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# Experimental Approach In A Problematizing Perspective For Sound Wave Teaching

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***Abstract:***
*Experimentation has been widely advocated as an effective strategy to make physics teaching dynamic and engaging, overcoming the traditional model of exclusively theoretical classes. By proposing practical activities, it is expected that students will become active and participatory agents, formulating hypotheses and constructing concepts in a more meaningful way. In this sense, this study aimed to investigate the impact of experimental activities with a problem-solving perspective on sound waves for ninth-grade students. The application was carried out in three meetings of 1 hour and 40 minutes each, in which students were challenged to solve problems and perform experiments. The qualitative research was conducted in a ninth-grade class. Data were collected through observation of classroom activities and analysis of students' responses. The results indicated that the approach used was effective, as it aroused students' interest, promoting active participation and the construction of knowledge about sound waves. Instead of simply transmitting information, they explored their own interests and the ability to learn autonomously.*

***Key Word****: Experimentation, Problems, Elementary education, Sound waves.*

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## I. Introduction

Education is becoming increasingly complex. Today's students have diverse opportunities to interact with the world, which can be beneficial to the teaching and learning process. However, if these interactions are not well directed, they can hinder the process. In the school environment, the widespread use of cell phones and technology has become a challenge. It is necessary to develop activities that make classes dynamic and interesting, encouraging students to disconnect from the virtual world and actively participate in discussions. By integrating the content with students' reality, it is possible to arouse curiosity and promote effective learning.

Constant changes in society require schools to adapt and offer quality education. To meet the needs of students and overcome the challenges of the contemporary world, it is necessary to rethink pedagogical practices and seek new ways to mediate knowledge. These points are fundamental concerns that need to be addressed to ensure a productive educational environment.

In the context of physics teaching, the complexity of certain topics can create obstacles to learning, demotivating students and compromising the effectiveness of the educational process.

Physics content, often present in students' daily lives, can go unnoticed due to a lack of adequate stimuli. Problematizing experimentation emerges as a promising strategy to engage students and make them protagonists of their own learning.

Teaching physics is a constant challenge, given the diversity of students' profiles and interests. It is essential that the teacher acts as a mediator, seeking strategies that make the subject accessible and meaningful for everyone, especially for those who have greater difficulties in areas such as the exact sciences.

Wave theory is a fundamental topic for understanding various natural and technological phenomena. However, its traditional position at the end of textbooks limits the time dedicated to this topic, preventing adequate in-depth study. It is necessary, therefore, to seek new pedagogical approaches that allow students to explore the richness of this content.

Limiting ourselves to the content of sound waves, this research aimed to plan and experience a teaching sequence based on experimental activities in a problematizing context with elementary school students.

## II. Literature Review

Physics teaching in basic education faces several challenges, such as poor working conditions, reduced number of classes, and the progressive loss of identity in the basic education curriculum. In addition, the traditional approach, focused on memorizing outdated content, limits students' learning[1,2,3]. It is essential to seek new ways of teaching physics that stimulate students' interest and active participation.

Throughout its history, physics teaching has been marked by debates about its objectives and purposes. Various proposals seek to transform the teaching of physics into a tool for the development of critical thinking and citizenship, preparing students to act consciously in their daily lives.

As basic education goes through a period of transformation in line with the implementation of the National Common Curricular Base (BNCC), whose purpose is to guide the development of a new curriculum in Brazil, it is observed that students need to develop specific skills in the area of natural sciences. The BNCC recommends that students be able to investigate, analyze, and discuss problem situations that arise in various sociocultural contexts, as well as understanding and interpreting laws, theories, and models, applying them to the resolution of individual, social, and environmental issues[4].

According to the BNCC, physics teaching in elementary school should provide students with an understanding of the fundamental concepts of the discipline, promoting investigation, experimentation, and reflection on physical phenomena[5]; and relate to everyday situations as well as the scientific context. Physics cannot be taught as if it were a vast set of formulas and correct answers, where each question has an answer[6].

In this sense, research in physics teaching converges on the studies that experimental activities have been consolidated and have grown significantly in this decade, with the objective of replacing, when possible, traditional verbal classes with experimental activities[7,8].

The teacher plays a fundamental role in the classroom, acting as a mediator in the construction of knowledge by students. This approach contrasts with the traditional model, in which the teacher holds all knowledge. It is important to propose challenges to students to stimulate the construction of knowledge and the approximation to scientific culture[9].

Unlike the traditional model, in which the teacher exposes the content, the approach with a problematizing perspective places him as a mediator, encouraging students to question, investigate, and propose solutions to real or fictitious problems related to physics[10].

One of the fundamental characteristics of this approach is the use of questions as a starting point for learning. These questions are presented to students in a way that challenges them to think critically, apply the physical concepts learned, and seek solutions through experimentation, analysis, and group discussion[11, 12].

The approach with the problematizing perspective values the contextualization of knowledge, connecting physical concepts to students' daily lives. In this way, physics becomes relevant, motivating students to learn[13].

Problematization represents a paradigm shift in physics teaching, placing the student at the center of the learning process and encouraging the active construction of knowledge[14]. This approach promotes reflective and contextualized learning, preparing students to apply the principles of physics creatively and innovatively in their lives.

Therefore, we use an Experimental Approach in a Problematizing Perspective (AEXPP), as it starts from a problem and then, with the help of the teacher, aims to find solutions through experimentation. These activities promote discussion and exchange of ideas among students, stimulating the construction of knowledge in a collaborative way[15, 16, 17].

The AEXPP confirms what is expected and described in the BNCC[4]. AEXPP is an experimental process that develops from the demarcation of a theoretical problem[18]. It is an experimentation that aims to search for a solution through a question posed.

In physics teaching, AEXPP allows students to investigate phenomena such as sound waves in an active and collaborative way. By proposing questions and stimulating experimentation, this approach favors the construction of significant knowledge and the understanding of physical concepts[19].

## III. Methodology

The research methodology adopted was qualitative and translational, given its appropriateness for the school setting.

Qualitative research allowed for the collection of data directly in the school environment, providing an understanding of the problem[20]. Translational research, in turn, made it possible to connect theory to practice, transforming theoretical knowledge into concrete actions in the classroom.

Translational research in the classroom transforms it into a space for scientific investigation, where students experience the process of knowledge construction [6, 21].

Experimentation in a problematizing perspective, in this context, is a learning engine. Instead of simply transmitting knowledge, the teacher challenges students to investigate, proposing problems that stimulate curiosity and the search for answers. Experimentation, then, becomes a path to the construction of knowledge.

The didactic intervention, directed at 9th-grade elementary school students, consisted of three 1 hour and 40-minute meetings, in which students were challenged to solve problems and conduct experiments. This practical approach allowed students to construct their own knowledge about waves, developing skills such as observation, data analysis, and problem-solving.

The choice of the topic of sound waves was motivated by several factors: the proximity to students' daily lives and the need to correct common conceptual misconceptions related to the intensity and amplitude of waves.

Starting from provocative questions, group discussions encouraged students to apply the concepts of sound waves to everyday situations, promoting a deeper understanding of the topic.

In the 1st meeting, we had a discussion about the concept of what a wave is, seeking to understand the students' prior knowledge, with the following question: “On a rainy or stormy day we perceive the flash and the noise of lightning and thunder, respectively, which reach us. Describe how this reaches us, justify your answer?” In the 2nd meeting the question was “What happens to our body when it is hit by a strong wave when entering the sea?”; and, in the 3rd meeting it was: “Is it possible to see a sound wave?” In Table no 1 we present the experiments carried out and characteristics of the meetings of the didactic intervention.

**Table no1:** Description of the meetings, with their characteristics and experiments.

| MEETINGS | CHARACTERISTICS | EXPERIMENTS |
|---|---|---|
| 1st | Central Theme: Waves and their characteristics<br>Objectives: To understand what a wave is; to identify the different forms of waves; to understand the definitions of frequency, period, and wavelength.<br>Contents: Concept of waves; Frequency, period, and wavelength. | 1 - Understanding a wave using a rope, exploring transverse waves.<br>2 - Understanding a wave using toy springs, exploring longitudinal waves.<br>3 - Understanding the energy transmission of a wave, using domino pieces.<br>4 - Understanding the speed of wave propagation and its relation to the density of the medium, using domino pieces. |
| 2st | Central Theme: Waves and their energy transport<br>Objectives: To understand that waves carry energy; To gather information about mechanical waves and their types, transverse and longitudinal.<br>Content: Classification of mechanical waves; Energy transport and wave propagation speed. | 5 - Understanding wave propagation using a series of skewers joined by tape and jelly beans.. |
| 3st | Central Theme: Sound and Musical Instruments<br>Objectives: To comprehend the nature of sound; To recognize sound characteristics such as timbre, pitch, and volume (sound intensity).<br>Content: Sound; Musical instruments. | 6 – Using the xylophone as a musical instrument.<br>7 – Constructing a musical instrument using PVC (polyvinyl chloride) pipes |

## IV. Result And Discussion

The results and discussions of the didactic intervention regarding the application of the teaching sequence were presented sequentially, following the structure of the meetings, allowing for the identification of the advances and challenges at each stage, carried out in a 9th-grade class of basic education, composed of 25 students in the city of Santa Cruz do Capibaribe in the state of Pernambuco. Each meeting lasted two class hours, equivalent to 90 minutes each (the duration of 1 class in this school is 45 minutes).

**1st Meeting**

The first meeting started with Question 1. The following responses were obtained:
Student 1: Because lightning is slower than light.
Student 2: Because the sound of lightning is slower than its light.
Student 3: Because when lightning or thunder occurs, the light they emit travels fast.
Teacher, [...] that's what happens at the São João festival, we see the flashes of fireworks and then we hear the sound, I think it's the same.

Next, we asked guiding questions to deepen the understanding of what a wave is. For each one, we present the answers given by some students.
How do you define a wave?
Student 1: It's what we see in the sea.
Student 2: It's what reaches our cell phone.
Student 3: It's what makes us tune into car radios.
Student 4: It's sound.

What is the main characteristic of a wave?
Student 1: It's something that makes a boat go up and down in the sea.
Student 2: It's something that goes from one side to the other.
Student 3: It's something that makes boats rock.
Student 4: It travels through space.

After answering these questions, we proposed experiments to the students to uncover some of the secrets of waves. We asked them to do a group work for that. Thus, we divided the class into 5 groups of 5 students.

We started with Experiment 1 by fixing one end of a rope to the wall and asking a student to produce a pulse at the other end (Figure 1). The other students observed the propagation of the disturbance along the rope to identify the crest and trough of the wave.

Initially, they called it height, speed, and width, for amplitude, frequency, and wavelength, respectively. However, they struggled until the teacher intervened. By varying the "height" - amplitude and "speed" - frequency of the pulses in the rope, we observed directly the influence of these quantities on the characteristics of the wave. By increasing the "height" of the crests and troughs became larger, while by increasing the speed, the width-size of the wave decreased, evidencing the inverse relationship between these two quantities.

This activity allowed students to understand the relationship between amplitude, frequency, and wavelength, as well as observe the phenomenon of reflection at the fixed end of the rope. However, with their own detonations, without technical or scientific definitions.

**Figure no1:** Creating waves in a rope during the didactic intervention.

Next, we replaced the string with plastic springs, Experiment 2, and asked students to disturb the spring at a certain height from the ground and then disturb the spring vertically by executing only one pulse.

Then we asked them to repeat the experiment on the ground, that is, horizontally. And then they performed the perturbation movement as was done with the string, from side to side. With this, they were able to differentiate types of waves in terms of the direction of perturbation and propagation, that is, a longitudinal wave from a transverse wave in a spring, for which the teacher had to intervene (Figures 2a and 2b).

Then a student stated that it would be easy to remember, because the transverse wave described a T, vibrating in one direction and propagating in another; while the longitudinal wave would have the same direction.

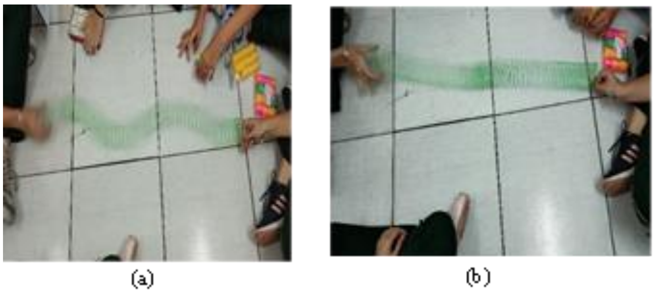


**Figure no2:** Transverse waves (a) and longitudinal waves (b) in a spring.

Based on their perceptions, we introduced the precise concepts of amplitude, frequency, and wavelength, relating them to the wave characteristics observed by the students.

As an experimental activity, we proposed Experiments 3 and 4. To begin, we divided the class into groups of 5 students, and each group received a set of dominoes, a needle (or pin), and adhesive tape. The task was simple but challenging: to build a line of dominoes, positioning them vertically and close together. On the last piece, a needle was fixed so that its tip was directed towards the balloon, positioned about 10 cm away.

The teacher emphasized that each group should line up the dominoes standing up (vertically) forming a straight line with the pieces close to each other (like an Indian file), on the last piece of the domino, the pin should be fixed on it so that the tip should be pointing towards a balloon. The balloon should be in front of this last piece. Figure 3 shows how the assembly was carried out by the students. Thus, it was asked that each group disturb the first domino piece.

The students emphasized at the end that "all the dominoes" were disturbed until the last domino with a pin burst the "balloon". They observed that when the first piece was disturbed, the propagation extended to all the pieces, and as a consequence, the last piece containing the pin burst the balloon.


**Figure no3:** The propagation of a disturbance with an experiment using domino pieces by two groups.

The students were instructed to repeat the domino experiment, but this time placing the pieces farther apart. The goal was to observe how the distance between the pieces would affect the wave propagation and the subsequent balloon burst. The results varied, with some groups managing to pop the balloon more easily than others.

The students and teacher discussed the experiment's results, trying to understand why some groups succeeded in popping the balloon while others didn't. The hypothesis raised was that the distance between the dominoes influenced the wave's speed and, consequently, the force with which the balloon was hit.

The experiment was used to introduce the concept of energy transfer. Students realized that, although the dominoes moved, no matter was transferred between them. What propagated was energy, causing the pieces to fall and eventually the balloon to burst.

Using the Phet wave introduction simulator, students explored wave characteristics such as amplitude, frequency, and wavelength, visualizing them in different media like water and air. By comparing these characteristics with the wave behavior observed in the domino experiment, students could establish connections between the physical world and scientific concepts.

The teacher adapted the language and examples to facilitate the understanding of elementary school students about the concept of waves. He used everyday situations, such as swinging a rope, to demonstrate how energy propagates through a wave without the matter moving. He compared the propagation of sound in different media and introduced concepts like amplitude, frequency, and wavelength in a simple and visual way, using analogies with a runner's movement and examples of objects like springs. The goal was for students, through their observations and experiences, to be able to visualize and understand the concepts of waves and their relationship with the world around them.

**2st Meeting**

The second meeting addressed the main characteristic of a wave: the transport of energy, not matter. We started this meeting with the following questions and observed the responses.
What happens to our body when it is hit by a strong wave when entering the sea?
Student 1: It knocks me down.
Student 2: The wave drags me to the beach.
Student 3: The fall is ugly.

And what happens if you are in the deepest part after the waves break?
Student 1: I just go up and down when the wave passes over me.
Student 2: It lifts me up.
Student 3: It doesn't drag me.
Student 4: It makes me float, going up and down.

What is sound and can it transport matter?
Student 1: It's a noise, I think it transports without us seeing it.
Student 2: It's what we hear. And I don't know what it transports.
Student 3: It's a type of wave. And I don't think it transports matter.
Student 4: It's a mechanical wave. [...] I remembered the end of the class, now I think it transports matter.

The teacher asked the students to assemble a wave machine. To do this, each group was provided with tape, barbecue skewers, and jelly beans. Divided into groups, the students, with the teacher's guidance, built their own generators (Experiment 5). In order to prevent any skewers from falling, the teacher, along with the students, applied a second layer of tape, so that the skewers were centered on these tapes. Additionally, he helped each group of students to place jelly beans at the ends of the skewers as shown in Figure 4. With the wave machine assembled, the teacher asked the students to lift one of the barbecue skewers from the end and observe what happened to the other skewers (Figure 5).

At the end of this meeting, the students were excited with the machine production. From there the teacher questioned how would be the propagation in diverse means. In the excitement, they understanding how the waves behaved in diverse means, associating its propagation speed with the distances between the molecules.

**Figure no4:** Students and their group constructing the wave machine.

**Figure no5:** A wave machine built by a group of students.

**3st Meeting**

We started with the problematizing question 3, "How can we differentiate the sound emitted by a piano from a flute?" Some answers to these questions are presented below.
Student 1: Generally, the sound emitted by a piano is softer than the flute.
Student 2: The sounds emitted by them are very different.
Student 3: They have different characteristics. And then with guiding questions, before starting the experiments.

Can sound drag any object?
Student 1: No, since sound is a wave, and
Student 2: Waves don't drag anything.

Can sound propagate in a vacuum?
Student 1: Yes, it can.
Student 2: No, because there is nothing in a vacuum, not even sound.
Student 3: It can, I have watched movies and series where we hear explosions in space.
Student 4: I think it can.

When you are watching a movie or listening with the sound very high what does your Father/Mother say?
Student 1: Turn down the volume.
Student 2: Mine too, turn down the sound.
Student 3: Mine says turn down the sound.

To better understand how sound behaves, we proposed two excerpts from the Star Wars movie (https://www.youtube.com/watch?v=1g3_CFmnU7k) that have epic battles in space with sounds of shots and explosions and from the Gravity movie (https://www.youtube.com/watch?v=8GQccUSonGY) where explosions also occur and there are no sounds emitted by them. To prove that sound does not propagate in a vacuum, we showed another video that shows a bell inside a bell jar.

In the movie excerpts, we see space battles with incredible explosions, but if we stop to think, why don't we hear the noise of these explosions? This happens because there is no air in space, and sound needs air to propagate.

To prove this, we had a video of a very simple experiment: a bell inside a glass bell jar. As the air is removed from the bell jar, the sound of the bell becomes weaker and weaker until it disappears completely.

Then, we gave each group a xylophone, and we told them to observe the instrument carefully (Experiment 6). Then we asked the following question. (1) “Why can different musical notes be recognized on a xylophone?”; (2) “What differentiates the production of each note?”

They began to play randomly, whereupon the teacher asked them to observe, in particular, the plates of each xylophone (Figure 6). As there were three different xylophone models available, the students noticed something curious: despite being similar instruments, each produced sounds with unique characteristics. When they listened to the two notes, the students realized that, even though they were the same note, each had a different sound.

**Figure no6:** Students using a xylophone.

When comparing the different xylophones, they realized that each one had its own unique sound, even when playing the same notes. This is due to timbre, which they had previously referred to as a different sound. Afterwards, with the teacher's help, they explained that timbre is like a 'fingerprint' of sound. Each of our voices also has a different timbre. They gave an example to all groups, using the voices of students singing the same musical note. Pitch, on the other hand, is related to the frequency of vibrations. High-pitched sounds vibrate faster than low-pitched sounds. And volume depends on the intensity of the vibration. When we speak loudly, the vibrations are stronger, and when we speak softly, the vibrations are weaker.

To continue our exploration, we proposed building a musical instrument. The instrument was the Pan flute, or Experiment 7. For this, we used pre-cut PVC pipes to avoid any danger to the students. Thus, each group received a personalized table with the exact measurements to create their own instruments. With the help of a ruler, and with the pipes already cut, they joined them together in ascending order, forming a musical scale.

Then, the teacher helped them to seal one end of each pipe, transforming the set of pipes into a pan flute (Figure 7). It should be said that the fun was guaranteed as they explored the different sounds that could be produced.

While the students were building their musical instruments, the teacher posed the following guiding questions: (1) “How can we tell the difference between two sounds produced on the same musical note?”; (2) “What is the difference between pitch and volume of a sound?”.

Timbre is the characteristic that allows us to distinguish between two sounds of the same pitch and intensity but produced by different sound sources. In the case of the pan flute (Figure 8), even when playing the same note on pipes of different sizes, the timbre of the sound will be slightly different. This is due to the physical characteristics of each pipe, such as the material, size, and shape of the mouthpiece, which influence the shape of the sound wave produced.

As they became excited, the teacher issued a challenge: “Who can create the most beautiful melody?” So, all the groups tried. And the teacher helped everyone by saying that the way the air is blown and the shape of the tube opening affect the timbre.

**Figure no7:** The construction of a pan flute.

**Figure no8:** Finished pan flute.

Later, we asked them to associate the size of each flute with the xylophone's plates. It was remarkable how they associated the sizes of each of the flute's pipes with the sizes of the xylophone's plates.

When playing the pan flute, the students were able to experiment and notice these differences. When blowing into pipes of different sizes, they noticed that the sounds produced were either higher or lower pitched, which referred to the pitch. And by varying the blowing force, the sound could be louder or softer, meaning they had increased or decreased the volume, respectively.

Regarding the answers, considering they were from 9th-grade students, they were deemed adequate as they presented the concepts concisely. The teacher can use these answers to introduce concepts that the students intuitively knew but couldn't name while exploring the musical instruments worked on.

To wrap up the discussion, the teacher also used a simulator to emphasize that when you throw a stone into a lake, waves form and spread across the water's surface. Sound works similarly, but instead of water, it's the air molecules that vibrate. When something vibrates, like the strings of a guitar, these vibrations propagate through the air as sound waves and reach our ears.

The pitch of a sound is related to the frequency of these vibrations. Frequency is the number of times a wave vibrates in one second. Timbre is what allows us to distinguish between two sounds of the same pitch and intensity but produced by different sources. Volume is the intensity of the sound and is related to the amplitude of the sound wave. The greater the amplitude, the stronger the vibration and the louder the sound.

The flute depends essentially, on the one hand, on the nature and direction of the air wave and, on the other hand, on the length of the air column. It is a wind instrument. The xylophone, on the other hand, is a percussion instrument. We saw that it is made of wooden plates or slats, arranged in horizontal rows, forming a kind of keyboard.

As an analogy, we asked them to imagine that the xylophone bars were springs of different sizes. Smaller springs vibrate faster when released, just like the shorter bars of the xylophone.

By blowing into a tube of the pan flute, we cause the air inside the tube to vibrate. This vibration also propagates through the air in the form of sound waves. You explored the different sounds that can be produced by varying the blowing force and choosing tubes of different sizes. The students demonstrated enthusiasm and participation during the experimental activities, asking relevant questions and proposing hypotheses about the behavior of sound waves.

AEXPP provided an environment that stimulated students' curiosity and encouraged them to seek answers. Considering the Freirean conception, in which dialogue and the joint construction of knowledge are valued, we can say that this approach can contribute to the formation of the students. The experimentation through the problems can stimulate the investigation, the reflection and the construction of meanings, besides developing skills such as the resolution of the problems, the teamwork and the own autonomy of the student [22, 23, 24].

The questionings were fundamental for the construction of the knowledge by the student[25]. This approach placed the student in a continuous process of reflection; because when problematizing and realizing the experiments, the teacher encouraged the student to question, investigate and search for answers, transforming him into an active subject of the teaching and learning process. The experimental activities, when instigating the curiosity and the investigation, provide to the students an active role in the construction of the knowledge. When manipulating materials and observing phenomena, they develop skills of interpretation and analysis of data, what contributes for an efficient learning[26].

The experience of the student is fundamental in the teaching-learning process[27]. The previous knowledges that the student brings for the classroom mold his form of understanding the world and the school contents. The teacher must consider this baggage and use it as starting point for the construction of new knowledges.

Considering the exposed, the application of the AEXPP, emerges as a viable option to contextualize physical phenomena in diverse scenarios and to face specific challenges. This provides to the students the opportunity to express their ideas, to deal with difficulties during the construction of the knowledge and to explore skills, besides the merely logical-mathematical.

## V. Final Considerations

In an increasingly dynamic educational scenario, it is essential to find ways to make physics teaching relevant and engaging for students. Instead of simply transmitting information, we seek to arouse students' curiosity and interest, connecting physical concepts with their everyday experiences that are part of their lives.

By placing the student at the center of the teaching and learning process, experimentation from a problematizing perspective has proven to be a good tool to make physics teaching attractive and understandable. This approach, which stimulates curiosity and critical thinking, promotes a better understanding, especially for those who find difficulties in abstract concepts such as sound waves. By connecting physical concepts to everyday life and allowing students to learn at their own pace, this approach contributes to an inclusive and effective teaching, preparing students for the challenges of the contemporary world. Experimental teaching allows students to learn at their own pace. In addition, the practical and collaborative nature of experimental teaching can help overcome obstacles such as lack of attention and difficulty in understanding abstract content.

## References

[1]. Costa L., Barros M. O Ensino De Física No Brasil: Problemas E Desafios In Book: Educação No Século Xxi, V. 39 - Matemática, Química, Física, 2019.
[2]. Moreira Ma. Ensino De Física No Século Xxi: Desafios E Equívocos. Revista Do Professor De Física, V. 2, N. 3, P. 80–94, 2018. 2018.
[3]. Moreira M A. Grandes Desafios Para O Ensino Da Física Na Educação Contemporânea. Revista Do Professor De Física, V. 1, N. 1, P. 1-13, 2017.
[4]. Brasil. Ministério Da Educação. Base Nacional Comum Curricular (Bncc)Brasília: Mec/Sef, 2018.
[5]. Guimarães Ua, Martins Krf. O Ensino De Física Na Educação Básica Brasileira. Revista Ft, Ciências Exatas E Da Terra, Ciências Humanas, V. 27, Ed. Edição 124/Jul 2023, 2023.
[6]. Moreira, Ma. Uma Análise Crítica Do Ensino De Física. Estudos Avançados, V. 32, N. 94, 2018.
[7]. Silva A L, Moura P R G, Pino, Jcd. Atividade Experimental Problematizada (Aep) Como Uma Estratégia Pedagógica Para O Ensino De Ciências: Aportes Teóricos, Metodológicos E Exemplificação. Experiências Em Ensino De Ciências, V. 12, N. 5, 2017.
[8]. Fracalanza H, Amaral Ia, Gouveia, Msfo Ensino De Ciências No Primeiro Grau. São Paulo: Atual, 1986.
[9]. Carvalho Ap. O Ensino De Ciências E A Proposição De Sequências De Ensino Investigativas. In: Carvalho Ap (Orgs.) Ensino De Ciências Por Investigação: Condições Para Implementação Em Sala De Aula. São Paulo: Cengage Learning, P. 1-20, 2013.
[10]. Delizoicov D. Problemas E Problematizações. In: Pietrocola M (Org.). Ensino De Física: Conteúdo, Metodologia E Epistemologia Numa Concepção Integradora. Florianópolis: Ed. Da Ufsc, 2001.
[11]. Delizoicov D. Problemas E Problematizações. In: Pietrocola M. (Org.). Ensino De Física: Conteúdo, Metodologia E Epistemologia Numa Concepção Integradora. 2. Ed. Florianópolis: Ufsc, 2005.
[12]. Freire P. Educação Como Prática De Liberdade. Rio De Janeiro: Paz E Terra, 1974.
[13]. Campos Bs, Fernandes Sa, Ragni Acpb, Souza N. F. Física Para Crianças: Abordando Conceitos Físicos A Partir De Situações-Problema. Revista Brasileira De Ensino De Física, V. 34, N. 1, P. 1402-1- 1402-15, 2012.
[14]. Muenchen C, Delizoicov, D. Os Três Momentos Pedagógicos E O Contexto De Produção Do Livro “Física”. Revista Ciência & Educação - Bauru, V. 20, N. 3, P. 617-638, 2014.
[15]. Reis Ef, Schwarzer, Ch, Strohschoen Aag. A Experimentação No Ensino De Ciências – Reações Químicas No Ensino Fundamental. Revista Educação Pública, V. 20, N. 9, 2020.
[16]. Mota Cmv, Cavalcanti Gmd. O Papel Das Atividades Experimentais No Ensino De Ciências, Anais: Vi Colóquio Internacional Educação E Contemporaneidade, São Cristóvão-Se, Brasil, 2012.
[17]. Bondia Jl. Notas Sobre A Experiência E O Saber Da Experiência. Revista Brasileira De Educação, N. 19, P. 20, 2002.
[18]. Silva Al, Moura Prg, Pino Jcd. Atividade Experimental Problematizada (Aep) Como Uma Estratégia Pedagógica Para O Ensino De Ciências: Aportes Teóricos, Metodológicos E Exemplificação. Experiências Em Ensino De Ciências, V. 12, N. 5, 2017.
[19]. Delizoicov D, Angotti Ja; Pernambuco Mm. Ensino De Ciências: Fundamentos E Métodos. 2ª. Ed. São Paulo: Cortez, 2007.
[20]. Chizzotti A. Pesquisa Em Ciências Humanas E Sociais. 4. Ed. - São Paulo: Cortez, 2000.
[21]. Silva, Am, Frant Jb, Chaves R. Uma Pesquisa Translacional Em Educação Matemática Em Perspectiva. Boletim Grupo De Estudos E Pesquisas Em Educação Matemática, N. 80, P. 249-272, 2022.
[22]. Freire P. Pedagogia Do Oprimido. Rio De Janeiro-São Paulo: Paz E Terra, 2021.
[23]. Campos Bs, Fernandes As, Ragni Acpb, Souza Nf. Física Para Crianças: Abordando Conceitos Físicos A Partir De Situações-Problema. Revista Brasileira De Ensino De Física, V. 34, N. 1, P. 1402-1- 1402-15, 2012.
[24]. Monteiro Maa, Teixeira Opb. Propostas E Avaliação De Atividades De Conhecimento Físico Nas Séries Iniciais Do Ensino Fundamental. Caderno Brasileiro De Ensino De Física, V. 21, N. 1, P. 65-82, 2004.
[25]. Delizoicov D. Problemas E Problematizações. In: Pietrocola, M. (Org.). Ensino De Física: Conteúdo, Metodologia E Epistemologia Numa Concepção Integradora. 2. Ed. Florianópolis: Ufsc, 2005.
[26]. Francisco Junior We, Ferreira Lh, Hartwig R. Experimentação Problematizadora: Fundamentos Teóricos E Práticos Para A Aplicação Em Salas De Aula De Ciências. Revista Química Nova Na Escola, N. 30, 2008.
[27]. Delizoicov D, Angotti Ja, Pernambuco Mm. Ensino De Ciências: Fundamentos E Métodos. São Paulo: Cortez, 2002.