REVISTA CÁTEDRA

Innovación didáctica para la comprensión del concepto de vacío en hidrostática

Didactic innovation for the understanding of the concept of vacuum in hydrostatics

Franklin Molina-Jiménez
Universidad Central del Ecuador, Quito, Ecuador
femolina@uce.edu.ec
https://orcid.org/0000-0002-2374-2192

Lucia Goyes-Chulde
Unidad Educativa Municipal Calderón, Quito, Ecuador
uemc.lgoyes@gmail.com
https://orcid.org/0000-0001-7806-5312

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Resumen

El presente artículo describe una propuesta de innovación didáctica dirigida a mejorar la comprensión del concepto de vacío, que es estudiado en la hidrostática rama de la física y constituye uno de los temas más complejos e importantes de comprender, ya que está involucrado en muchas actividades que el ser humano desarrolla, desde el proceso fundamental de respirar, hasta el de generar numerosos avances científicos e industriales.

La ausencia total de la materia en un determinado lugar recibe el nombre de vacío, ha sido analizada de varias formas, principalmente de forma experimental, sin embargo, la presente propuesta está dirigida a estudiarla desde el punto de vista teórica y comprobar su existencia en forma práctica, a través de la aplicación de la técnica didáctica de la pregunta respuesta y de la estrategia grupal investigación en el laboratorio respectivamente.

La investigación se desarrolló bajo un proceso de índole cuantitativo, cuasi experimental, inductivo en la que intervinieron treinta y tres estudiantes de la Carrera de Pedagogía de las Ciencias Experimentales, Matemática y Física, quienes trabajaron en dos momentos, en los que se estableció que el porcentaje promedio de comprensión del tema analizados en el *pre*test y *postest* se incrementó del 44.70% al 79.55%. Esto permitió intuir que el empleo de la propuesta de innovación didáctica, basada en la aplicación de la técnica didáctica preguntas respuestas y de la estrategia investigación de laboratorio conllevó a mejorar la comprensión del concepto de vacío, además de verificar cómo influye este en el quehacer diario.

Palabras clave

Comprensión, didáctica, estrategia, innovación, técnica, vacío.

Abstract

This article describes a proposal of didactic innovation aimed at improving the understanding of the concept of vacuum that is studied in the hydrostatic branch of physics, and constitutes one of the most complex and important topics to understand, since it is involved in many activities that the human being develops, from the fundamental process of breathing, to the one of generating numerous scientific and industrial advances.

The total absence of matter in a given place is called a vacuum, and it has been analyzed in several ways, mainly in an experimental way. However, the present proposal is aimed at studying it from a theoretical point of view and verifying its existence in a practical way, through the application of the didactic technique of the question-answer and the group research strategy in the laboratory, respectively.

The research was developed under a quantitative, quasi-experimental, inductive process in which thirty-three students of the Pedagogy of Experimental Sciences, Mathematics and Physics Career took part. They worked in two moments, in which it was established that the average percentage of understanding of the subject analyzed in the pre-test and post-test increased from 44. 70% to 79. 55%, allowing us to intuit that the use of the didactic innovation proposal, based on the application of the didactic technique questions and answers and the laboratory research strategy, led to a better understanding of the concept of vacuum, in addition to verifying how it influences our daily work.

Keywords

Understanding, didactics, strategy, innovation, technique, emptiness.

1. Introduction

Physics, being an experimental science that studies all the phenomena that govern nature, means that the learning and understanding of this branch of human knowledge is not forged from an agile menara in the cognitive structure of the students that attend the different academic levels where this science is taught. In addition, the nature of science and the development of scientific knowledge significantly influences the way it is taught, being reflected in the methods used by the teacher, in their performance and decision-making in the natural science classroom, as pointed out by Rua and Alzate (2012), these notions create the need to seek teaching strategies that allow for a better understanding and analysis of these phenomena that are studied in the classrooms of the Experimental Mathematics and Physics Science Teaching Career and then tested and verified in the laboratory of the Physics Unit of the Central University of Ecuador, by students in regular courses.

The present research work presents an innovative didactic proposal that seeks to improve the understanding of the concept of vacuum, which is analyzed in hydrostatics, a branch of hydraulics that studies fluids in a state of equilibrium. This proposal is oriented to enable students to effectively assimilate the concepts related to it.

The didactic proposal is based on the process of asking the students questions, since the art of asking is the art of continuing to ask, and this means that it is the art of thinking (Gadamer, 2007), which will allow us to determine the level of knowledge acquired by them when observing the recreation of the vacuum phenomenon in the physics laboratory.

The aim is to create an innovative teaching alternative, in an attempt to generate understanding not only of the proposed subject, but of others related to physics, so that other teachers working in the centre of studies where the research is being carried out can improve their teaching and learning process and thus the academic performance of the students, which for Cascón (2000) "constitutes the demonstration of their knowledge of the different areas or subjects, which the system considers necessary and sufficient for their development as active members of society" (p.11).

Related works such as Urbina's 2008 and Sanchez's 2010, the use of questions in the university environment is considered as background to the research carried out. In this document a review of the research carried out is made, the definition of didactic innovation is analyzed, the level of understanding according to Bloom's (2013) " the study of the concept of vacuum and others related to the east through the use of physics laboratory equipment that allows to determine the difference of pressures between two media (p. 2), the absence of sound in the vacuum, the methodological process carried out to execute the research with its respective statistical analysis of the results obtained when applying a pre-test and post-test, to finally present the conclusions.

2. Theoretical Foundations

2.1 Teaching innovation

One of the characteristics that every teacher must possess is the willingness to always modify his or her way of teaching, since teaching physics is a function of scientific and technological advances. That is to say, to generate activities that involve processes of educational innovation, an aspect that Imbemón 1996, González and Escudero 1987 point out as an action or sets of actions that lead to internal and qualitative changes in a teacher's educational work in order to improve understanding, efficiency and effectiveness in the solution of problems generated immediately.

According to Tejada (2012), innovation can be considered to be t"he nucleus of a renovating action generated within the classroom (p. 6). Renewals imply new situations within a context that can sometimes generate reforms in educational processes. However, these innovations cannot always generate reforms, establishing that the teacher must innovate to renew the teaching strategies used in the teaching process with their students, an action that develops in the classroom in order to understand the concepts in a meaningful way.

These significant learnings should be considered to be the product of innovative experiences that for Torre (1997) "can become the first phase of more far-reaching innovations" (p.46). Confirming that innovations arise from innovative experiences generated in the classroom.

In this perspective Capelástegui affirms that one of these innovative experiences linked to the initiative generated by the teacher in his didactic procedure, is that of seeking changes in the use of didactic strategies oriented towards the transfer of knowledge, group work, collaborative work and the simulation of real situations, aspects that are considered in the present investigation (Capelástegui, 2003).

The principles of constructivist learning founded by Piaget 1929, Vygotsky 1930 and Ausubel 1978 establish that the subject constructs knowledge in an active way, interacting with the object of study. In the case of learning physics, this is done in the laboratory. The new knowledge acquires meaning when it is related to the previous knowledge, that is to say, the concept of vacuum will be well founded when the student understands the meanings about hydrostatics, atmospheric pressure and boiling; and is able to find the applications that the concept of vacuum has in everyday life.

According to Oviedo (1983), the use of didactic procedures to obtain a certain result "includes strategies and techniques" (p. 24). According to Szczurek (1989), strategy is the "set of deliberate actions and organizational arrangements to coordinate (direct) the teaching and learning system" (p. 89). These strategies may be masterful, cooperative, individual, and group strategies.

In this research, the group strategy is applied since it emphasizes the joint work of students in cooperative learning activities, subordinated to the tutoring of the teacher in which his or her role constitutes being a learning facilitator, as stated by Bastidas 2004. The group strategy with which they develop the entire research process includes experimental work in the laboratory. Its importance lies not only in the possibility of observation and experimentation on reality and development of experimental skills, but also and perhaps more strongly in the possibility they offer to relate theories and models with experience and to provide an opportunity for students to know how scientific knowledge is constructed, as confirmed by Hodson (1988), who conceives "experimental work (laboratory practices) as a fundamental pillar for teaching" (p. 67).

According to Bastidas (2004), the technique constitutes a "particular way of using an instrument and/or resource on which teaching is based" (p. 121). The technique that is proposed to be used in research to improve the physics learning process is the question-answer, which allows the organization of mental schemes in students to facilitate the construction of concepts.

Gadamer (2007) points out that the "art of asking, is the art of continuing to ask and this means that it is the art of thinking" (p. 134). This allows us to affirm that the questions asked by scientists have allowed us to obtain decisive answers for the benefit of scientific development and to search for new strategies to improve science education.

Raising questions, whether by the teacher or the student, leads to developing in greater relevance the capacity to construct new significant knowledge that allows for structuring new mental schemes such as abstraction and reasoning, allowing for an increase in the scientific background of all those involved. Rojas (2009), in his research on the pedagogical function of the question in the processes of learning, reasoning, cognitive and metacognitive influences in science, determined that "questions systematically contribute to the construction in students of the processes of reasoning in Science" (p. 156).

Questions must meet certain basic characteristics in order to be asked. Rojas (2009), points out that questions must be reflexive, contextualised, decisive, divergent, linguistic and must include as requirements for their formulation the use of question marks at the beginning and end of the question, as well as having a subject, predicate and verb (p. 45).

2.2. Compression

According to Boostrom (2005) “real significant learning is not generated from activities involving memorisation but, on the contrary, activities that allow the exercise of skills for information processing” (p. 45) the acquisition and development of concepts, decision-making, the selection of alternatives, analysis, synthesis, interpretation, problem solving and the creation of new ideas. In this sense, it is understood that teachers need to have a model that makes it possible to discern how to foster meaningful learning in students and that makes possible the development of these skills.

Within the Cognitive Taxonomy of learning proposed by Bloom are the levels of knowledge, understanding, application, analysis, synthesis and evaluation. In this sense, it can be established that comprehension constitutes the ability to understand or apprehend; where the student knows what is being communicated and makes use of the materials or ideas presented to him, without having to relate them to other materials or perceive the totality of their implications. The material requires a process of transference and generalization, which demands a greater capacity for abstract thinking (Bloom, 1964).

It requires the learner to explain the relationships between data or principles governing classifications, dimensions or arrangements in a given subject, knowledge of the fundamental criteria governing the evaluation of facts or principles, and knowledge of methodology, principles and generalizations, such as translation, interpretation and extrapolation.

Finally, understanding can be considered as a flexible performance capability which allows to establish according to Perkins (2003) that "understanding is the ability to think and act flexibly from what one knows" (p. 70). In this context, the idea of understanding occurs when the student is able to act flexibly in tasks that involve multiple responses and performance of activities oriented to generating significant learning processes.

2.3 The vacuum in hydrostatics

The concepts have been created since the human being had the capacity to abstract, that is, to take from the environment where we inhabit significant and intrinsic elements of each object or phenomenon and to associate those elements according to similarities and differences in order to generate knowledge. As Sager (1993) points out, concepts are used "to structure knowledge and perception of the surrounding world and make use of language for its formation and communication" (p.34). This argument guides the process of understanding many observable physical phenomena.

For Ausubel (1978) "concepts constitute objects, events, situations or properties that possess common criteria attributes and are designated, in a given culture, by some accepted symbol" (p.89); in this way, concepts are related among themselves to generate a new cognitive structure.

According to Moreira the acquisition of concepts can occur in two ways, by formation, in which concepts are acquired through direct experiences during different stages of human development and by assimilation in which concepts are formed as more vocabulary is acquired and associations can be established in the cognitive structure with these words and thus form a new cognitive structure (Moreira, 2010).

Taking into account the above, understanding the concept of emptiness becomes a little complex since the human being can infer the concept of matter in a general way to everything that surrounds us; that is, the amount of substance that occupies a place in space and possesses mass, form, weight and volume, so it is observable and measurable and even more so if we consider that Light does not have mass, however its energy and its moment can be measured.

Pierre Gassendi 1592, the pioneer of science, considered the vacuum as an undetectable medium where atoms could move, expand and compress. On the other hand, Newton recognizes vacuum as a means of absolute immobility. Christian Huygens defines it as a subtle and elastic material medium. Nicolas Malebranch spoke of the elemental unity of subtle, psychic matter. Similarly, Benjamin Franklin 1752 spoke of a vibratory substance that filled all space, but shared with a hypothetical imponderable fluid, electricity. Additionally, Lomonosov defined it as a material medium that fills the interatomic interstices. Dalton considered it indispensable for the life of the atom. Charles Caesar, without enunciating the vacuum, describes the fact that a gas can disappear at -273 °. Augustin Fresnel recognized the vacuum as the material support of light waves. In Maxwell's theories, empty space appears as a conductor of stresses and energies responsible for electromagnetic actions.

In Maxwell's theories, empty space appears as a conductor of stresses and energies responsible for electromagnetic actions. In the 19th century, Ángelo Secchi points to vacuum as the cause of light and electric phenomena that vibrate in the former and move in the latter. The modern conception of vacuum is based on the experiment carried out by Torricelli, who in 1644 experimented with a vertical tube of one meter in length closed at the top, in which 76 cm of mercury rises under normal conditions over a receiver that is also full of mercury, this effect indicates the pressure of the surrounding air, in addition to the area of the tube above the limit of mercury being empty, a condition that allows mercury to be suspended (Young, 2009). This experiment reached the equivalence of atmospheric pressure with the height reached by mercury in an empty tube, which was called a barometer.

Otto Von Guericke in Germany in 1654 built the first vacuum pump to be able to suck the air inside a container composed of two attached hemispheres, which were pulled by 16 horses in two groups of 8 in opposite directions. (Young, 2009). With this experiment he showed that when the sphere was emptied of air, that is, when it was in a vacuum, the force of the horses was unable to separate the hemispheres, thus affirming that the pressure of the surrounding air exceeds the force performed by the horses and when the container contains air a slight force manages to take off the hemispheres, currently known as the Magdeburg hemispheres (Young, 2009).

Einstein considered the vacuum as the existence of electric masses, physical reality within the vacuum. Finally, it is possible to consider the conception of Carl Sagan (1980) astronomer, astrophysicist and scientific divulger recognized by his studies made on the structure of the universe, who affirmed that "The atoms are, in their greater part, empty space. Matter consists mainly of nothing..." (p. 160).

By virtue of these statements, the need and importance of developing a proposal of didactic innovation aimed at establishing new work alternatives both in the classroom and in the physics laboratory is establishe.

3. Metodology.

The proposal of didactic innovation is oriented to be developed in two moments. These are described below.

The first moment of the research is developed within the classroom of the Pedagogy Career of Experimental Mathematical and Physical Sciences of the Faculty of Philosophy, Letters and Education Sciences of the Central University of Ecuador, where the teacher, based on different activities, guides the students to the understanding of the concepts of hydrostatics, vacuum, atmospheric pressure, boiling, sound, mechanical wave, Magdeburg hemispheres. The thirty-three teacher-oriented students learn about the existence of vacuum with its properties and its importance through the execution of the master strategy, discussion-type lecture (Bastidas, 2004), in which the topics are previously studied by the participants, after which they are discussed in learning groups. Participants can ask questions to the instructor or vice versa.

A masterful explanation is given based on four activities, how a vacuum is created using a device called a "vacuum pump" and the effects it produces on an inflated balloon and the incidence of this phenomenon on humans. The difference between the concepts of boiling and boiling generated in water is analysed. It is also explained that, in a vacuum, sound does not propagate and finally it is established how the pressure exerted by the air is in all directions through an instrument called the Magdeburg hemisphere. Once the concepts and examples have been exposed to the students, the level of understanding of them is verified through the application of the pretest (Table 1).

The second moment of the research is executed in the laboratory of the Physics Center of the Central University of Ecuador, where the work with the students is executed through the group strategy called laboratory research (Bastidas, 2004), which consists of collecting data in an organized and systematic way that proves or refutes theories and hypotheses, or that expands the knowledge of phenomena in situations controlled by all the students inside or outside a laboratory, but following the experimental method.

The thirty-three students, through an experimental process and guided by the teacher, performed four experimental activities using the pump, vacuum bell and plate, beaker, balloon, water, cell and Magdeburg hemispheres, as follows:

- The first activity is intended to verify the effects that the vacuum produces on a half inflated balloon inside the chamber. When the pump is turned on, the air inside is sucked out and the students observe how the balloon increases in size, a phenomenon that allows the students to obtain the respective conclusions, aimed at determining the degree of abstraction that the student possesses when faced with the physical phenomenon called homeostasis.

- The second activity proposed determines the difference between boiling and boiling, for which water is placed in a beaker, which is introduced into the interior of the vacuum chamber and then the pump is turned on. After a few minutes the students verify the boiling process of the water without increasing the temperature.

- The third activity verifies how sound, being a mechanical wave, needs a medium to propagate, while in the vacuum it does not propagate. To do this, a lighted cell phone is placed inside the vacuum chamber with the music player turned on, the air is extracted from the chamber and the sound is reduced.

- The fourth activity allows verifying the existence of the atmospheric pressure and how this acts on all the beings that inhabit the earth's surface, for which the laboratory equipment called Magdeburg hemispheres is used, which consists of two hemispheres joined together against each other, and that by sucking the air from the interior of the hemispheres using the pump generates the vacuum, remaining united in such a way that it is pulled from the ends by the students and by effect of the existence of the external pressure these do not separate.

The pre-test and the post-test are based on multiple choice items, in which there are questions with several answer options, of which only one is undoubtedly correct. (López, et al., 2013). These items seek the comparison and evaluation of ideas, concepts related to emptiness.

The questions posed in each of the items of the pre-test and post-test, which allowed the answers to be given to the research, are oriented in:

For the first activity:

- The balloon inside the vacuum chamber starts to increase its volume since the external pressure of the balloon compared to the internal pressure of the balloon is: higher, equal, lower or none.
- Homeostasis is a characteristic that bodies possess when the internal pressure of the body compared to the external pressure is: equal, greater, less or null.
- The balloon inside the vacuum chamber, increases its volume because it creates: large volumes of air, vacuum, high air masses or higher air density.

For the second activity:

- The water bubbles that are produced in a vacuum are the effect of: an increase in temperature, a decrease in temperature, the absence of air or an increase in the volume of air.
- The separation of water molecules inside the vacuum chamber is due to the water being in the process of: freezing, compression, boiling or decompression.
- Boiling means that the water temperature: decreases, increases, balances or deteriorates.
- Boiling means that the water molecules: join together, separate, intertwine or hit.
- There is some difference between boiling water and boiling water: yes, no, none or possibly.

For the third activity:

- The sound of the music emitted by the cell phone: it increases in intensity, decreases in intensity, maintains the intensity or disappears.
- The cause of not hearing the music inside the vacuum chamber is: too much air inside, a mass of air was created, no air or little air.

For the fourth activity:

- When you start pulling the ends of the spheres, they separate: yes, no, easily or with difficulty.
- The pressure that the air exerts around the hemispheres is: at the top of these, at the bottom, in all directions or in no direction.
- When opening the air inlet tap in the hemispheres, it: continues to exert pressure, continues to exert force, enters and separates the hemispheres or compresses the walls of the hemispheres.

By analyzing the number of correct answers after applying the pre-test and post-test to the students, it can be determined that they have been able to understand the concepts related to the vacuum, which would allow the generation of significant learning processes.

4. Results

In order to evaluate the understanding of what was done in an experimental way, students answer the questions posed in their worksheet, constituting the post-test. (Table 1)

QUESTION	PRE-TEST		POST-TEST	
ACTIVITY 1	**EFFECT OF THE VACUUM IN A BALLOON**			
RIGHT	13	39.39%	22	66.67%
WRONG	20	60.61%	11	33.33%
ACTIVITY 2	**THE DIFFERENCE BETWEEN BOILING AND BOILING WATER**			
RIGHT	15	46.46%	28	84.85%
WRONG	18	53.94%	5	15.15%
ACTIVITY 3	**AIRBORNE SOUND PROPAGATION**			
RIGHT	15	45.45%	26	78.79%
WRONG	18	54.55%	7	21.21%
ACTIVITY 4	**MAGDEBURG HEMISPHERES**			
RIGHT	16	48.48%	29	87.88%
WRONG	17	51.52%	4	12.12%

Table 1. Results by activity developed

The results obtained when evaluating the students' answers in the pre-test and post-test process allow us to establish relevant information regarding the use of the group strategy called research in the laboratory and of the didactic technique, question-answer in the teaching-learning process of the concepts related to the vacuum and to verify its effects, information that will allow us to guide the establishment of a proposal of didactic innovation.

The successes obtained in a range between 1 and 33 of the tests and post-tests developed by the students were considered on the basis of an integer and its equivalent in percentages. Thus, the values of success in answering the questions of the first activity related to the effect of the vacuum on a balloon in relation to the pre-test and the post-test had a positive variation of 27.28% (Table 1), allowing to establish that the balloon inside the hood increases its volume due to the creation of the vacuum, and the effect of the homeostasis that the bodies have on the earth's surface can be modified in the absence of air.

For the second activity, the variation is 38.39 % (Table 1), it states that students do establish the difference between the concepts of boiling and boiling of water and that there is a way to generate boiling without increasing the temperature. The third activity has a variation of 33.34 % (Table 1), consequently, the students understand that the cause of not listening to the music inside the vacuum chamber is due to the absence of air inside the chamber since the sound is a mechanical wave. The fourth activity has a variation of 39.40% (Table 1), so they verify that the atmospheric pressure acting on any object on the earth's surface is present. It should be noted that the questions related to the Magdeburg hemisphere have the highest percentage of variation in correct answers (39.4%).

Finally, the average percentage of variation comparing the four activities together is 34.85 % (Table 2), showing that students improved their understanding of the properties that vacuum has on bodies. These statements can be better visualized in Figure 1, which expresses the variation of the hits in percentage of the pre-test and post-test.

QUESTIONS	PRE-TEST		POST-TEST	
RIGHT	14.75	44.70%	26.25	79.55%
WRONG	18.25	55.33%	6.75	20.45%

Table 2. Average of the four activities developed

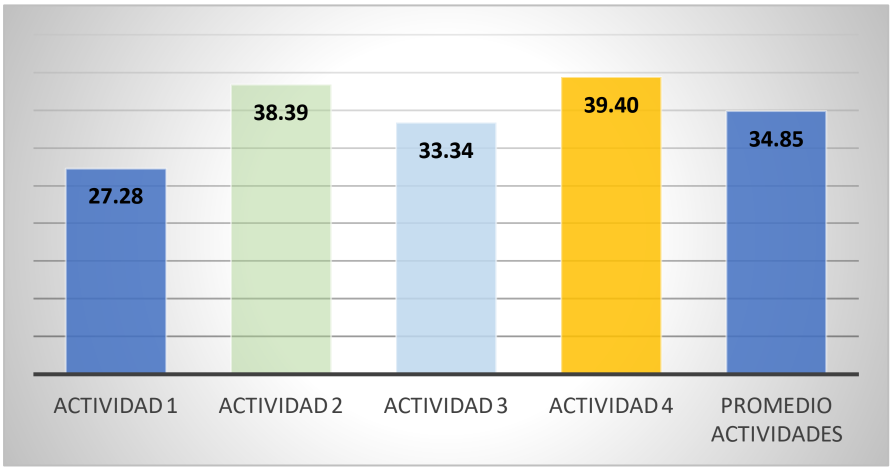

Figure 1. Variation of the increase in the percentage of right between the pre-test and post-test

5. Discussion.

The results allow establishing that the present proposal of didactic innovation to improve the understanding of the concept of vacuum and to verify its effects, using the didactic technique of questions and answers and the group strategy of research in the laboratory, does contribute to improve the teaching-learning process and therefore improve the processes of understanding the concepts studied in Physics.

For the questions addressed to the students, the multiple choice item format was used since, according to García (2006), this type of format allows "to evaluate a wide range of learning objects from factual to procedural knowledge" (p.21). Furthermore, this evaluation allows for objectivity, that is, it does not admit the interpretation of the answer

As Sánchez (2010) points out, "the use of questions in the university environment allows students to learn how to learn, promotes discussion of content, and maintains good interaction and participation during the class, which leads to significant learning" (p.22). These statements make it possible to establish that the process developed in this research is good enough to continue applying them in subsequent situations within the classroom.

As can be seen in Table 2 and Figure 1, the average percentage of students who correctly respond to the questions posed in each of the activities in the first moment executed in the classroom through the pretest and later in the second moment developed in the physics laboratory through the post-test, increases from 44.70% to 79.55%. In this way, it can be stated that the use of the didactic proposal based on laboratory research and the application of questions addressed to students leads to the understanding of concepts related to vacuum.

Research carried out by Urbina (on methodological strategies to enhance the understanding of Physics allowed her to establish that work should be encouraged with the real and effective participation of students in the educational process, an assertion that has been corroborated by the present research allowing to establish the validity of this (Urbina,2008, p. 56)

Research carried out by Urbina on methodological strategies to enhance the understanding of Physics allowed him to establish that work should be promoted with the real and effective participation of students in the educational process, a statement that has been corroborated by this research allowing the establishment of validity of this.

In this research, unlike the ones carried out by Urbina 2008) and Sanchez 2017, it was carried out through practical activities, using the Physics laboratory equipment, making them more significant for the learning of concepts; therefore, the answers obtained when answering the post-test had a greater range of correct answers. For this reason, the feasibility of carrying out this activity in the classroom and complementing it in the physics laboratory on a regular basis can be considered, depending on the topics covered in hydrostatics.

6. Conclusions.

University teachers must develop new didactic proposals for learning that promote scientific, critical and reflective thinking towards physics in students, and one of them is that teachers must consider the need to pose questions to their students throughout the teaching-learning process carried out in the classroom and in the physics laboratory, in order to achieve an environment of constant work by the student. Moreover, this didactic strategy can be replicated in other institutions aligned in the field of higher education, in order to verify its validity with other groups of students and in other contexts.

Learning by asking questions contributes to improving the learning capacity and even more so the cognitive structure of the individual. To achieve this process, statements must be clear and understandable, allowing sufficient time for reading, understanding the question and selecting the answer.

It was possible to determine which work executed by students is effective in the educational process, allowing for the generation of truly significant learning processes.In addition, future research should consider how the use of information and communication technology influences the process of teaching and learning concepts related to the vacuum.

Reference

Ausubel, D. (1978). Psicología Educativa, un punto de vista cognitivo. Trillas. México.

Bastidas, P (2004). Estrategias y Técnicas didácticas. Editorial S&A. Quito. Ecuador.

Boostrom, R. (2005). The foundation of critical and creative learning in the classroom. New York, Teachers College Press.

Capelástegui Pérez-España, Pilar (2003). Breve Manual para la narración de experiencias innovadoras. Documento en línea: http://www.upch.edu.pe/faedu/documentos/enlaces/guia.pdf (OEI Madrid: Organización de Estados Americanos para la Educación, la Ciencia y la Cultura

Cascón, I. (2000). Análisis de las calificaciones escolares como criterio de rendimiento académico. En red. Recuperado en: http://www3.usal.es./inico/investigacion/jornadas/jornada2/comunc/cl7.html

Dale H. (2012). Teorías del aprendizaje. Una perspectiva educativa. Pearson Educativa. Sexta edición. México.

De Old, K. (2014). El vacío es materia. Kaosenlared. Recuperado el 2 de marzo de 2020 de: https://kaosenlared.net/el-vacio-es-materia-aproximaci-n-a-la-f-sica-3-edici-n/

Eduteka, Tecnologías de Información y Comunicación para Enseñanza Básica y Media (2013). Taxonomía de Bloom. Recuperado en mayo de 2020, de: http://eduteka.icesi.edu.co/articulos/TaxonomiaBloomCuadro

Gadamer, H. (2007). Análisis de la conciencia efectual. En Verdad y Método. Salamanca, Sígueme.

García, R. (2006). Evaluación del aprendizaje en el nivel universitario: elaboración de exámenes y reactivos objetivos. Recuperado el 17 de junio de 2019 de: www.academia.edu/16517753/Evaluación_del_aprendizaje_en_el_nivel_universitario_elaboración_de_exámenes_y_reactivos_objetivos.

González González, M. T. y Escudero Muñoz, J. M. (1987). Innovación Educativa: teorías y procesos de desarrollo. Barcelona, España: Humanitas.

Hodson, D. (1988). Experiments in science and science teaching, Educational Philosophy y Theory.

Imbernón, F. (1996). En busca del discurso educativo. La escuela, la innovación educativa, el currículo, el maestro y su formación. Buenos Aires, Argentina: Magisterio del Río de la Plata.

Kaosenlared. (2020). Recuperado de: https://kaosenlared.net/colectivo-kaosenlared-quienes-somos/

López, A., Sánchez, H., Espinosa, J. y Camona M. (2013). Elaboración de ítems de opción múltiple. Instituto Nacional de Evaluación Educativa. Quito. Ecuador. https://www.educar.ec/servicios/1-manualelaboracionitems-ineval.pdf

Moreira, M. (2010). ¿Por qué conceptos? ¿Por qué aprendizaje significativo? ¿Por qué actividades colaborativas? ¿Por qué mapas conceptuales? Revista Curriculum 23.

Oviedo, J. (1983). Programa de Formación de Capacitadores Técnico Pedagógico en el Área de planificación Curricular. Pontificia Universidad Católica del Ecuador, Facultad de Ciencias de la Educación. Departamento de pedagogía. Quito. Ecuador.

Perkins, David. (2003). ¿Qué es la comprensión? En: Martha Stone Wiske (Comp.), La enseñanza para la comprensión. Vinculación entre la investigación y la práctica. Trad.: Cristina Piña. Buenos Aires, Argentina: Paidós.

Rojas, R. (2009). Las preguntas y la ciencia escolar: una experiencia con la segunda infancia. Tecne, episteme y didaxis: TEA.

Rua A y Alzate, O. (2012). Las prácticas de laboratorio en la enseñanza de las ciencias natrales. Revista Latinoamericana de Estudios Educativos (Colombia), vol 8.

Sagan, C. (1980). Cosmos. Recuperado el 2 de mayo de 2020 de: http://www.librosmaravillosos.com/Cosmos

Sager, J. (1993). Curso práctico sobre el procesamiento de la terminología. Fundación German Sánchez Ruipérez. Madrid.

Sánchez, I. (2010). Aprendizaje basado en preguntas y su impacto en las estrategias de aprendizaje en Física. X Congreso internacional sobre investigación en didáctica de las Ciencias. Chile.

Szczurek, M. (1989). La estrategia instruccional. Investigación y Posgrado. Recuperado de: https://es.slideshare.net/BelkysGuzman/la-estrategia-instruccional-mario-szczurek

Tejada, J. (2012). Los profesores como agentes de la innovación educativa. Recuperado de: https://www.researchgate.net/publication/283350211_Los_profesores_como_agentes_de_la_innovacion_educativa

Torre de la, Saturnino. (1997). Innovación Educativa I. El proceso de innovación. Madrid, España: Dykinson, S. L.

Urbina, I. (2008). Estrategias metodológicas para potenciar la comprensión de la Física. *Revista Ingenio,* p 27. Colombia.

Young. H. (2009). Física universitaria volumen 1. Decimo segunda edición. Pearson Educación. México.

Authors

FRANKLIN MOLINA-JIMÉNEZ obtained his Master's degree in University Teaching and Educational Administration at the Universidad Tecnológica Indoamérica (Ecuador) in 2011. He obtained his Bachelor's degree in Education Sciences, Mathematics and Physics Specialization at the Central University of Ecuador in 1995.

He collaborated as professor of Algebra at the University of the Armed Forces ESPE. Currently, he is a professor of Physics and Didactics of Mathematics and Physics in the Pedagogy of Experimental Mathematical and Physical Sciences Career at the Faculty of Philosophy, Letters and Education Sciences at the Central University of Ecuador. Its main research topics are oriented to the didactics of physics and flat geometry. First place in the contest organized by the Secretary of Municipal Education of Quito and the Fidal Foundation in the category Tics applied to the process of teaching and learning, he is the author of chapters of books on physics and flat geometry, papers and articles published in several magazines.

LUCIA GOYES-CHULDE obtained her Master's degree in University Teaching and Educational Administration at the Universidad Tecnológica Indoamérica (Ecuador) in 2011. She obtained her Bachelor's degree in Science of Education with a specialization in Mathematics and Physics at the Central University of Ecuador in 1995.

She teaches physics and mathematics in public and private institutions and currently teaches Physics at the Calderón Municipal Education Unit. First place in the contest organized by the Secretary of Municipal Education of Quito and the Fidal Foundation in the category Tics applied to the process of teaching and learning. Her main research topics are oriented to the didactics of Physics.