



Title: Impact of theoretical teaching, laboratory practice and the use of specialized software in the meaningful learning of university students

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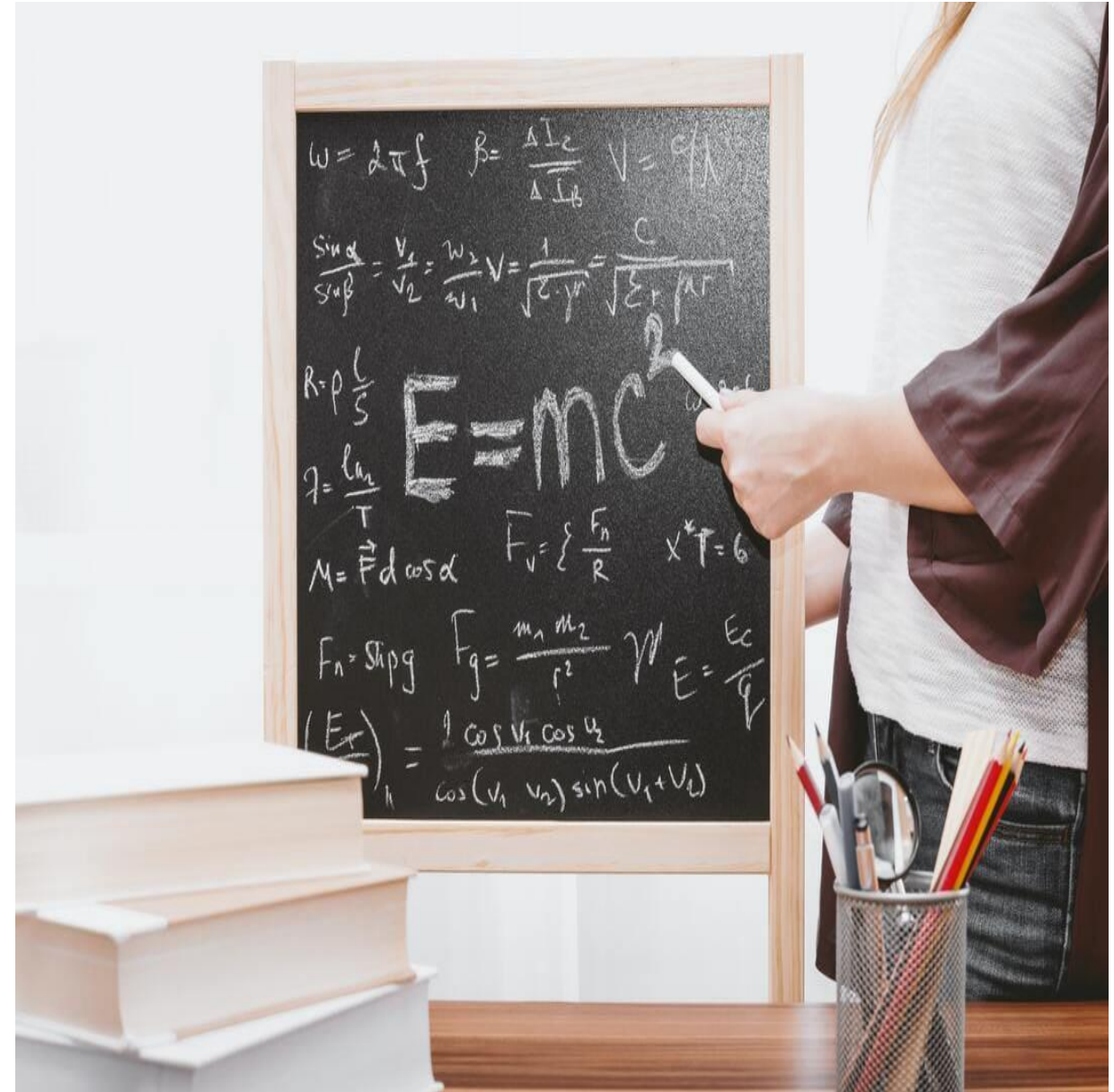
Holdings

Mexico	Colombia	Guatemala
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Introduction

The teaching-learning process of university students in exact sciences must go beyond the traditional approach and incorporate new styles that have a positive impact on their academic training.

This implies both the understanding of concepts, models and theories, as well as practice in the laboratory and the use of specialized software for the validity of the results and interpretation of the theory reflected in practice, in order to achieve meaningful learning considering the constructivist approach.



Introduction



In this sense, the research question is formulated as follows: What is the impact of theoretical training on the subject: “Determination of the coefficients of adiabatic compressibility and volumetric expansion of triblock copolymers, through experimental data of density and speed of sound”, complemented with practices in the laboratory and the use of specialized software, in the meaningful learning of the undergraduate student?

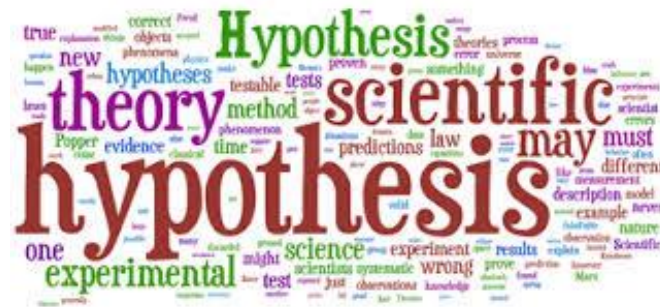


In the current era, the teaching-learning process faces new challenges, in which academics must use innovative methodologies in order to achieve true meaningful learning in university students. Also, students have to join with an active participation so that the learning objectives are achieved, that is, leave aside the passive attitude, where only the teacher is the one who transmits the knowledge.

Introduction

H_0 : Theoretical training on the topic: "Determination of the coefficients of adiabatic compressibility and volumetric expansion of triblock copolymers, through experimental data of density and speed of sound", complemented with practices in the laboratory and the use of specialized software, not significantly influences the meaningful learning of the undergraduate student.

H_a : Theoretical training on the subject: "Determination of the coefficients of adiabatic compressibility and volumetric expansion of triblock copolymers, through experimental data of density and speed of sound", complemented with practices in the laboratory and the use of specialized software, influences significantly in the meaningful learning of the undergraduate student.



State of the art

Teaching-learning:

Teaching is the process by which knowledge about a subject is transmitted. While learning is the process in which a person acquires knowledge, data and information to solve specific situations, it is also learned by trial and error (Cabrera-Medina et al., 2016).

Traditional teaching model:

The teaching-centered model conceives knowledge as an external construction from a set of scientific knowledge of a discipline that the teacher is responsible for transmitting to the students, for which the teacher is responsible for organizing the information developed by the scientists. (Gargallo-López et al., 2011).

Constructivist learning model:

The constructivism approach conceives the student as responsible for their own learning and their skills, which requires the identification of the problem, as well as the knowledge that they have and that they want to investigate for the solution of the problem with critical thinking and creativity; while the teacher is responsible for facilitating the didactic strategy (Lozano-Ramírez, 2020).

Problem-based learning:

This learning allows students to develop critical skills through thinking and problem solving with a high cognitive level, in order for the student to be interested in the subject and also to achieve learning. In this regard, it is highlighted that learning is the responsibility of the student (Ramos & Palacios, 2007).

State of the art

Laboratory practices:

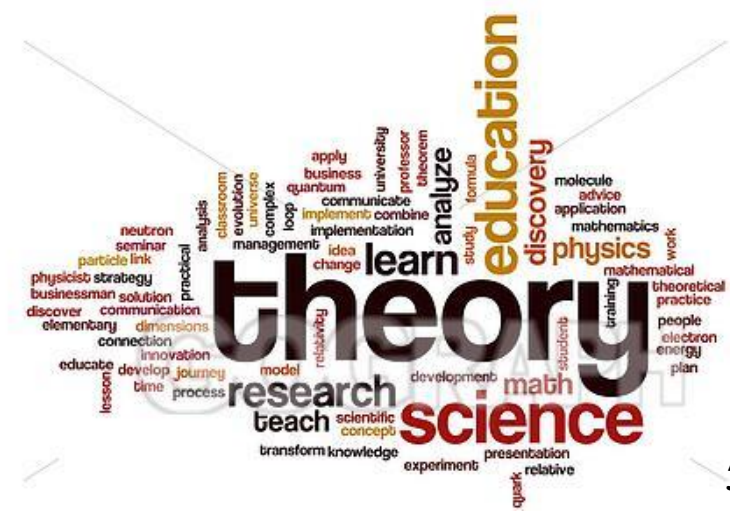
Laboratory practices are understood as a didactic strategy for the generation of scientific knowledge (Espinosa-Ríos et al., 2016) and if before carrying out an evaluation is applied to know what the students know, during the practice will show greater motivation and interest, promoting the development of certain scientific skills.

OriginPro software:

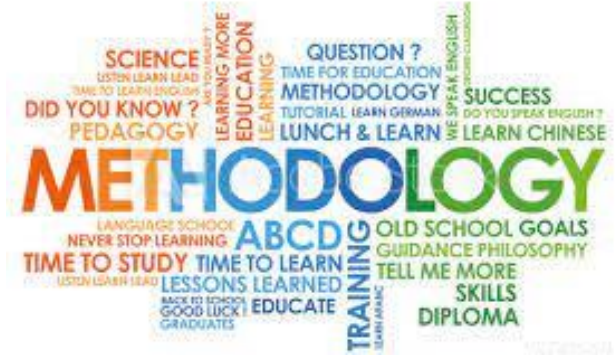
The OriginPro software is integrated as a computer system, which consists of different functions that are used for different branches such as mathematics, statistics, physics, chemistry, among others. The students can view the graphs generated by entering the data and execute the specific functions of the phenomenon analyzed, allowing greater interpretation, which is a pedagogical tool for motivation and improvement of student expectations (Zavaleta & Moreno, 2019).

Meaningful learning:

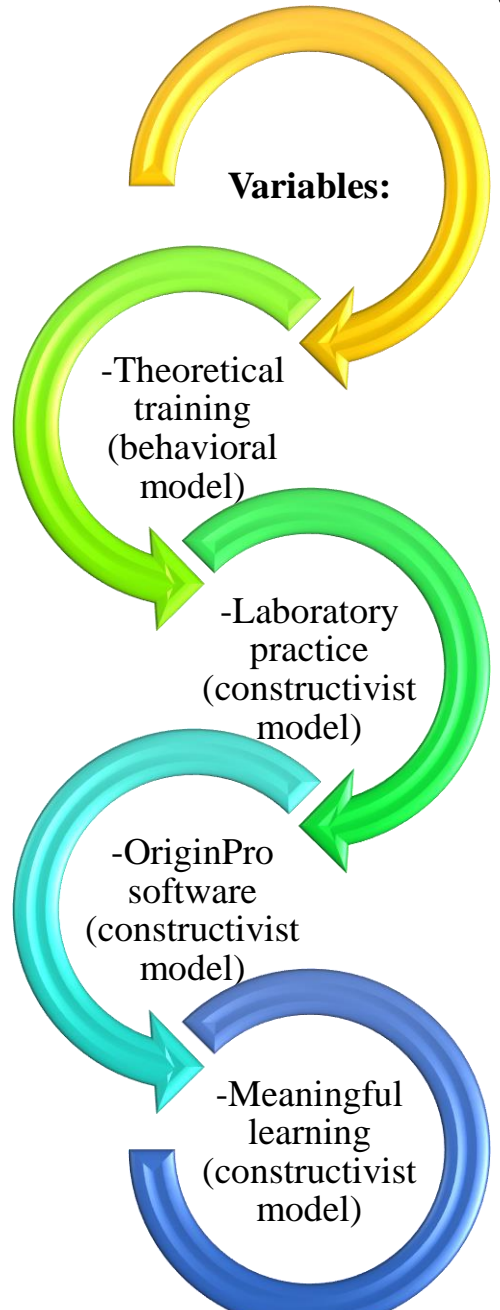
The meaningful learning theory postulated by Ausubel et al. (1976) affirms that the acquisition of new knowledge in students is based on previous knowledge, which allows them to interrelate what they have learned with what is new to learn, different from rote learning.



Methodology



Type and design of research: This research was developed under a quantitative, experimental and longitudinal approach (Hernández et al., 2014; and Bernal, 2016).



Measuring instrument:

The measurement instrument consists of three questions on demographic variables and twenty reagents, the first nineteen contemplate knowledge questions about the subject "Determination of the coefficients of adiabatic compressibility and volumetric expansion of triblock copolymers, through experimental data of density and speed of sound" and the last question in the pre-test refers to the need to apply theoretical and practical teaching-learning methodologies to improve learning, while in the post-test it refers to the impact achieved after the applied methodologies.

Methodology

The method used to collect information was longitudinal, that is, a pre-test and a post-test were applied twice in person in the classroom, a space where the participating undergraduate students met as intact groups.

The students answered three questions of the categorical variables referring to demographic data and 19 reagents with response options, of which they selected one for each question.

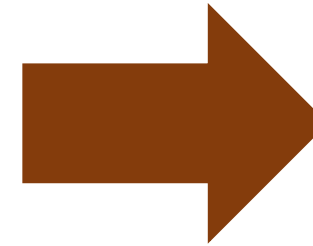
Also in the post-test questionnaire, the last question served to assess the impact of the implementation of the didactics strategy teaching-learning, on a Likert scale from 1 to 5, from very negative to very positive.

At that time, the link to the questionnaire was sent electronically and they were given advice on how to fill it out.

In addition, a final item was added to the pre-test regarding the need to implement the didactic strategy, on a Likert scale from 1 to 5.

Methodology

Participants: 91 undergraduate students from the third to sixth semester of the degrees in Chemistry, Chemical Engineering and Biological Pharmaceutical Chemist participated, who were selected through the type of non-probabilistic sampling of the type of intact groups (McMillan & Schumacher, 2005). The characteristics of the selected sample are detailed below (see table 1).



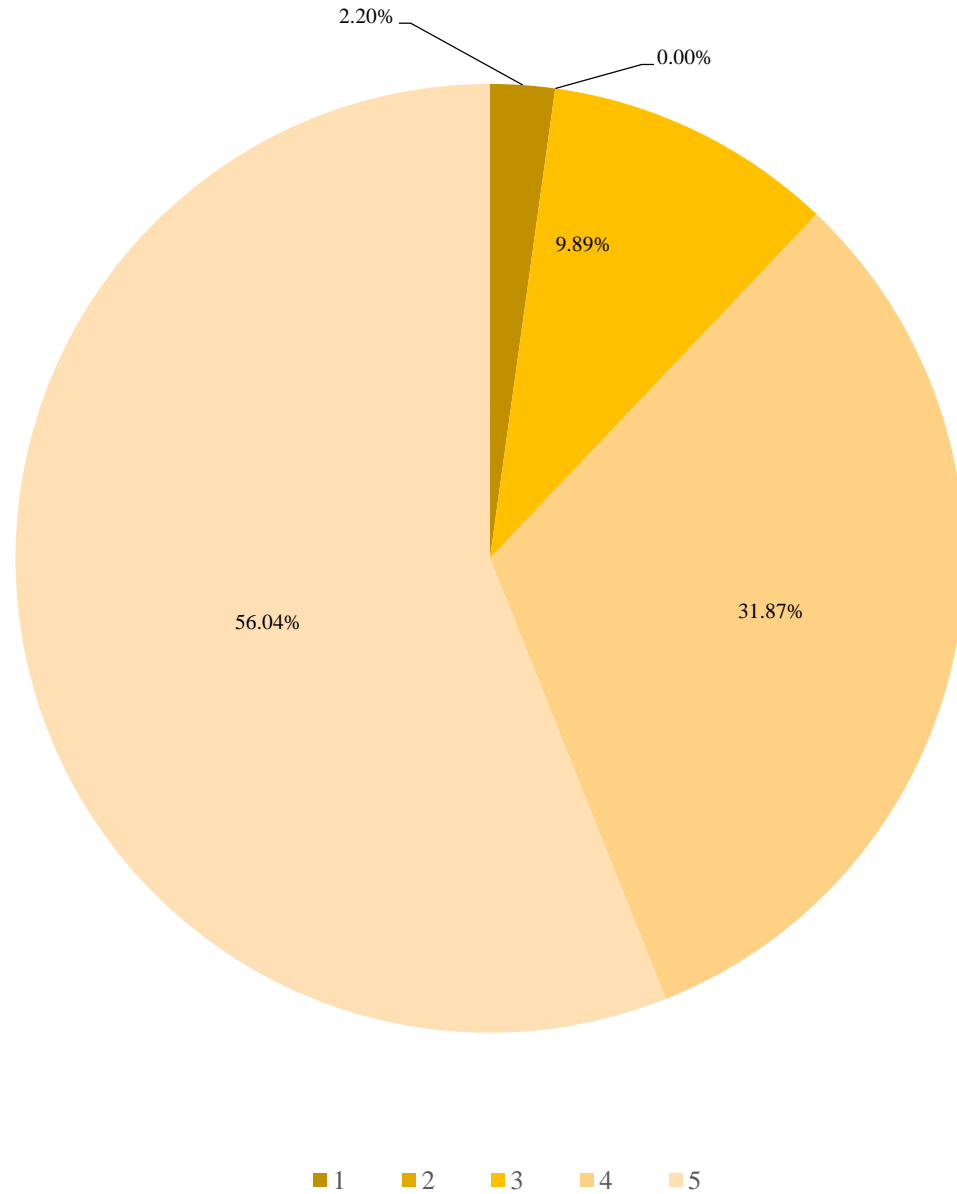
Sociodemographic variables	Sample profile
Age	17-20 years = 60% 21-24 years = 34% 25 years and more = 6%
Sex	Male = 29%; Feminine = 71 %
Bachelor's degree	Chemistry = 2% Pharmaceutical chemist biologist = 94% Chemical engineering = 4%

Table 1 Sample characteristics. *Source: Own elaboration (2022).*

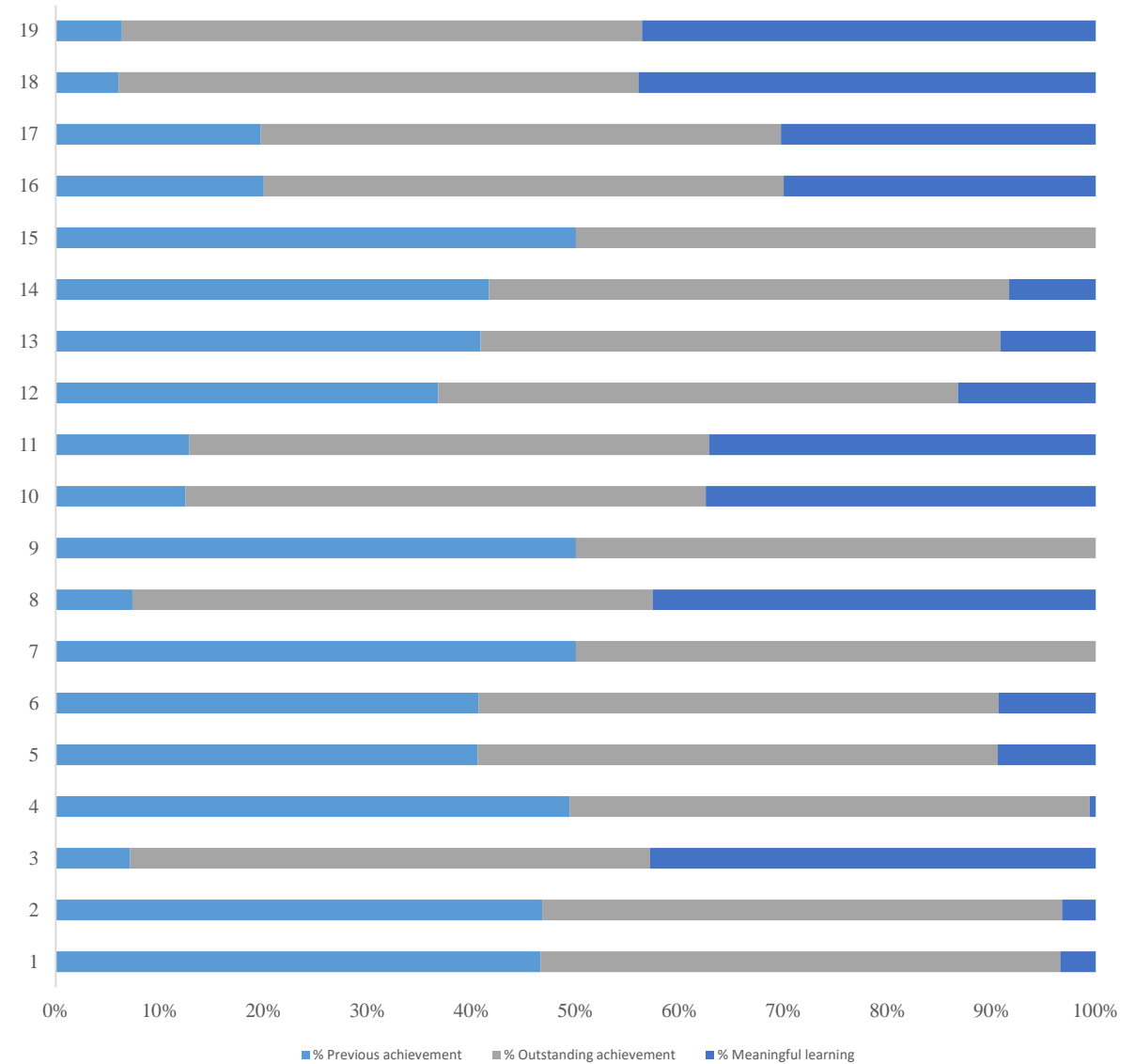


Data analysis: Descriptive statistics were used for data analysis, counting, tables and graphs, comparing the findings of the pre-test and the post-test, for the test of the central hypothesis.

Results

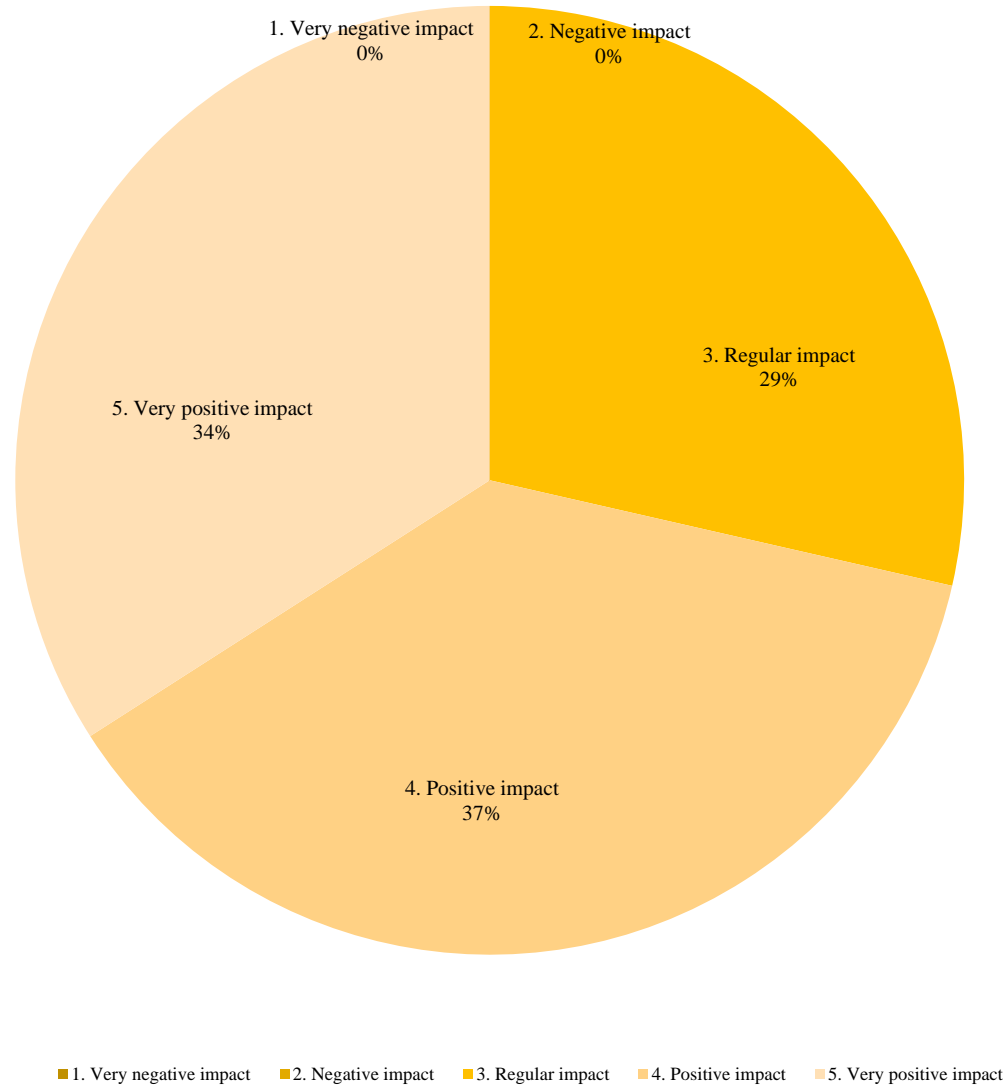


Graph 1 Identification of the need to implement the theoretical and practical didactic strategy. *Source: Own elaboration based on the data obtained from the pre-test (2022).*



Graph 2 Percentage contrast of previous achievement, outstanding achievement and meaningful learning. *Source: Own elaboration based on the data obtained from the pre-test and the post-test (2022).*

Results



Graph 3 Identification of the implementation of the theoretical and practical didactic strategy in the meaningful learning of the students. *Source: Own elaboration based on the data obtained from the post-test (2022).*



Items	Previous achievement (%)	Outstanding achievement (%)	Meaningful learning (%)
1	90.11	96.70	6.59
2	31.87	34.07	2.20
3	9.89	69.23	59.34
4	92.31	93.41	1.10
5	47.25	58.24	10.99
6	67.03	82.42	15.38
7	45.05	45.05	0.00
8	9.89	67.03	57.14
9	92.31	92.31	0.00
10	18.68	74.73	56.04
11	10.99	42.86	31.87
12	54.95	74.73	19.78
13	63.74	78.02	14.29
14	65.93	79.12	13.19
15	85.71	85.71	0.00
16	30.77	76.92	46.15
17	30.77	78.02	47.25
18	7.69	63.74	56.04
19	7.69	60.44	52.75

Table 2 Percentage contrast of previous achievement, outstanding achievement and meaningful learning. *Source: Own elaboration based on the data obtained from the pre-test and the post-test (2022).*

Annexes

A. Pre-test questionnaire

<p>Pre-test questionnaire</p> <p>The present survey has the purpose of detecting the level of knowledge that the students of the Bachelor of Chemistry, Bachelor of Chemical Engineering and Bachelor of Chemical Pharmaceutical Biologist enrolled in the University Center of Exact Sciences and Engineering of the University of Guadalajara, have regarding the subject "Determination of the coefficients of adiabatic compressibility and volumetric expansion of polymeric systems through experimental data of density and speed of sound", in order to generate a theoretical-practical didactic strategy that contributes to the meaningful learning of the student.</p> <p>It is important to mention that the information you provide will be handled confidentially, so it will not affect the current course grade. Initially, answer your general data according to the options provided for it and then answer the questions and/or statements numbered from 1 to 20, selecting the option that best reflects your knowledge.</p> <p>1.- Which of the following statements define a polymer?</p> <p>a) Macromolecules made up of the repetition of a simple unit known as a monomer, arranged sequentially: linear, branched, grafted, star-like or in blocks</p> <p>b) Amphiphilic chemical substances that manage to reduce the surface tension of a liquid</p> <p>c) Chemical substances that have the same composition or molecular formula, but with different physical and structural properties</p> <p>2.- Select from the following industries, the one that you consider uses polymers the most in the manufacture of its products:</p> <p>a) Pharmaceutical</p> <p>b) Automotive</p> <p>c) Textile</p> <p>d) Cosmetics</p> <p>e) Oil company</p> <p>f) Food</p> <p>3.- Do you know the commercial triblock copolymers (Pluronic)?</p> <p>a) Yes</p> <p>b) No</p> <p>4.- Which of the following answers define density?</p> <p>a) Physicochemical property that relates the amount of mass in a given volume of a substance</p> <p>b) Physical vector magnitude that relates the change of position with respect to time</p> <p>c) It is the resistance that some substances have during the process of fluidity and deformation</p> <p>5.- What effect is manifested in the density of Newtonian fluids when the temperature increases?</p> <p>a) Density increases</p> <p>b) Density decreases</p> <p>c) Density remains constant</p> <p>6.- Which of the following answers define the speed of sound?</p> <p>a) Physical vector magnitude that relates the change of position with respect to time</p> <p>b) It is the speed of propagation of sound waves through a given medium as a function of temperature</p> <p>c) It is the resistance that some substances have during the process of fluidity and deformation</p> <p>7.- What effect is manifested in the speed of sound of Newtonian fluids when the temperature is increased?</p> <p>a) The speed of sound increases</p> <p>b) The speed of sound decreases</p> <p>c) The speed of sound remains constant</p> <p>8.- Do you know the effect of the density and the speed of sound in Pluronic/Water solutions when the temperature is increased?</p> <p>a) Yes</p> <p>b) No</p> <p>9.- By means of which instrument it is possible to determine the density and speed of sound of solutions?</p> <p>a) Electronic hydrometer</p> <p>b) Viscometer</p> <p>c) Tensiometer</p>	<p>10.- Do you know any model of electronic density meter?</p> <p>a) Yes</p> <p>b) No</p> <p>11.- Have you made any measurement of the density and speed of sound in an electronic densimeter?</p> <p>a) Yes</p> <p>b) No</p> <p>12.- What does the coefficient of volumetric expansion physically indicate (α)?</p> <p>a) Isothermal compression of matter as a function of pressure</p> <p>b) Isobaric expansion of matter as a function of temperature</p> <p>c) The effect between expansion and compression</p> <p>13.- What does the isothermal compressibility coefficient physically indicate (κ)?</p> <p>a) Isothermal compression of matter as a function of pressure</p> <p>b) Isobaric expansion of matter as a function of temperature</p> <p>c) The effect between expansion and compression</p> <p>14.- What is the equation that defines the coefficient of volumetric expansion (α)?</p> <p>a) $\alpha = \left[-\left(\frac{1}{V}\right) \left(\frac{dV}{dT}\right)_P \right]$</p> <p>b) $\alpha = \left[\left(\frac{1}{V}\right) \left(\frac{dV}{dT}\right)_P \right]$</p> <p>c) $\alpha = \left(\frac{dP}{dT}\right)_V$</p> <p>15.- What is the equation that defines the coefficient isothermal compressibility (κ)?</p> <p>a) $\kappa = \left[-\left(\frac{1}{V}\right) \left(\frac{dV}{dP}\right)_T \right]$</p> <p>b) $\kappa = \left[\left(\frac{1}{V}\right) \left(\frac{dV}{dP}\right)_T \right]$</p> <p>c) $\kappa = \left(\frac{dP}{dT}\right)_V$</p> <p>16.- Have you calculated the value of the coefficient of volumetric expansion using experimental data on the density and speed of sound?</p> <p>a) Yes</p> <p>b) No</p> <p>17.- Have you calculated the value of the isothermal compressibility coefficient using experimental data on the density and speed of sound?</p> <p>a) Yes</p> <p>b) No</p> <p>18.- Do you know the software used to process data, <u>OriginPro</u>?</p> <p>a) Yes</p> <p>b) No</p> <p>19.- Have you ever used the <u>OriginPro</u> software to process data and make graphs?</p> <p>a) Yes</p> <p>b) No</p> <p>20.- At what level, from 1 to 5, do you consider it necessary to receive training that contributes to your academic training, both with theoretical and practical support in the subject "Determination of adiabatic compressibility coefficients and volumetric expansion of polymeric systems using data experiments of density and speed of sound", complementing it with practices in the laboratory and the use of specialized software?</p> <p>1) Strongly disagree</p> <p>2) Disagree</p> <p>3) Neither agree nor disagree</p> <p>4) <u>Agree</u></p> <p>5) <u>Totally agree</u></p>
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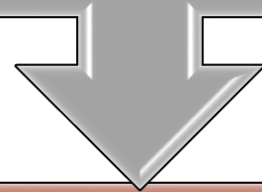
B. Post-test questionnaire

It includes questions from 1 to 19 of the pre-test, only question 20 is replaced by the impact measurement, on a Likert scale, as follows:

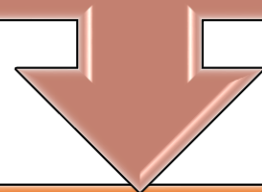
20. At what level from 1 to 5 does the theoretical and practical training received on the subject of "Determination of the coefficients of adiabatic compressibility and volumetric expansion of triblock copolymers, through experimental data of density and speed of sound", complemented with practices in the laboratory and the use of specialized software, impact your academic training?
- 1) Very negative impact
- 2) Negative impact
- 3) Regular Impact
- 4) Positive impact
- 5) Very positive impact

Conclusions

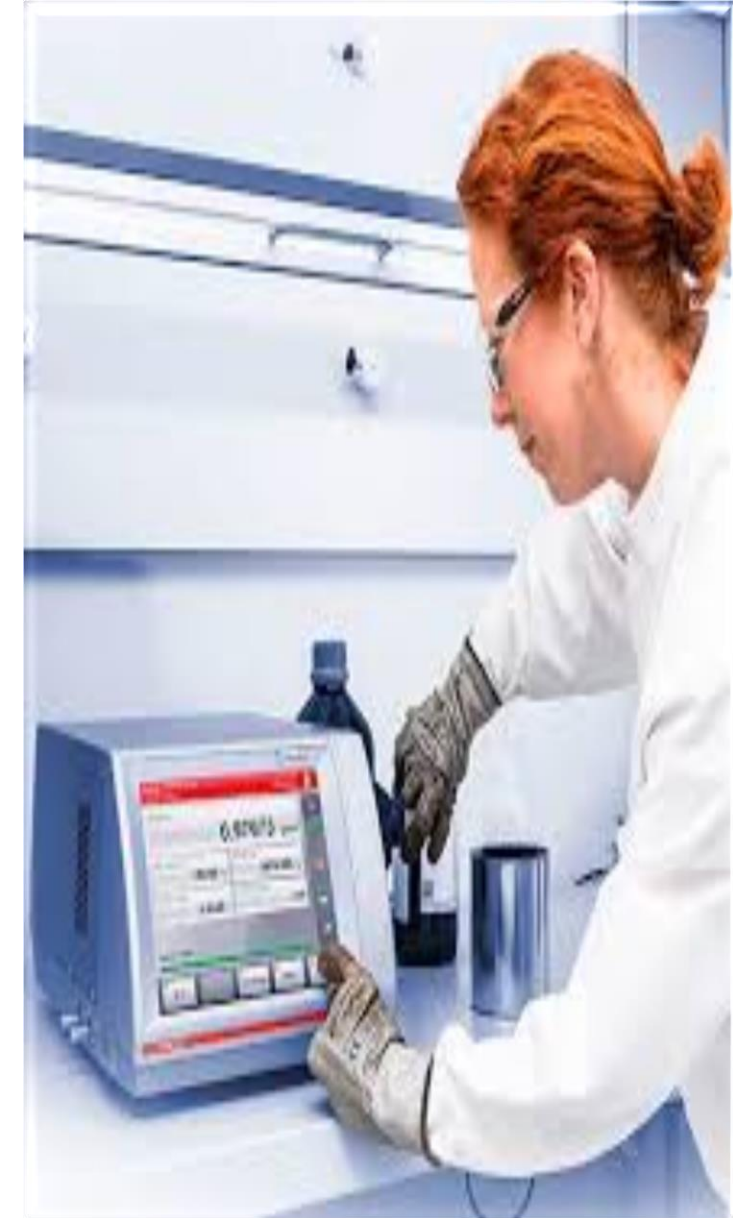
The analysis of the state of the art and the results obtained, consequently allow us to conclude that the teaching-learning process is constantly changing, from the traditional teacher-based teaching approach to the student-based learning approach, the latter supported in constructivist theory.



The foregoing is due to the new demands in the training of the next professionals, who after graduating from a professional career must have significant learning, that is, learning added to previous knowledge and with applicability in the real world.



Hence, the new teaching-learning strategies that include the classic master class, problem-based learning such as experimental learning, laboratory practices and the implementation of information technologies such as specialized software.



Conclusions

With this research, a direct contribution to the theory of meaningful learning of the constructivist approach was achieved, given that with the analysis of the state of the art and the results obtained, two evaluation instruments previously validated by experts were generated, in which qualitative and quantitative variables were incorporated, which allowed describing the population under study and confirming the theory, in addition to identifying the significant percentage of learning achieved.

Likewise, the central hypothesis was verified, given that the null hypothesis was rejected and the alternative was accepted, where: Theoretical training on the subject: "Determination of the coefficients of adiabatic compressibility and volumetric expansion of triblock copolymers, through experimental data from density and speed of sound", complemented with practices in the laboratory and the use of specialized software, significantly influences the meaningful learning of the undergraduate student.



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