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Low-cost materials for experimentation in Physics teaching in São Raimundo Nonato-PI

ARTICLE

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Abstract
Physics, as a philosophical line of nature, mathematically formalized and associated with everyday life, has shown a lack of interest and lack of affinity among students studying Physics. Therefore, this research work aims at the teaching-learning process applied to high school students in relation to the teaching of Physics based on experimentation with low-cost materials to assist them in this process. With the aim of improving physics teaching, a study was carried out in a public school in the municipality of São Raimundo Nonato-PI, using low-cost materials for experimentation. Thus, it was possible to analyze the skills and competencies related to the Physics discipline and diagnose the students' opinions. The results show that experimental practices are a motivational factor for students studying Physics.
Keywords: Physics teaching. Experimentation. Low cost materials.

Materiais de baixo custo para experimentação no ensino de Física em São Raimundo Nonato-PI

Resumo
A Física, como uma linha filosófica da natureza, formalizada matematicamente e associada ao cotidiano, tem apresentado desinteresse e falta de afinidade por parte dos discentes que cursam a disciplina. Logo, este trabalho de pesquisa tem como meta o processo de ensino-aprendizagem aplicado aos alunos do ensino médio em relação ao ensino de Física a partir da experimentação com materiais de baixo custo para auxiliá-los nesse processo. Objetivando aprimorar o ensino de Física, foi desenvolvida uma pesquisa em uma escola pública do município de São Raimundo Nonato-PI, através de uma ação docente que utilizou materiais de baixo custo para experimentação. Assim, foi possível analisar as habilidades e competências relacionadas à disciplina de Física e diagnosticar a opinião dos

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alunos. Os resultados apresentam que práticas experimentais são um fator motivacional para os alunos que cursam a disciplina de Física.
Palavras-chave: Ensino de física. Experimentação. Materiais de baixo custo.

1 Introduction

Currently, not only the teaching of physics, but teaching in general faces many difficulties. Araújo and Abib (2003) point out that, in particular, the subject of Physics has abstract content, and it is natural that many students in public high schools find it difficult to understand. This leads to a lack of interest in the subject during classes and throughout high school. Thus, it is common to find students who have little interest in actually learning the related and proposed content, and are only concerned with the basics, which is learning the formulas and doing memorization exercises in order to get a grade and not flunk the subject, leaving aside the understanding of physical phenomena.

In order to intervene in this problem, we sought to bring experimentation into the classroom as a different object of study for physics classes, enabling students to actively participate in lessons. Research shows that experimentation continues to be a topic of great interest to researchers, with a wide range of approaches and purposes for teaching physics (Araújo; Abib, 2003, p. 176). Experimental practices have therefore become a methodological procedure used as a resource in the teaching and learning process in high school physics classes.

According to Silva and Rocha Filho (2010), by observing physical phenomena and proving the formulas and theories taught in the textbooks and texts adopted through low-cost experimental practices carried out in the classroom, it is possible to arouse greater student interest in the subject presented.

The procedure aims to minimize the difficulties faced in traditional physics teaching. The results aim to show investigations and advantages, focusing on the importance and trends that emerge with the application of experimental procedures in physics activities in the classroom.

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Although much research has been done on the subject and many authors emphasize the importance of this teaching tool in schools, it is often attributed only as a motivating factor that draws students' attention to Physics classes (Silva; Rocha Filho, 2010). However, the use of this tool should not only be classified as a motivational instrument, but also as an element that will positively aid student learning.

From this perspective, Araújo and Abib (2003), referring to the direction of the activities, believe that the appropriate use of experimental methodologies enables the formation of scientific knowledge without devaluing the students' prior knowledge. This approach contributes to more active student participation, as well as reflection and restructuring of the concepts studied by the students.

In the work of Borges (2002, p. 294), the author indicates that teaching could be improved by introducing practical lessons, stating that "students should get to know some of the main products of science, have experience with them, understand the methods used by scientists to produce new knowledge and how science is one of the forces transforming the world".

In this way, we can identify the significant importance of experiments in understanding the events studied, since the process of experimentation in physics teaching is associated with the manipulation of objects and ideas that negotiate meaning with each other and have the opportunity to relate phenomena, because:

> The importance of experimentation in physics teaching is justified when we consider its pedagogical function of helping students to understand physical phenomena and concepts. The clear need for students to relate to the phenomena to which the concepts refer justifies experimentation as part of the school context, without it representing a break between theory and practice (Plicas; Pastre; Tiere, 2010, p. 2).

According to Gonçalves and Marques (2006, p. 226), it is necessary that "carrying out experimental activities contributes to enriching students' knowledge of the role of experimentation in the production of scientific knowledge." It also discusses where science is involved and how it is present in everyday life, creating a link between scientific knowledge and the student's reality. This aims to arouse greater interest in the subject and

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ensure that experimentation is not just a demonstration of a physical phenomenon, but also allows this phenomenon to be placed in a context where it can be seen that it really exists.

From the same perspective, Moraes (2009, p. 6) emphasizes that "if learning is meaningful, the student will feel more motivated to learn. And this learning is made possible when physics is taught in a contextualized way, so that it is very close to the student's reality."

According to Loss and Machado (2005), physics is presented in disagreement with what students and teachers experience, full of concepts. Contextualization is necessary so that students know what they are working on. In the same vein, Pietrocola (2005) affirms the importance of knowing physics as a science of nature and the need for a precise understanding, since the physical world is closely related to the everyday world.

Physics should therefore be geared towards students' everyday lives, so that they have a more critical and meaningful view of the world in which they live. Borges (2002) also highlights the mistake of confusing experimental activities with the need for sophisticated spaces, since these activities can be carried out in the classroom. The richness of this type of activity lies in giving students the opportunity to work with things and objects as if they were others, in an exercise of symbolization or representation.

The same aspect is discussed by Capistrano (2020, p. 2), who states that an experiment that allows students to manipulate materials or an experimental demonstration by the teacher does not always need to be associated with sophisticated apparatus. What matters is the organization, discussion and reflection on all the stages of the experiment. The author also emphasizes the importance of experimentation in physics teaching, pointing out that "through this method, students' difficulties in understanding physics content can be overcome, making the study more enjoyable and contributing to an increase in scientific knowledge applied to students' daily lives."

This is based on the use of low-cost, easily-acquired equipment and materials, so that they can be used in schools that don't have the necessary laboratories or material resources. This approach encourages active student participation, piques their curiosity and interest, and favors learning. It also helps to create a motivating, enjoyable, challenging

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environment that is conducive to the production of knowledge, skills, attitudes and competences.

Experimentation with low-cost materials is therefore justified in the process of teaching physics as an aid in the teaching-learning process or in the process of constructing scientific knowledge. This does not exclude the traditional form of teaching, but integrates it with experimental activities, since the construction of concepts in the development of this project establishes an articulation with different scientific and technological instruments.

Therefore, this research project is based on the following problem: to what extent do experimental practices carried out in the classroom, using low-cost materials, constitute fundamental tools for the learning process in physics teaching?

In an attempt to answer this question, the study presents a field of research in this area, as well as researchers focusing on the importance of experimental activities in public high school classrooms in Physics subjects. It also analyzes the view that students at the Centro de Ensino de Tempo Integral Moderna (CETI-Moderna) in the municipality of São Raimundo Nonato-PI have in relation to experimentation, where the use of low-cost materials can positively assist in the teaching and learning process of students studying Science and its Technologies.

2 Methodology

This research used a qualitative approach and applied questionnaires to the students with objective questions about some fundamental concepts: Thermodynamics and Electric Charges. The questionnaires were administered in May and June 2022, at two different times and on different days. At first, only the questionnaire was administered. On the second day, a brief explanation was given of the content according to the grade of the class, the low-cost material used to make the apparatus was presented, the experiment was carried out and the questionnaire was administered again. The questionnaires applied at both times were the same.

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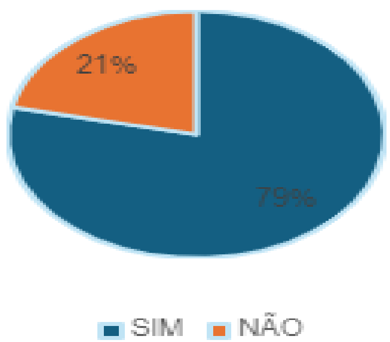
The research was carried out at the state public school, CETI-Modern, in the city of São Raimundo Nonato - PI, where the aim was to obtain students' views on the teaching of physics. The research was carried out in the high school classes of 2nd year D and 3rd year C, considering that this sample is representative of the profile of the students investigated. The result was a case study, seeking to understand the students' conceptions of physics teaching and to investigate how these conceptions can contribute positively to the teaching and learning process in the subject.

3 Results and Discussion

The results of this research were presented by comparing the results of the first and second questionnaires. A total of 56 students took part in the survey, divided into 2nd and 3rd year classes. The first question was the same in both questionnaires and asked whether the students were aware of the existence of a laboratory in the school. The results are shown in Figure 1:

Figure 1. School laboratory



Source: Questionnaires. Elaborated by the authors.

The results shown in Figure 1 show that the CETI-Moderna school has a space called "laboratory", but it doesn't function as such and has no instruments for this purpose, as the space in question is used as a storage room.

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In questions 2 to 10, a questionnaire was drawn up about the area of knowledge of Physics, called Thermodynamics, which is covered didactically in the 2nd year high school class.

2nd year D class.

The second question refers to the concept of thermometry: What is thermometry?

(a) is the part of thermology concerned with the study of velocity, its trajectories and inertial references.

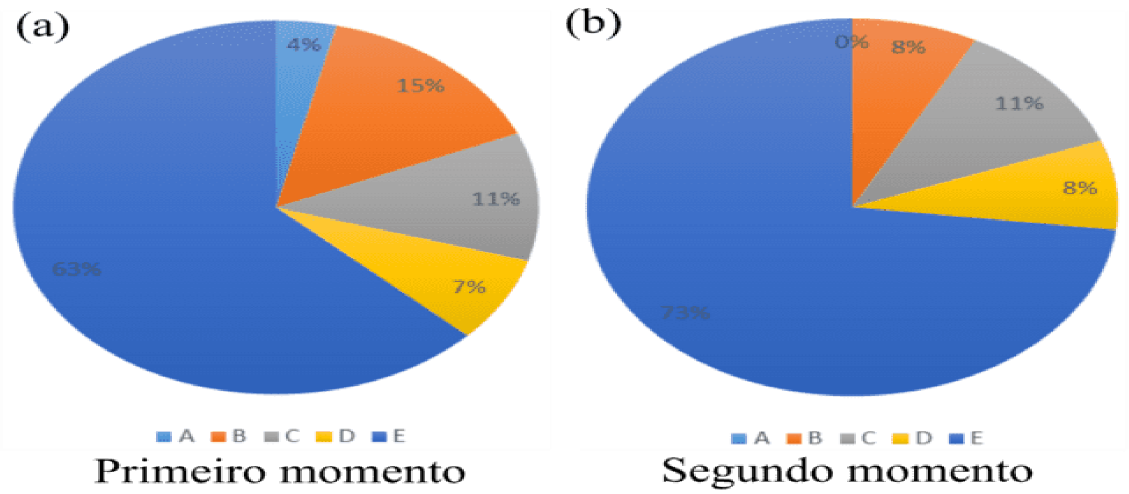
(b) is the part of thermology concerned with the study of the force applied to a body by its displacement.

(c) is the part of thermology concerned with the study of atoms and molecules.

(d) is the part of thermology concerned with the study of heat and its transformations;

(e) is the part of thermology concerned with the study of temperature, thermometers and thermometric scales.

Figure 2. Students' answer to the second question.



Source: Questionnaires. Elaborated by the authors.

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There was a 10% improvement in the correct alternative, going from 63% to 73% for letter E. In the third question, the question refers to the definition of temperature: What is Temperature?

(a) is a physical quantity that measures the average force of each degree of freedom of each of the particles of a system in thermal equilibrium

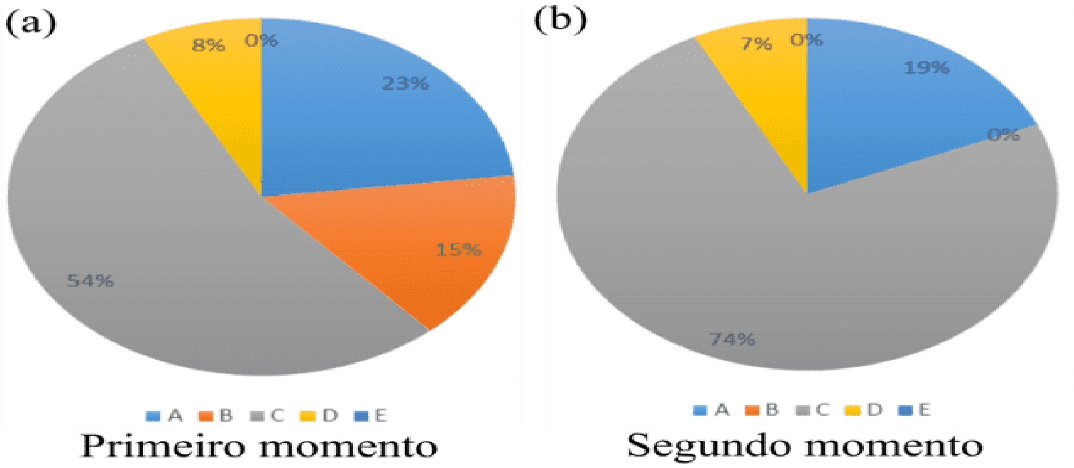
(b) is a physical quantity that measures the average potential energy of each degree of freedom of each of the particles of a system in thermal equilibrium

(c) is a physical quantity that measures the average thermal energy of each degree of freedom of each of the particles of a system in thermal equilibrium

(d) is a physical quantity that measures the average kinetic energy of each degree of freedom of each of the particles of a system in thermal equilibrium

(e) is a physical quantity that measures the average acceleration of each degree of freedom of each of the particles of a system in thermal equilibrium.

Figure 3. Students' answers to the third question.



Source: Questionnaires. Elaborated by the authors.

The results presented in Figure 3 show that, even though the majority of the 2nd year D class got the correct alternative right, we saw a 20% improvement in assertiveness

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after experimenting with low-cost materials, with more students answering the correct alternative, C. In these results, we can see that, even though the students had theoretical knowledge acquired in the Thermodynamics lectures, the experimental practice improved their understanding of the fundamental concepts of the physical definition of temperature.

The fourth question asked about calorimetry: What is calorimetry?

(a) is a branch of physics that studies the exchange of energy between bodies or systems when this exchange takes place in the form of heat.

(b) is a branch of physics that studies the exchange of energy between bodies or systems when this exchange takes place in the form of temperature.

(c) is a branch of physics that studies energy exchanges between bodies or systems when these exchanges take the form of work.

(d) is a branch of physics that studies the exchange of energy between bodies or systems when this exchange takes place in the form of force between atoms and molecules.

(e) is a branch of physics that studies energy exchanges between bodies or systems when these exchanges take the form of torque and linear momentum.

The results obtained (see Figure 4) show that, even though the students already had some correct knowledge about an important area of Physics, Thermometry, after the second teaching moment using experimentation with low-cost materials in the lecture, there was a 16% increase in the choice of the correct alternative, letter A. By visualizing physical phenomena through an experiment, it can be seen that practice makes students associate their understanding of fundamental concepts with the theoretical foundations presented in a lecture.

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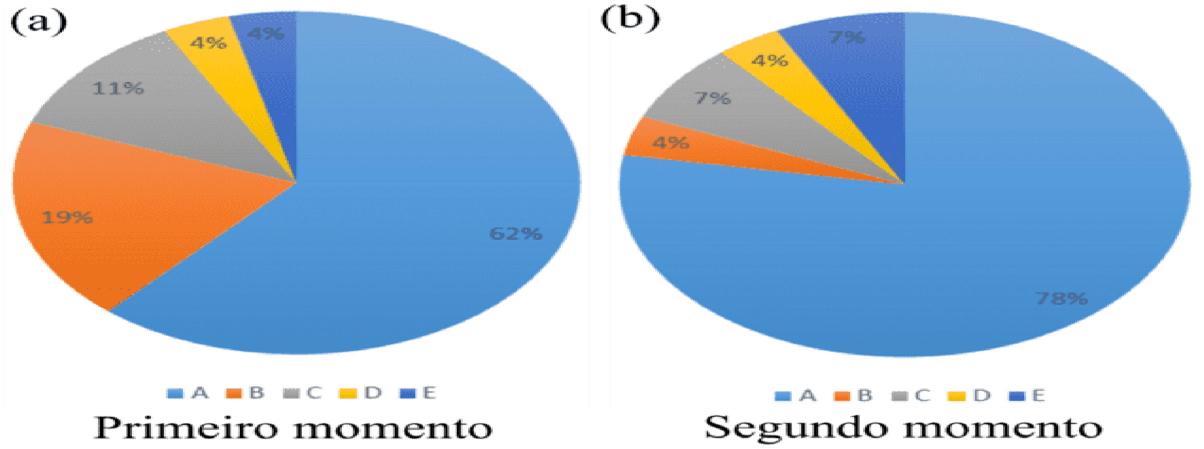
Figure 4. Students' answers to the fourth question.



Source: Questionnaires. Elaborated by the authors.

In the fifth question, the students were asked about heat: What is heat?

(a) is thermal energy at rest from one body to another, due solely to a difference in temperature.

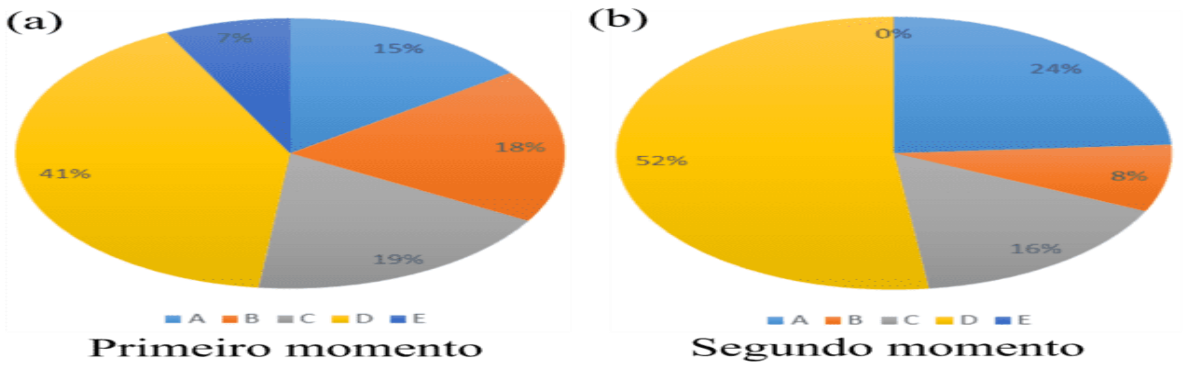
(b) is not thermal energy in transit from one body to another, due solely to a difference in temperature.

(c) is thermal energy in transit contained in a body.

(d) is thermal energy in transit from one body to another, due solely to a difference in temperature.

(e) None of the above.

Figure 5. Students' answers to the fifth question.



Source: Questionnaires. Elaborated by the authors.

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In the results shown in Figure 5, success was observed with an 11% increase in the assertiveness of the correct alternative, letter D. In the next question, a question from ENEM (National High School Exam), 2020, was applied, which aimed to understand thermal equilibrium.

The sixth question was described as follows (Brasil, 2020): A thermometer manufacturer states in its instruction manual that the instrument must be in contact with the body for three minutes in order to measure the temperature. These thermometers are made with a mercury-filled bulb connected to a glass capillary tube. According to thermodynamics, this procedure is justified because:

(a) the thermometer and the body have the same internal energy.

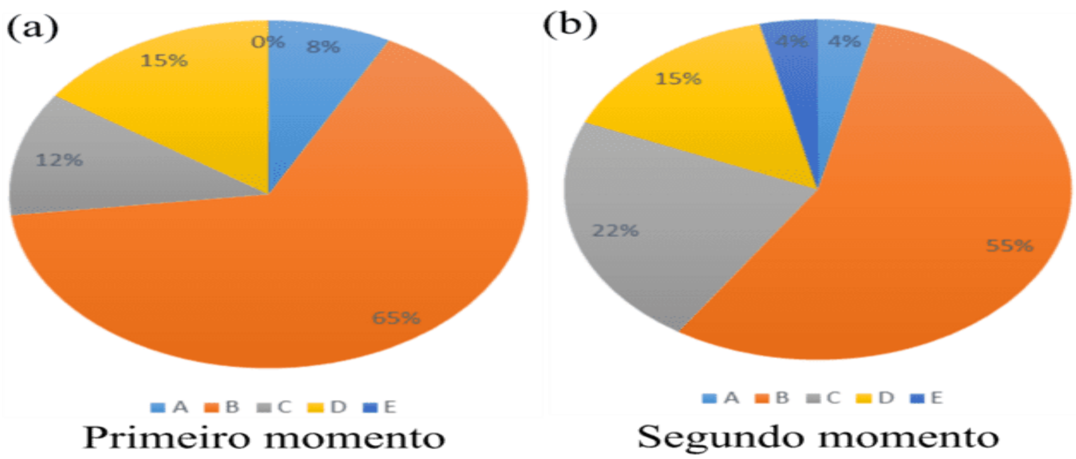
(b) the temperature of the body passes into the thermometer.

(c) thermal equilibrium is reached between the bodies.

(d) the amount of heat in the bodies is the same.

(e) the heat from the thermometer passes into the body.

Figure 6. Students' answers to the sixth question.



Source: Questionnaires. Elaborated by the authors.

Although the incorrect results were still higher, there was a 10% increase in the choice of the correct alternative, C, from 12% to 22%. In the seventh question, another ENEM question, from 2020, was applied, with the aim of understanding the process that

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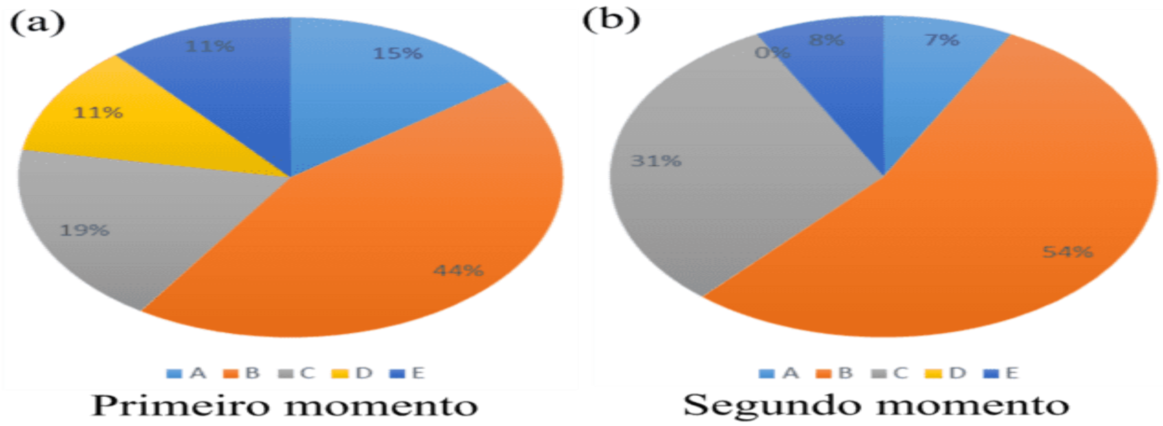
gives fried foods their crunchiness, placing in the development of the question a situation that could explain the reason for this process.

The seventh question had the following description (Brasil, 2020): Frying food is a thermal process that takes place at high temperatures, approximately 170ºC. In this condition, foods rich in carbohydrates and proteins undergo rapid dehydration on their surface, making them crispy. A person wants to fry all the frozen breaded chicken from a box. To do this, she adds all the contents at once to a pan of vegetable oil at 170ºC, the volume of which is sufficient to cover all the pieces. But, to her frustration, at the end of the process they turn out to be soaked in oil and not crispy. The units don't have the desired appearance because of:

(a) partial evaporation of the oil.
(b) decrease in oil temperature.
(c) excessive dehydration of the units.
(d) thermal barrier caused by stuffing.
(e) absence of proteins and carbohydrates in the units.

Figure 7. Students' answer to the seventh question.



Source: Questionnaires. Elaborated by the authors.

The results obtained on this question (see Figure 7) were satisfactory, with a 10% increase in the assertiveness of the correct alternative, B, after the practice of the second pedagogical moment, which included practical lectures with experimentation using low-cost

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materials. In the eighth question, another question from ENEM 2013 was applied, with the aim of understanding the phenomenon of thermal equilibrium. The question was worded as follows (Brasil, 2013): We often refer to hot days as "hot" days. We often hear expressions like "it's hot today" or "it's very hot today" when the ambient temperature is high. In a scientific context, is the meaning of "heat" used in these expressions correct?

(a) yes, because the heat of a body depends on its temperature.

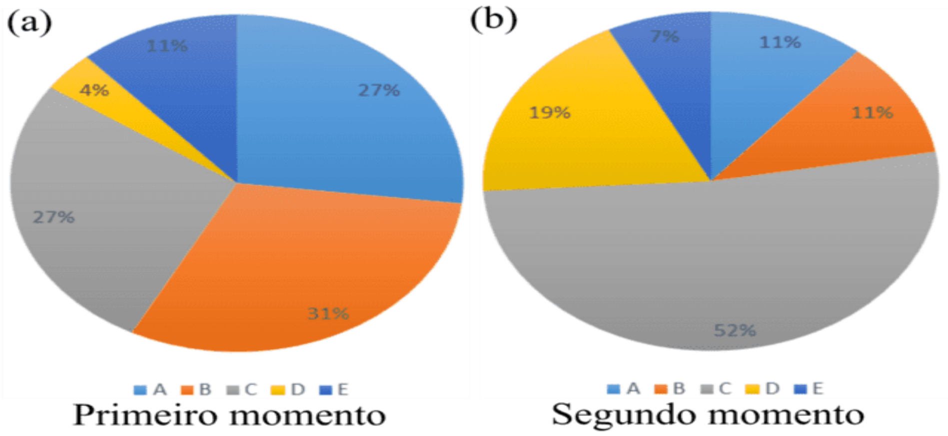
(b) yes, because heat is synonymous with high temperature.

(c) no, because heat is thermal energy in transit.

(d) no, because heat is the amount of thermal energy contained in a body.

(e) no, because heat is directly proportional to temperature, but they are different concepts.

Figure 8. Students' answers to the eighth question.



Source: Questionnaires. Elaborated by the authors.

The results presented in this ENEM question (see Figure 8) were positive, with an increase of 25% in the assertiveness of alternative C, from 27% to 52% between the two moments. In the ninth question, also from the 2012 ENEM, students had to answer how they understood the process by which increasing the flow of water lowers the temperature.

The ninth question was described as follows (Brasil, 2012): Electric showers have a switch to regulate the summer/winter temperature and to turn the shower off. You can also adjust the water temperature by opening or closing the damper. Opening it lowers the

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temperature and closing it raises it. Increasing the water flow reduces the water temperature:

(a) the surface area of the water inside the shower increases, increasing heat loss by radiation.

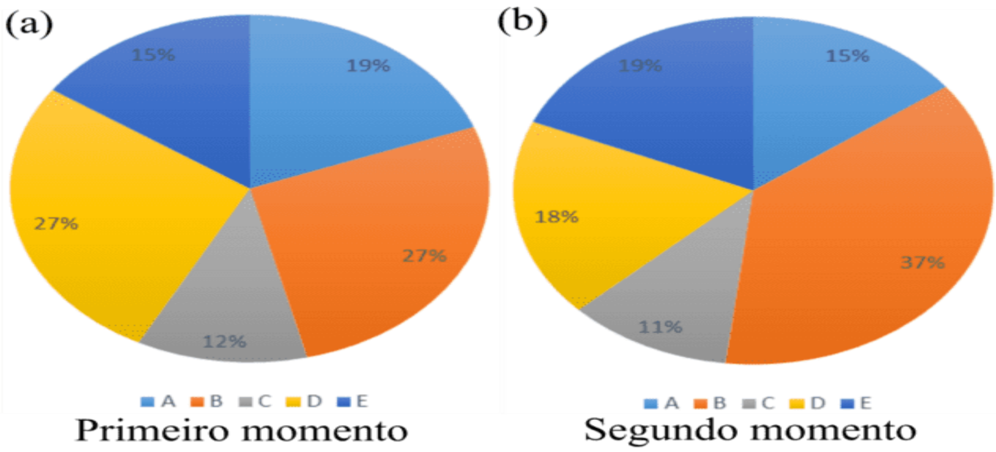
(b) the specific heat of the water increases, making it harder for the mass of water to heat up in the shower.

(c) the thermal capacity of the water/shower combination decreases, also decreasing the combination's ability to heat itself.

(d) the contact between the shower's electric current and the water is reduced, also reducing its ability to heat the water.

(e) the contact time between the water and the shower head decreases, reducing the transfer of heat from one to the other.

Figure 9. Students' answer to the ninth question.



Source: Questionnaires. Elaborated by the authors.

The results obtained in this ENEM question (see Figure 9) show that 15% of the students answered correctly in the first moment with alternative E and, in the second moment, 19%. In the tenth question, also from ENEM, students had to answer about the process of heat transfer.

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The question is worded as follows: On days with low temperatures, people wear coats or wool sweaters in order to minimize the sensation of cold. Physically, this sensation occurs because the human body releases heat, which is the energy transferred from one body to another due to the difference in temperature between them. Wearing wool clothing reduces the sensation of cold because:

(a) has the property of generating heat.

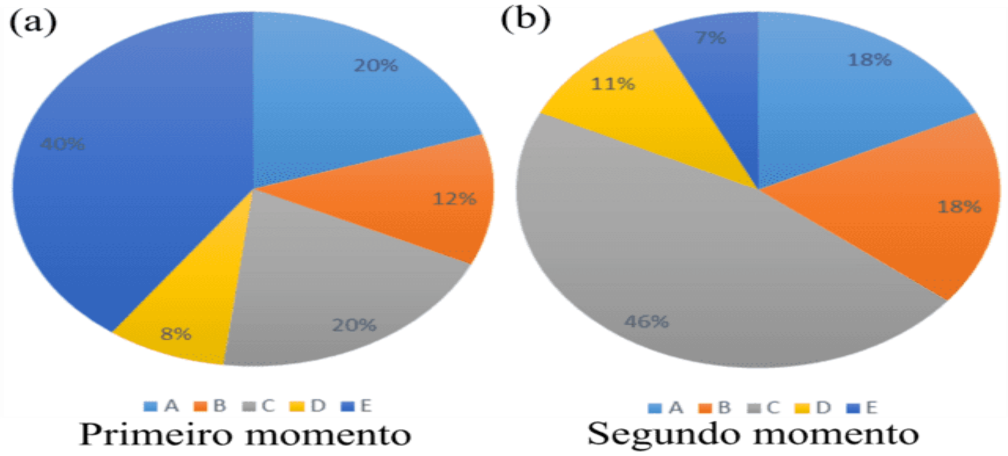
(b) is made of dense material, which prevents cold air from entering.

(c) reduces the rate of heat transfer from the human body to the external environment.

(d) its main characteristic is the absorption of heat, facilitating thermal equilibrium.

(e) is in direct contact with the human body, facilitating heat transfer by conduction.

Figure 10. Students' answers to the tenth question.



Source: Questionnaires. Elaborated by the authors.

In the results shown in Figure 10, there was an increase of 26%, from 20% to 46% assertiveness in alternative C, after the second pedagogical moment with the practical lecture with experimentation using low-cost materials. It can be seen that experimentation in the classroom is essential and fundamental for improving the quality of the teaching-learning process in Physics.

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For the 3rd year high school class, questions 2 to 7 dealt with an area of Physics knowledge called Electricity.

3rd year C class.

The second question posed to third-year students concerns the definition of electric charges: What is electric charge?

(a) is a fundamental physical property that determines heat interactions.

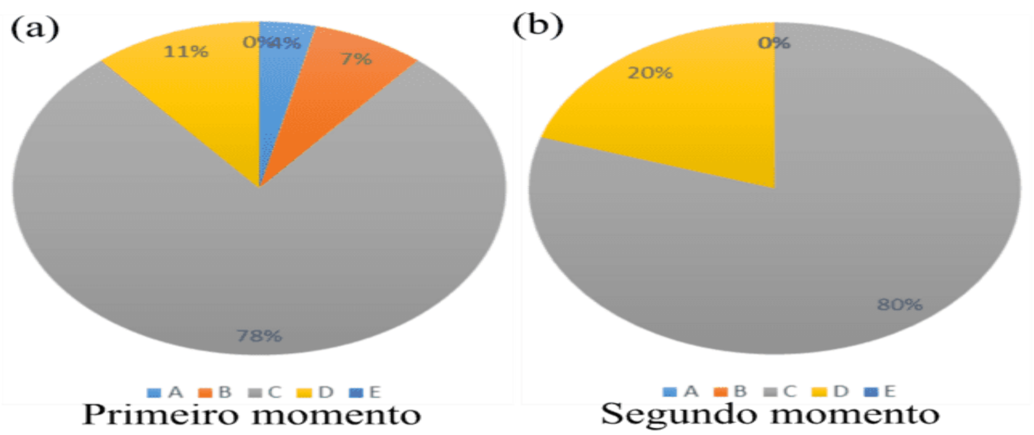
(b) is a fundamental physical property that determines thermal interactions.

(c) is a fundamental physical property that determines electromagnetic interactions.

(d) is a fundamental physical property that determines thermal and electromagnetic interactions.

(e) None of the above.

Figure 11. Students' answers to the second question.



Source: Questionnaires. Elaborated by the authors.

At the first moment, a good assertiveness result was obtained, with 78% choosing alternative C, and at the second moment this rate rose to 80% (see Figure 11). The third question concerns electrification by friction: In an electrification by friction, is it correct to say that...?

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(a) no electrons flow during the process;

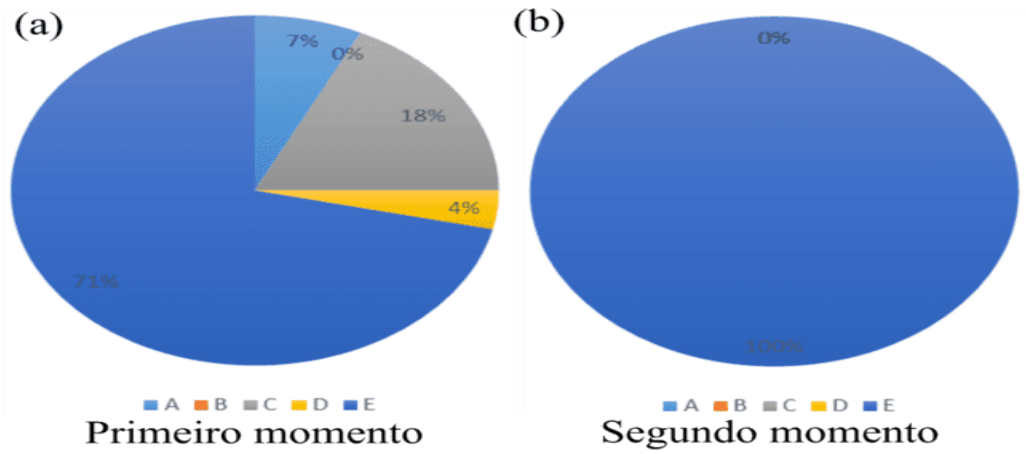
(b) both bodies become neutral.

(c) both bodies become positive (have given up electrons).

(d) both bodies become negative (have received electrons).

(e) one of the bodies becomes negative (has received electrons) and the other becomes positive (has given electrons).

Figure 12. Students' answers to the third question.



Source: Questionnaires. Elaborated by the authors.

In the results shown in Figure 12, there was a significant increase in assertiveness, from 71% to 100% when choosing alternative E. The fourth question, from ENEM 2016, concerns electrical resistivity. The question was worded as follows (Brasil, 2016): During the formation of a thunderstorm, several electrical discharges are observed, the lightning, which can occur: from the clouds to the ground (downward discharge), from the ground to the clouds (upward discharge) or between one cloud and another. Upward and downward discharges can occur due to the accumulation of positive or negative electrical charges, which induces an opposite polarization in the ground. These electrical discharges occur due to an increase in the intensity of:

(a) the Earth's magnetic field.

(b) the electric current generated inside the clouds.

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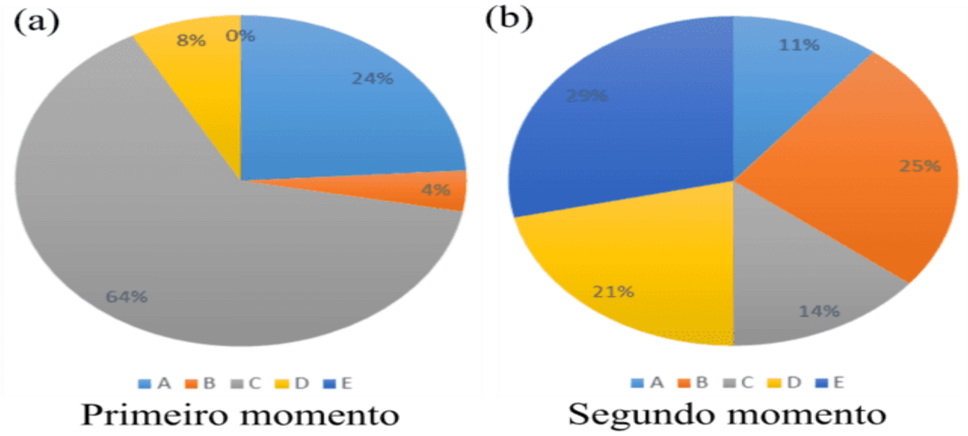
(c) the electrical resistivity of the air between the clouds and the ground.

(d) the electric field between the clouds and the Earth's surface.

(e) the electromotive force induced in the charges accumulated in the ground.

Figure 13. Students' answers to the fourth question.



Source: Questionnaires. Elaborated by the authors.

The results shown in Figure 13 show that even though the majority of students did not get the correct alternative, letter D, there was an increase from 8% to 21% in the number of correct answers. This is an important and relevant result, as it represents the efficiency of experimentation using low-cost materials in physics classes in the teaching-learning process. The fifth question, also from the 2010 ENEM, dealt with another electrostatic shielding situation.

The question had the following description (Brasil, 2010): Two sisters who share the same study room agreed to buy two boxes with lids so that they could keep their belongings in their boxes, thus avoiding clutter on the study table. One of them bought a metal box and the other a wooden box with different areas and side thicknesses to make it easier to identify. One day, the girls went to study for their physics exam and, as they settled down at their study table, they put their cell phones inside their boxes. Throughout the day, one of them received phone calls, while the other's friends tried to call and received the message that the cell phone was out of range or switched off. To explain this situation, a

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physicist should say that the material in the box whose cell phone didn't receive the calls is:

(a) wood, and the telephone didn't work because wood is not a good conductor of electricity.

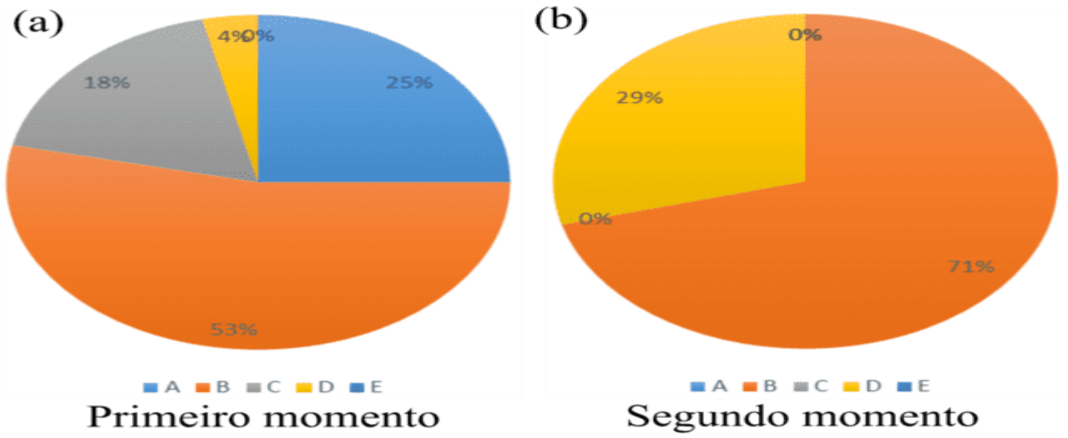
(b) metal, and the telephone didn't work because of the electrostatic shielding provided by the metal.

(c) metal, and the telephone didn't work because the metal reflected all kinds of radiation that hit it.

(d) metal, and the telephone didn't work because the side area of the metal box was larger.

(e) wood, and the telephone didn't work because the thickness of this box was greater than the thickness of the metal box.

Figure 14. Students' answers to the fifth question.



Source: Questionnaires. Elaborated by the authors.

The data in Figure 14 shows a positive assertiveness result for the ENEM question. The correct alternative, B, was marked by 53% of the class at the first moment and by 71% at the second moment. An 18% increase in assertiveness. The sixth question dealt with the process of electrification by electrostatic induction: If a neutral body is placed in contact with a negatively electrified body, then the neutral body is grounded, then the grounding is

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disconnected and the charges are separated, what is the final charge acquired by the initially neutral body?

(a) it remains neutral;

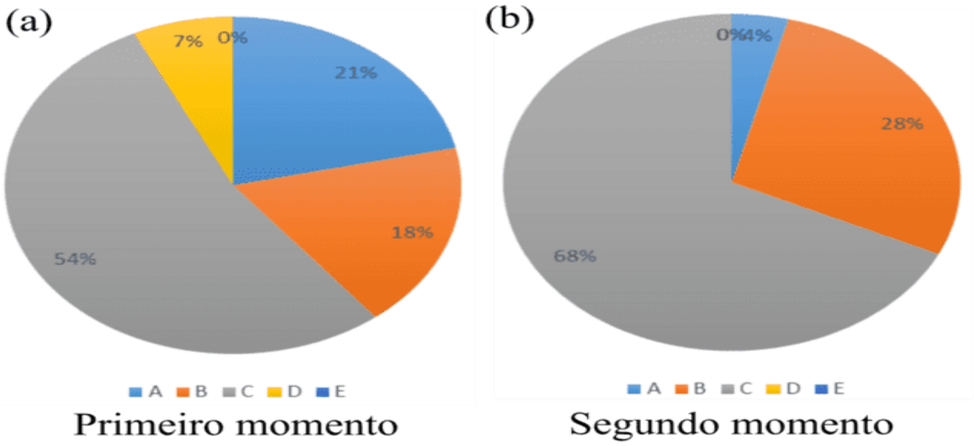
(b) it acquires a positive charge;

(c) acquires a negative charge;

(d) electrically neutralizes the other body.

(e) none of the above.

Figure 15. Students' answer to the sixth question.



Source: Questionnaires. Elaborated by the authors.

The data shown in Figure 15 shows that after the second pedagogical moment, a lecture with experimentation using low-cost materials, there was a 10% increase in assertiveness, with the correct alternative being B. The seventh and final question asked about the structure of the atom: According to classical physics, the main elementary particles that make up the atom are:

(a) protons, electrons and electric charge.

(b) protons, neutrons and electrons.

(c) electrons, neutrons and atom.

(d) neutrons, negative and positive.

(e) none of the above.

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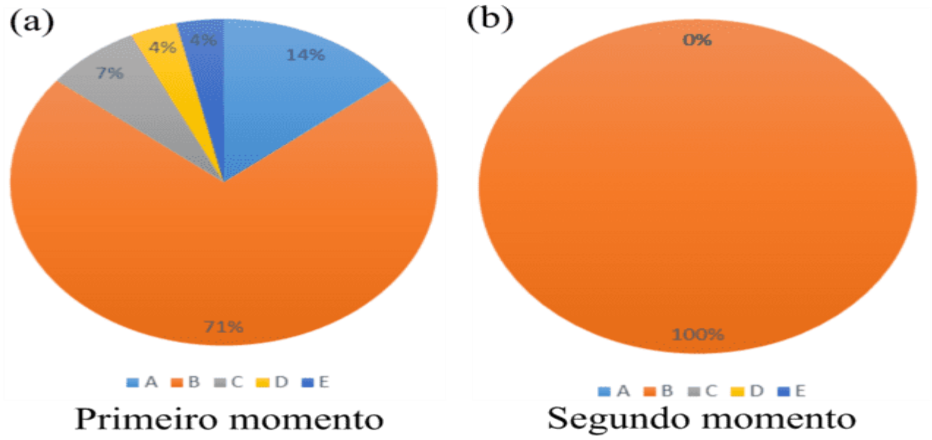
Figure 16. Students' answer to the seventh question.



Source: Questionnaires. Elaborated by the authors.

After practicing the pedagogical moments, there was a positive result (see Figure 16), where the assertiveness of the correct alternative, letter B, went from 71% to 100%. As was shown in the questions previously applied to the 2nd year class, experimentation with low-cost materials showed positive results in the teaching and learning process in the 3rd year class. Therefore, the results of the research show that there is an alternative to minimize the lack of appropriate laboratories for teaching physics in public high schools.

4 Conclusions

The research reinforces the importance and need for innovation in physics teaching, in the sense of bringing the content to the student in a different way to the traditional method, removing the idea of complexity and inability to learn physics. Students want to learn, but as long as this is done in a contextualized way and they can actively participate in the teaching and learning process.

It is worth emphasizing that experimentation does not replace the textbook, the blackboard, the definition of concepts and the application of calculations, but it strengthens

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and contributes significantly to the learning process and the identification of everyday physical phenomena. Through experimentation in the classroom, the research achieved the expected result by promoting the insertion of content in a diversified, didactic and easily accessible way, demonstrating that a sophisticated space is not necessary for teaching and learning to take place effectively.

Therefore, the study showed that teaching and learning can take place by planning the space, the content and the use of easily accessible, low-cost objects. It should be emphasized that public schools need to have laboratories, where the development of scientific knowledge gains strength. However, in the absence of these resources, experiments using low-cost materials are a viable alternative for teaching physics.

References

ARAÚJO, M. S. T. d.; ABIB, M. L. V. d. S. Atividades experimentais no ensino de física: diferentes enfoques, diferentes finalidades. **Revista Brasileira de ensino de física**, v. 25, p. 176–194, 2003.

BRASIL. Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (Inep). Exame Nacional do Ensino Médio (Enem). Prova de Ciências da Natureza e suas Tecnologias. Prova de Matemática e suas Tecnologias. **2º Dia - Caderno 5 – Amarelo – Aplicação digital, Questão 97**. 2020. Disponível em: https://www.gov.br/inep/pt-br/areas-de-atuacao/avaliacao-e-exames-educacionais/enem/provas-e-gabaritos. Acesso em: 21 mar. 2022.

BRASIL. Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (Inep). Exame Nacional do Ensino Médio (Enem). Prova de Ciências da Natureza e suas Tecnologias. Prova de Matemática e suas Tecnologias. **2º Dia – Caderno 5 – Amarelo – Reaplicação/PPL, Questão 119**. 2020. Disponível em: https://www.gov.br/inep/pt-br/areas-de-atuacao/avaliacao-e-exames-educacionais/enem/provas-e-gabaritos. Acesso em: 21 mar. 2022.

BRASIL. Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (Inep). Exame Nacional do Ensino Médio (Enem). Prova de Ciências Humanas e suas Tecnologias. Prova de Ciências da Natureza e suas Tecnologias. **1º Dia - Caderno 3 - Branco – Reaplicação/PPL, Questão 84**. 2013. Disponível em: https://www.gov.br/inep/pt-br/areas-de-atuacao/avaliacao-e-exames-educacionais/enem/provas-e-gabaritos. Acesso em: 25 mar. 2022.

DOI: https://doi.org/10.47149/pemo.v7.e12367
https://revistas.uece.br/index.php/revpemo
ISSN: 2675-519X
Esta obra está licenciada com uma Licença Creative Commons Atribuição 4.0 Internacional.

BRASIL. Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (Inep). Exame Nacional do Ensino Médio (Enem). Prova de Ciências Humanas e suas Tecnologias. Prova de Ciências da Natureza e suas Tecnologias. **1º Dia - Caderno 3 - Branco – Reaplicação/PPL, Questões 52 e 58**. 2012. Disponível em: https://www.gov.br/inep/pt-br/areas-de-atuacao/avaliacao-e-exames-educacionais/enem/provas-e-gabaritos. Acesso em: 29 mar. 2022.

BRASIL. Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (Inep). Exame Nacional do Ensino Médio (Enem). Prova de Ciências Humanas e suas Tecnologias. Prova de Ciências da Natureza e suas Tecnologias. **1º Dia - Caderno 9 - Branco – Reaplicação/PPL, Questão 79**. 2016. Disponível em: https://www.gov.br/inep/pt-br/areas-de-atuacao/avaliacao-e-exames-educacionais/enem/provas-e-gabaritos. Acesso em: 25 mar. 2022.

BRASIL. Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (Inep). Exame Nacional do Ensino Médio (Enem). Prova de Ciências Humanas e suas Tecnologias. Prova de Ciências da Natureza e suas Tecnologias. **Dia 1 - Caderno 1 - Azul – Aplicação regular, Questão 78**. 2010. Disponível em: https://www.gov.br/inep/pt-br/areas-de-atuacao/avaliacao-e-exames-educacionais/enem/provas-e-gabaritos. Acesso em: 29 mar. 2022.

BORGES, A. T. Novos rumos para o laboratório escolar de ciências. **Caderno Brasileiro de ensino de Física**, v. 19, n. 3, p. 291–313, 2002.

CAPISTRANO, L. L. M. Caminhos e descaminhos das aulas experimentais no ensino de física. **Cadernos Macambira**, v. 5, n. 2, p. 312–321, 2020.

GONÇALVES, F. P.; MARQUES, C. A. Contribuições pedagógicas e epistemológicas em textos de experimentação no ensino de química. **Investigações em Ensino de Ciências**, v. 11, n. 2, p. 219–238, 2016.

HEINECK, R.; VALIATI, E. R. A.; ROSA, C. d. Software educativo no ensino de física: análise quantitativa e qualitativa. **Revista Iberoamericana de Educación, Organización de Estados Iberoamericanos para la Educación, la Ciencia**, v. 42, n. 6, p. 1–12, 2007.

LOSS, L.; MACHADO, M. de. L. Pressupostos teóricos e metodológicos da disciplina de física: experiências didáticas. **XVI Simpósio Nacional de Ensino de Física**. Rio de Janeiro, 2005.

MORAES, J. U. P. A visão dos alunos sobre o ensino de física: um estudo de caso. **Scientia Plena**. v. 5, n. 11. 2009.

Rev. Pemo, Fortaleza, v. 7, e12367, 2025
DOI: https://doi.org/10.47149/pemo.v7.e12367
https://revistas.uece.br/index.php/revpemo
ISSN: 2675-519X
Esta obra está licenciada com uma Licença Creative Commons Atribuição 4.0 Internacional.

MUSSI, R. F. de F.; MUSSI, L. M. P. T.; ASSUNÇÃO, E. T. C.; NUNES, C. Pi. Pesquisa quantitativa e/ou qualitativa: distanciamentos, aproximações e possibilidades. **Revista Sustinere**, v. 7, n. 2, p. 414–430, 2019.

PIETROCOLA, M. **Ensino de física: conteúdo, metodologia e epistemologia em uma concepção integradora.** [S.l.: s.n.], 2005.

PLICAS, L. M de A.; PASTRE, I. A.; TIERA, V. A. O. O uso de práticas experimentais em Química como contribuição na formação continuada de professores de Química. **Instituto de Biociências, letras e Ciências Exatas–UNESP**, São José do Rio Preto, 2010.

ROSA, C. T. W. da. **A metacognição e as atividades experimentais no ensino de Física**. 2012.

ROSA, C. T. W. da; DARROZ, L. M.; MARCANTE, T. E. A avaliação no ensino de física: práticas e concepções dos professores. **Revista electrónica de investigación em educación en ciencias**, Unicen, v. 7, n. 2, p. 41–53, 2012.

SILVA, M. N. M.; ROCHA FILHO, J. B. da. O papel atual da experimentação no ensino de física. **Salão de Iniciação Cientifica**, XI, p. 903–905, 2010.

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