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Preconceptions about concepts of dynamics in students who begin their studies in the Pedagogy Redesign of Experimental Sciences

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Abstract

The research was based on the investigation of the preconceptions about dynamics concepts in students who entered in 2018 (period 2) of the Pedagogy of Experimental Sciences Redesign of the ULEAM Extension Chone. The results of the research carried out by means of a diagnostic test are shown, as a way of projecting an estimate of the phenomenon in the national educational dimension. *The problem of learning Newtonian concepts presents various difficulties that lead to conceptual errors*. A classification of topics was carried out on the preconceptions of the students in the theoretical framework. Through the analysis of preconceptions, the causes of conceptual errors are revealed to improve student learning. The objective was to diagnose by means of a questionnaire to detect the conceptual errors of the students with respect to the dynamics of the particle. The research has a qualitative, quantitative, and documentary approach, in addition to the inductive and descriptive method. The applied technique was a questionnaire to perform the analysis and interpretation of the results of the preconceptions. It was found that alternative preconceptions affect the concept of this and the need to analyze, improve and propose a teaching-learning model based on a conceptual change was observed.

Keywords: Preconceptions, particle dynamics, conceptual change, constructivism.

1. Introduction

The research was based on helping students change their conceptual errors for new concepts, so that a conceptual change occurs in the educational field in the teaching of physics. Preconceptions are not seen as errors or something negative, but as cognitive structures that interact with the information that comes from the external world and that plays an important role in learning.

The concept of force is one of the essential concepts in the study of particle dynamics. Within the classical context this concept is fundamental in the learning of this science. The average college-going student shows difficulty in reasoning, their reading comprehension only works at very low levels. To overcome these difficulties, it is necessary to notice the preconceptions that students have for a conceptual change, before beginning the learning of Newtonian mechanics. All learning happens in stages, the passage through each of these depends on the student and the content to be learned. Education is a dialectical, historical and cultural process, which is transformed influenced by the changes experienced by the social, cultural, economic and political environment where it takes place. In this regard and, in correspondence with the arguments offered by (Guadalupe et al., 2007, p. 27), a quality education must allow the acquisition of relevant knowledge for people, it must be relevant and capable of taking diversity into account, characterized by its fairness and its inclusive nature.

It is undeniable that students come to the classroom with "knowledge" acquired from the basic experience and their experiences; These "knowledge" that respond to the appreciations of common sense, are immediate and although they are obstacles, they become the fundamental piece to form scientific concepts in students. It is not, therefore, as a science teacher, to promote these obstacles in students, since it cannot be ignored that, from an early age, they have already formed this "knowledge". It is about taking this "knowledge" as the starting point for the acquisition of new concepts, for which it is necessary for the teacher to identify them, and then build and put into play a series of situations, in which the students, become aware of their own mistakes and from an internal discussion of intellectual regret, emerge a clear understanding of the concepts accepted by scientific communities. (Franco, 2013, p. 16)

With the intention of responding to these research problems, the objective was to diagnose the conceptual errors of the students with respect to the dynamics of the particle by means of a questionnaire.

Returning to a past of errors, the truth is found in a true state of intellectual repentance. Indeed, it is known against a previous knowledge, destroying badly acquired knowledge or overcoming that which, in the spirit itself, hinders spiritualization. (Bachelard, 2000, p. 15).

"Psychologically there is no truth without a rectified error. An objective attitude psychology is a history of our personal mistakes" (Bachelard, 2000, p. 281). The current scientific truth is organized, structured and built, starting from previous knowledge, of the dialectical negation of the previous knowledge and its formulation on the new knowledge.

Bachelard's position is that the new knowledge does not start from nothing but assumes a previous empirical knowledge that is negated and dialectically replaced by the new, according to the law of the negation of the negation, conditioned.

Materials and methods

The applied methodology has a qualitative approach, allows to investigate, analyze, and understand, from the disciplinary and didactic perspective of the knowledge of the correct concepts of Newtonian mechanics and the analysis of the alternative preconceptions of the students in the learning of the Kinematics and dynamics of the particle entering the University of the Redesign Pedagogy of Experimental Sciences.

As a qualitative approach in research that studies didactic phenomena, Quintana (2006) points out that education has to do with human actions, where the reality that is going to be analyzed in its natural context that characterizes learning difficulties is studied, having keep in mind that education has to do with human actions.

Some quantitative contributions were valued as indicated, Hueso and Cascant (2012, P. 1) based on the use of statistical techniques to know certain aspects of interest about the population being studied, such as the collection of information through surveys and the analysis of the data through descriptive statistics, the study phenomenon was characterized, applying the heuristic method, in order to find and solve a problem; the inductive method, because in the course of information processing new concepts were introduced to perceive the results with a certain level of generality.

As (Tamayo, 2001) indicates, the researcher sees the setting and the people from a holistic perspective, trying to understand them within their own frame of reference. It was used in the documentary method by reviewing texts and articles according to the study topic (Martínez, 2004).

The population studied was 242 students from the ULEAM Extension Chone Pedagogy of Experimental Sciences Redesign, from which 36 second semester students were randomly selected, who entered the ULEAM Extension Chone Pedagogy of Experimental Sciences Redesign.

Analysis and discussion of the results

The results shown are the data obtained from the questionnaire designed to find out the prior knowledge that students entering the Universidad Laica Eloy de Manabí (ULEAM) had, Chone extension of the Pedagogy Redesign of Experimental Sciences where the students bring mental models to the classroom with which they explain the world: they are simple causal models, since "all events have a cause". They are his models "of common sense" or spontaneous thinking (Galagovsky et al., 2001, p. 231), which are also called ideas or preconceptions.

Difficulties in learning caused by alternative

preconceptions Erroneous preconceptions or alternative conceptions are defined as that knowledge of the student different from scientific knowledge and that is usually prior to instruction, these have four fundamental characteristics that serve to define it.

- They are not scattered ideas but are structured to form true cognitive schemes that are highly resistant to being changed.
- They do not match the explanations of science. They coincide in many cases with the conceptions that scientists had throughout history.
- They fundamentally affect students' understanding of natural phenomena and their explanation.
- They must be overcome or eliminated in order for students to achieve scientific knowledge.

According to Ausubel (1983) cited by Silva (2014) "the most important factor that influences the student is what the student already knows. Find out this and teach yourself accordingly" (P. 40). This theory holds that the individual learns by receiving verbal information, relating it to the previous knowledge that every individual carry with him and in this way gives new knowledge a special meaning.

As Piaget (1983) cited by Silva (2009) says "the learner becomes a protagonist of their learning, which develops in two processes within education: the conductive part and the affective part, with an open and flexible curriculum" (P. 24). Constructivism allows content and methodologies as means to develop capacities and values.

As indicated by Vygotsky (1979) cited by Ruiz (2010) defines the development zone "is nothing other than the distance between the real level of development, determined by the ability to independently solve a problem and the level of potential development, determined by solving a problem under the guidance of an adult or in collaboration with another more capable partner" (P. 133). In the Vygotsky method, the teacher has the role of observing and diagnosing the level of knowledge that the apprentice possesses, this

being a potential to know and discover the mental processes that lead the apprentice to a more advanced level of knowledge, with the help from the teacher or a more knowledgeable peer to advance and reach the zone of proximal development.

Sometimes textbooks tend to reinforce these misconceptions. The concept system of the Physics subject is in constant conflict with the students' previous ideas or knowledge based on their daily experience, as they assure it (Benegas et al., 2010). With the intention of presenting an initial theoretical clarification about study in this research, it is assumed as preconceptions of the students those previous ideas or notions, relative to the knowledge system of the subject and that "are scientifically incorrect, unconnected and very resistant to change", as they point out (Carcavilla & Puey, 2019, p.2).

Conceptual change and constructivism

The traditional teaching of Physics has not yet solved the essential problem of student learning in the 21st century. Faced with this phenomenon, various authors have investigated learning strategies based on certain paradigms. One of these paradigms is the constructivist.

It can be called constructivist theory, anyone that understands that knowledge is the result of a process of construction or reconstruction of reality that has its origin in the interaction between people and the world. The central idea is that the elaboration of knowledge constitutes a modeling rather than a description of reality. (Microsoft Encarta, 2009)

On the other hand, the work of J. Piaget is joined by the contributions of D. Ausubel on meaningful learning. According to Ausubel himself, he conceives of learning as a process of attribution of meaning. The new must link with the previous is transformed and turns it into a more complex and deep knowledge. The apprentice also gains the ability to adapt to new situations in the process because he has a more solid knowledge, where the most elementary knowledge supports the most complex ones in a hierarchical structure. (Ausubel, 1964, cited by Sánchez-Cabrera et al., 2019, p. 127)

The constructivist theory of learning encourages the knowledge of mechanisms that facilitate this process in students. With this knowledge and an adequate application of methods, means and procedures by the teacher, it is possible to prepare the way towards a meaningful learning of its students during the teaching-learning process of science and of Physics. Consequently, D. Ausubel's theory of meaningful learning "facilitates the teaching-learning process of the Physics subject, considering the new technological reality and the challenges of today's more complex and globalized society" (Silva & Schirlo, 2014, p. 37).

The proposal to consider learning as a conceptual change exerted a particular influence on the rethinking of science teaching, based on the existing analogy between individual learning and the conceptual change in scientific disciplines that, as Hewson (1995) pointed out, was very fruitful and provided a suitable framework for the analysis of science learning. That is, relationships were established between research in science didactics (alternative ideas, conceptual change), cognitive psychology especially with authors such as: Ausubel, Piaget, Vygotsky, and the philosophy of science such as: Bachelard and Kuhn.

The conceptual change was considered similar, in a certain way, to the paradigm shifts in the sciences pointed out by Kuhn (1971) he related the conceptual change to Piaget's accommodation processes, without which Ausubel's meaningful learning did not seem possible. If there was no interaction between the previous conceptual structure and the new information, rote learning took place, erroneously named by Novar (1988), since all learning implies memory and produces changes in it, as stated (López, 2014), so Ausubel's name for repetitive learning seems better.

In a book published by the Polytechnic University of Catalonia, Spain, OmniaScience, echoed this concept by publishing the work by Resnick (1999) cited by Torre and Farrerons (2017), which thus summarizes the main characteristics of the constructivist vision: "who they learn actively construct meanings, they do not simply reproduce what they read or are taught; understanding something supposes establishing relationships, isolated fragments of knowledge are forgotten; all learning depends on previous knowledge ". (P.16)

In this research aiming to analyze the concepts that are considered basic, the Newtonian mechanics semester begins without questioning how these concepts are incorporated in the students, these concepts will be addressed in the class of level II, where it is assumed that these concepts were reviewed in high school. The concepts analyzed and applied are:

a.Law of action and reaction

b. Forces between solids in contact

c.Law of inertia

d. Law of Universal Gravitation

e.Law of Force

It was investigated through structured questions to the students of the second semester of the Pedagogy Redesign of Experimental Sciences. The first question was related to the Law of action and reaction, showing the results in table 1.

Table 1. Forces involved in a frontal collision between a truck and a small car during a collision

Alternatives	Frequency	Percentage (%)
The truck exerts a greater force on the car than the car on the truck	0	0
The car exerts a greater force on the truck than the truck on the car	0	0
Neither of them exerts a force on the other. The car is crushed because it is in the path of the truck	0	0
The truck exerts a force on the car, but the car does not exert any force on the truck	25	69.4
The truck exerts the same force on the car as the car on the truck	11	30.6

As can be seen, the students surveyed had the Law of Action and Reaction presented, noting that the highest percentage had it present in the answer D and E. The answer given evidence: that 69.4% answered literal D, most of the group, do not have a clear concept about Newton's Third Law, only 30.6% are clear about the concept that the car exerts the same force on the truck.

In the case of the question related to the action of a rubber ball that falls vertically bounces on the ground, the direction of its movement is reversed, the proposed answers are shown in table 2.

Table. Actuation of a rubber ball that falls vertically bounces on the ground, the direction of its movement is reversed

Alternatives	Frequency	Percentage (%)
The energy of the ball is conserved.	0	0
The momentum of the ball is conserved	18	50
The ground exerts a force on the ball that prevents it from falling and then pushes it upwardpushed upward.	10	27.8
The ground is in the path of the ball and the ball ishas to continue moving	8	22.2
None of the previous answers	0	0

As can be seen, the students have answered three aspects related to the questions, the greatest number of answers were related to the fact that the momentum of the ball is conserved, demonstrating the knowledge acquired when two solids come into contact what can happen.

It is noted that 78.8% answered the literals B and D, more than the ¾ parts of the group, do not have an accurate concept about forces between solids in contact, 27.8% answered the literal C, a small group if they are clear about the concept that the ground exerts a force on the ball that prevents it from falling and then pushes it upward.

It was investigated related to what would happen, if the tablecloth is quickly pulled from a table that has a set of dishes on it for a lunch, the results of the answers given by the students can be observed in table 3.

Table 3. It is quickly pulled the tablecloth of a table with dishes arranged on it

Alternatives	Frequency	Percentage (%)
A. The dishes tend to keep their place	22	61.1
B. The tablecloth drags the dishes	0	0
C. The dishes fall to the floor	14	38.9
D. The tablecloth drags the dishes and only half falls	0	0
E. None of the above	0	0

As you can see, the answer given indicates that 61.9% answered literal A, showing in this case that the majority of the group does have a clear concept of Inertia about of Newton's First Law that tableware tends to retain its place and only 38.1% are not clear about the Law of Inertia, demonstrating that the knowledge that a considered percentage of those surveyed have is not adequate.

Table 4 shows the responses selected by the surveyed students related to what happens when two bodies fall, one twice the other, at the same time and from the same height.

Table 4. Fall of two bodies with different masses

Alternatives	Frequency	Percentage (%)
A. The heaviest falls with half the time	7	19.4
B. They arrive at the same time	24	66.7
C. The less heavy falls after the heaviest	5	13.9
D. The heaviest falls with twice the time	0	0
E. None of the above.	0	0

As seen in the results obtained in the question related to the fall of two bodies with different masses, 66.7% of the students answered literal B, most of the group is clear about the concept of the Law of Universal Gravitation of that both bodies reach the ground at the same time; 19.4% answered letter A and 13.9% answered letter C, the latter two are not clear about the concept of this law, which shows a confusion of the concept of the Law of Universal Gravitation.

As a last example of knowledge obtained by the students, it was related to the application of a constant force on a body, showing the results in table 5.

Table 5. Application of a constant force on a body

Alternatives	Frequency	Percentage (%)
A. Se generates motion with constant speed	30	83.3
B. Motion is generated with variable speed	4	11.1
C. Uniform rectilinear motion is generated	2	5.6
D. All of the above	0	0
E. None of the above	0	0

As you can see the answer given For 83.3% the students answered letter A and 5.6 answered letter C, the vast majority of the group do not have a correct and clear concept about Newton's second Law, only 11.1% are clear about the concept of the force law that generates motion with variable speed.

In the last 20 years, many works have been carried out on conceptual change, this is a research trend that tries to base and promote a development of the curriculum based on a conceptual change, the generalized confusion of the basic concepts of particle dynamics. In most of the students, it is noted that they are not clear about Newton's second and third laws and of forces between solids in contact, which means that preconceptions prevail in students, and it is difficult for them to appropriate the new scientific concepts.

The change obtained is undoubtedly in the analysis of the laws of particle dynamics that has favored the creation of cognitive conflicts in students, both circumstances are fundamental for achieving a significant conceptual change in the learning of mechanics. Newtonian.

The questionnaire applied to the 36 students of the second semester, most of them are not clear about the concepts analyzed, which means that the population of the Pedagogy of Experimental Sciences redesign preconceptions affect the learning of particle dynamics.

Conclusions

The results obtained demonstrate the need to analyze, improve and propose a teaching-learning model based on a conceptual and methodological change, taking into consideration, as a starting point, the knowledge already existing in the student's mind.

It could be shown that alternative preconceptions affect the concept of this and the need to analyze, improve and propose a model based on a conceptual change is observed.

With the application of the questionnaire, it was possible to verify the existence of preconceptions about some concepts of dynamics manifested by students who enter the Pedagogy Redesign of Experimental Sciences. These preconceptions are stable cognitive structures that must be recognized by the teacher in order, based on them, to draw up learning strategies that allow the desired conceptual change to be brought about.

The use of preconceptions as a cognitive possibility, as a starting point for learning some dynamics concepts is viable and can be achieved through constructivist learning strategies.

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