great interest among students. The discussion of the meaning of the heart electrocardiogram and the defibrillator's use was part of the "Medical Symposium."
Figure 1. Results. Student's final grade. Pretest and posttest.

Students reacted positively to the proposal, as it is shown in the final course evaluation (Figure 1), where they answered anonymously and feeling free that the answer will not affect their final score. Some student's final thoughts about the course are presented:

- Student 1."I liked that the classes were not monotonous. We did different activities. The teacher was not just talking all the time."
- Student 2 "It was very didactic, complete and easy to understand, compared to my other classes, here they let me have fun."
- Student 3 "To be able to learn with experiments that make the theoretical class clearer. I like to learn."
- Student 4 "The topics that the teacher taught were very clear. We learned different applications of daily life. I especially enjoyed the way the teacher did a relation between the concepts of our area."

It can be added that students' disinterest was reduced, and they obtained more self-confidence about their Physics learning and expectations when they noticed that they were capable of understanding Physics concepts and apply them into Biological and Health Sciences areas. For all of the mentioned above, we consider that the investigation line of the proposal has given good results and is an excellent way to involve students in Physics because they can see a clear relation between Physics and their future professional career.

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