PRÁTICAS EDUCATIVAS, MEMÓRIAS E ORALIDADES

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Integrating knowledge: scientific experiments in Natural Sciences at a public school in Altamira-PA

ARTICLE

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Abstract
This study investigated the effectiveness of interdisciplinary nature science experiments in elementary school. Carried out at the Sol Nascente school, PA/ASSURINI, Altamira-PA, the research involved 25 9th grade students, using low-cost materials for Biology, Physics and Chemistry experiments. Data was collected using pre- and post-tests. All students signed a consent form and were aware that their answers would be used in the analysis. The results showed the importance of pedagogical practices adapted to the rural context for effective education, highlighting the appreciation of local culture and the formation of educated and politicized individuals. The research highlights the importance of assimilating content, raising awareness of the educational reality and valuing the method used.
Keywords: Practical activities; Rural teaching; Different sources of resources.

Integração de conhecimentos: experimentos científicos em Ciências Naturais em uma escola pública de Altamira-PA

Resumo
Este estudo investigou a eficácia de experimentos interdisciplinares de Ciências da Natureza no ensino fundamental. Realizado na escola Sol Nascente, PA/ASSURINI, Altamira-PA, a pesquisa envolveu 25 alunos do 9º ano, utilizando materiais de baixo custo para experimentos de Biologia, Física e Química. A coleta de dados foi feita por pré e pós-testes. Todos os alunos assinaram o Termo de Consentimento, cientes do uso de suas respostas na análise. Os resultados evidenciaram a importância de práticas pedagógicas adaptadas ao contexto rural para uma educação eficaz, destacando a valorização da cultura local e a formação de indivíduos conscientes e politizados. A pesquisa destaca a importância da assimilação dos conteúdos, da conscientização da realidade educacional e da valorização do método utilizado.
Palavras-chave: Atividades práticas; Ensino do campo; Fontes diferentes de recursos.

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1 Introduction

When prioritizing the quality of teaching in an effective and practical way, using methods that bring the content studied closer to the students through concrete activities, a challenge arises in the teaching of Natural Sciences. This is due to the tendency towards abstraction when approaching subjects in a purely theoretical way, with no connection to students' daily lives.

The situation is exacerbated by the negative impacts of the COVID-19 pandemic, which has required social isolation and the use of distance learning. It is therefore crucial to seek studies and measures to tackle this issue. Viviane and Costa (2010) highlight the importance of this approach given the difficulties already present in the educational environment, such as the lack of practical activities that promote interaction with the content through experimentation and the absence of an interdisciplinary approach.

In Natural Sciences classes, practical activities are essential for students to have direct contact with the concepts discussed in class, enabling them to observe organisms and natural phenomena, as well as handling equipment.

Several authors stress the importance of these practical activities as a complement to theoretical classes, highlighting the need for creativity, interactivity and contextualization for a more meaningful and transformative education, as Ferreira München (2020) points out.

In this way, we are reminded of the importance of well-structured planning and an appropriate approach to promote more collaborative learning, where individuals are not just passive recipients of information, but active builders of knowledge. In this sense, it is necessary to adopt effective methods to deal with the challenges identified, such as experimentation, for example.

It should be noted that carrying out experiments is important in the context of teaching natural sciences, as it is a fundamental part of scientific practice.

According to Rosito (2003, p. 51):

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> Approaching experimental activities from different perspectives, based on an analysis of articles on the subject, he identifies some of the main trends in work on the use of experimentation in secondary education, which according to him are: demonstration, verification and investigation.

As for the importance of engaging, quality teaching, Lacerda (2009) highlights the major changes in the educational scenario due to the constant transformations taking place in the world. This includes the rapid development of new technologies and increasingly frequent advances in the scientific field, prompting essential studies and discoveries.

These innovations require education professionals to constantly search for new knowledge, methodologies and teaching strategies. In this context, it is essential that educators are prepared to deal with the various challenges presented in the school environment and in society. Guimarães (2009, p. 198) also points out that "experimentation can be an effective way of creating real situations that promote contextualization and encourage investigation through questioning".

In addition to the use of experiments, there is support for the proposal of methods that encourage integration between the subjects of the curriculum and the phenomena studied, through interdisciplinary experiments that address themes from Biology, Physics and Chemistry. The contents of the natural sciences are often presented separately and without connection in the classroom, often prioritizing the repetition and memorization of information and concepts, despite discussions about meaningful learning and teaching strategies (Rosa *et al*., 2022).

Interdisciplinarity seeks the transition from fragmented to integrated teaching, requiring a collaborative school with a holistic and integrated vision, which promotes reflection, the exchange of knowledge and clear definition of objectives (Bovo, 2005).

> [...] the interdisciplinary methodology starts from a scientific freedom, based on the desire to innovate, to create, to go beyond and is raised in the art of research, not only aiming at technical-productive or material valorization, but above all, enabling human access, in which it develops the creative capacity to transform the concrete worldly and historical reality into a greater

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> acquisition of education in its sense of being in the world (Fazenda, 1979 *apud* Bovo, 2005, p. 02).

This highlights the importance of experimentation in the natural sciences using accessible materials, as suggested by Silva (2017). According to Wisniewski (1990), this method has characteristics that make it even more practical and viable, as it is easy, inexpensive and easily obtained, allowing students to visualize the presence of science in their daily lives.

Furthermore, due to its interdisciplinary nature, the promotion of creativity, interactivity and fun through playful activities is a crucial tool to be used in classrooms, with the aim of improving the teaching and learning process.

Taking into account the reality of most rural schools, where there are no advanced technological resources, and understanding that technology is not accessible to everyone, it is necessary for the educator to have the autonomy and creativity to use materials from the students' daily lives in order to improve the educational approach, as emphasized by Carvalho and Medeiros (2022).

In view of this, especially considering the abstract nature of teaching Nature Sciences based on content that is far removed from the reality of students in textbooks, and the need for remote teaching due to the COVID-19 pandemic, we sought to evaluate the effectiveness of using interdisciplinary Nature Sciences experiments in elementary school, in the final years.

Specifically, the objective was to provide engaging and effective teaching through practices with accessible materials; to foster interdisciplinarity to address aspects of Biology, Physics and Chemistry present in the Physical and Biological Sciences - PBS - subject; to combat the gaps in the teaching of Natural Sciences caused by remote teaching; to allow a deeper understanding of the topics studied only theoretically; and to arouse students' interest in the subject.

2 Methodology

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This study adopted a descriptive and action research approach to investigate the effectiveness of applying interdisciplinary experiments in the natural sciences (chemistry, physics and biology) in elementary school, in the final years. Action research was defined, according to Kemmis and McTaggart (1988), as an iterative process involving reflection and action by participants to improve practices and understandings. This method was chosen because it allowed the author, also acting as a teacher, to actively participate in the development and implementation of the practical activities, ensuring that the intervention was relevant to the educational context of the Sol Nascente school.

Data was collected through direct observations, assessment tests and questionnaires, and later tabulated for graphical analysis. The students' arguments have been transcribed in full and highlighted in italics for qualitative analysis, while the participants' identities have been protected and referred to by capital letters.

The parameters used to investigate the effectiveness of the experiments were based on criteria such as the students' level of engagement, the depth of their responses in the tests and the perceived relevance of the practical activities for understanding interdisciplinary concepts. These criteria were inspired by the theoretical-methodological framework of renowned authors in the field of education, such as Piaget (1976), who emphasizes the importance of interaction and the active construction of knowledge.

Data was collected from 25 9th grade students, 66.7% female and 33.3% male, aged between 13 and 15, all from rural communities. Before data collection, the nature, importance and objectives of the research were explained, with emphasis on voluntary participation. The students were informed about the nature and objectives of the study and gave their consent by signing the Informed Consent Form.

To ensure that the objectives of the study were aligned with the experiences and questions in the data collection instruments, the following questions were included:

"What do you understand by interdisciplinarity and how would you describe this approach?"

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"What is your opinion on the use of workbooks in remote learning compared to face-to-face classes?"

"What has been the most significant impact of the pandemic on your life?"

These questions were designed to directly reflect the objectives of providing engaging and effective teaching, fostering interdisciplinarity, combating the gaps in teaching caused by remote teaching, enabling a deeper understanding of topics and arousing students' interest in the subject.

Gathering and interpreting information

The tests were carried out face-to-face in several stages: initially, a pre-test questionnaire was administered to better understand the students' situation and their understanding of the problem. The questionnaire included questions about personal data, interdisciplinarity, natural sciences, practical lessons and remote lessons during the COVID-19 pandemic.

Next, interdisciplinary Nature Science experiments were carried out, followed by explanations of the content. Afterwards, an analysis was made of the contribution of the work through a post-test questionnaire, addressing questions about understanding and evaluation of the methodology used and the content discussed.

The explanation of the application of the experiments was preceded by a brief introduction to the practice carried out. Explanations were then given of the results obtained to address different topics in the area of Natural Sciences, promoting interdisciplinarity and reviewing content, with the aim of minimizing the impact on learning caused by the COVID-19 pandemic.

The three experiments dealt with Biology, Physics and Chemistry topics:

Experiment 1 - Baking soda and vinegar rocket. The materials used were PET bottles, a cork, cardboard, glue, dental floss, scissors, paper towels, a ruler, a pen, baking soda and vinegar.

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Figure 1 – The rocket is ready

Source: Authors, 2023

The students assembled a rocket and its launch pad, prepared the fuel and launched the rocket. Issues of sustainability and aerodynamics were discussed, as well as chemical reactions.

Experiment 2 - Reaction between battery solution and steel wool. The materials used were PET bottles, balloons, steel wool and battery solution. This experiment was demonstrated by the teacher for safety reasons. The steel wool was placed in the bottle and the battery solution was added, generating gas captured by a balloon. After carrying out the experiment, we discussed the processes of oxidation-reduction in the subject of Physical and Biological Sciences, inclined to the knowledge of Chemistry, the density of air in the subject of Physics, and the gases responsible for the formation of the atmosphere in the subject of Biology.

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In the third experiment, which consisted of building a homemade microscope, materials were used such as water, a syringe, a laser pen and cups for a stand, a PET bottle, a wooden stand, a light bulb, glass from empty containers and simple batteries.

Figure 2 - Homemade microscope already built

Source: Authors, 2023

The aim was to compare dirty water with filtered water by pouring each into the syringe and slowly expelling a drop, placing it between the support glasses. The laser light was then directed at the drop of water, projecting and magnifying the micro-organisms on the wall.

The final discussion covered the importance of the microscope in Biology, the preservation of water, the refraction of light and light beams in Physics, as well as the composition and importance of sanitizing agents used in water treatment and the elimination of micro-organisms in Chemistry.

The research was descriptive in nature, with both a qualitative and quantitative approach. In this way, we sought to understand the participants' different views on the

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proposed questions, while measuring the percentages of responses to ensure more concrete and interpretable results. According to Vergara (2000), descriptive research exposes the characteristics of a specific population or phenomenon, establishing relationships between variables and defining their nature.

The qualitative approach adopted sought to understand the complexity of the participants' views. In the quantitative approach, the percentages of responses were measured to ensure more objective results.

In addition, the work used the prior knowledge of the author, who also works as a teacher, and was characterized as action research. The data was tabulated to allow for graphical analysis, with the arguments transcribed in full and identified in italics, while the participants were identified by capital letters to preserve their privacy.

3 Results and Discussion

The COVID-19 pandemic has imposed significant challenges on teaching, highlighting the need for innovative pedagogical approaches. Interdisciplinarity, as an educational strategy, offers an integrated view of topics, overcoming segregation between disciplines and promoting a more holistic understanding of knowledge (Minello, 2017).

This study revealed, through student feedback, a disconnect in the application of this concept, even within the same field of knowledge, as illustrated in Table 1.

Table 1 - Students' Feedback on Interdisciplinarity

SAMPLING IN PERCENTAGES			
WRONG	**RIGHT**	**NO ANSWERS**	**TOTAL NUMBER OF STUDENTS**
66,7%	22,2%	11,1%	25

Source: Elaborated by the authors, 2023

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A comparative analysis of the students' answers reveals a varied understanding of the concept of interdisciplinarity. While Student A correctly described interdisciplinarity as a methodology that connects different disciplines for a broader understanding, Students B and C presented incorrect definitions, associating it with the evasion of responsibilities and a lack of discipline, respectively. However, all the participants who answered the questionnaire showed that they correctly understood the purpose of a practical lesson, indicating that they would experiment with equipment and materials to deepen their understanding of the topics covered.

These results highlight the importance of practical lessons in the educational process, especially in the context of the natural sciences. The students' unanimous understanding of the purpose of practical lessons indicates a solid basis for implementing such methods. Andrade and Viana (2017) emphasize the significant role of experimental classes, which, when combined with evaluative and mediating practices, enhance student learning.

Students' experience with practical activities varies between levels of education, with less than half of the sample having had this experience in elementary school and the rest in secondary school. This discrepancy suggests an opportunity to increase the frequency of practical classes in elementary school, giving students earlier exposure to experimental methods.

Carvalho and Medeiros (2022) point out that, despite the clear benefits, practical activities are underused, an observation that is corroborated by data showing that a large proportion of students have never had contact with such activities. This reinforces the need to integrate more practical activities into the curriculum, especially in rural schools, to stimulate interest and deepen students' understanding of natural science content.

The implementation of practical lessons is essential not only to engage students, but also to enable them to become active constructors of knowledge, applying what they learn in real contexts relevant to their lives. The research suggests

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that integrating theory and practice is a more effective approach to teaching science subjects, a view that is supported by 88.9% of the students who took part in the study.

Ronqui, Souza and Freitas (2009) state that practical lessons are valued and stimulate students' curiosity, allowing them to get involved in scientific investigations and develop problem-solving skills, as long as they are well planned. Agreeing with the importance of experimentation, Carvalho and Medeiros (2022) point out that practical activities place students as builders of knowledge, relating teaching to their reality and allowing the knowledge acquired to be applied beyond the classroom.

In this sense, it is essential to take care in the preparation and design of practical activities, promoting the integration of theory and practice in the approach to various contents. This is especially important because 88.9% of the students emphasized that the approach to Biology, Physics or Chemistry content in the PBS subject is more effective when there is the use of practical activities that combine theory and practice.

Considering the current pandemic scenario and the need for innovation in teaching after more than a year away from face-to-face classes, it is becoming increasingly essential to use experimental activities as a way of overcoming difficulties in understanding the content.

In agreement with Antunes, Porto and Queiroz (2022), who warn of the challenges brought about by COVID-19, it is essential to tackle these worrying issues by seeking solutions, remembering that these problems already existed and have intensified with the global health crisis.

Innovation in teaching, as highlighted by Von Linsingen (2010), is crucial for effective learning, which involves integrating different approaches and methodologies. By paying attention to the diverse realities of individuals, it is possible to find alternatives that improve the quality of teaching, even in the face of the challenges imposed.

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When asked about the effectiveness of using activity books in remote teaching, many pointed out that, although necessary, it is less efficient than face-to-face classes (Table 2).

Table 2. Student Feedback on the Approach Used During Social Distancing

SAMPLING IN PERCENTAGES				
Essential and fundamental...	Indispensable and reduced...	Unnecessary ...	Unnecessary and...	Total number of students
11,2%	88,8%	0%	0%	25

Source: Elaborated by the authors, 2023

Faced with the impacts of the COVID-19 pandemic in the area of education, students highlighted losses related to learning, lack of interest, school dropout and lack of interaction (Chart 1).

Chart 1 - Consequences of the Pandemic on Teaching and Learning according to Students

Consequences	Percentage of Students
Learning deficits	83,3%
Lack of interest	81,9%
Dropping out of school	69,5%
Lack of coexistence	45,7%
No answer	16,3%

Source: Elaborated by the authors, 2023.

The data reflects that the majority of students perceive remote learning as less efficient than face-to-face classes, with 88.8% considering workbooks indispensable but reduced in effectiveness. In addition, students reported several negative consequences of the pandemic on education, including learning deficits (83.3%), lack of interest (81.9%), dropping out of school (69.5%) and lack of coexistence (45.7%).

In this sense, Barbosa, Anjos and Azony (2022) draw attention to the numerous transformations that have occurred in the educational environment due to the COVID-19 pandemic, ranging from gaps in teaching to chronic issues in society, often related to social inequalities, whose impacts are more severe in peripheral regions.

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According to the authors, the problems highlighted during the pandemic already existed in the educational structure; however, the removal of face-to-face classes has only made them more visible and intensified. This is evidenced by the fact that 72.2% of students were unaware that Nature Sciences covers subjects such as Biology, Physics and Chemistry, which investigate nature in its entirety, as well as aspects of the universe.

This lack of knowledge was made explicit in the students' answers:

Student A: *Botany investigates plants.*
Student B: *It consists of research into the ecosystem.*

In this way, the gap in education, recently exacerbated by the global health crisis, and the lack of contextualization - without considering the real situation of the students - has grown significantly. Individuals and the separation between theory and practice are the main elements that arise in the current school reality. Thus, educational practices that bring individuals closer to the object of study are essential, as more practical teaching tends to attract students. This was proven when analyzing the data obtained after carrying out this study.

Dourado (2012) points out that practical classes are a valuable methodological resource for overcoming students' difficulties, encouraging them to think critically and solve practical problems. These activities promote a more in-depth investigation of the content and greater involvement with the disciplines, making them fundamental in the area of Nature Sciences, which is often perceived as abstract.

In view of these considerations, the use of practical lessons to address or revise natural science content represents a significant opportunity to build knowledge in a clear, participatory and effective way. This research showed that the students understood the content related to the three areas of knowledge - Biology, Physics and Chemistry - by carrying out experiments and evaluating the results obtained from the practicals, resulting in a high percentage of correct answers.

The good results achieved with the experiments demonstrate the effectiveness of innovative and participatory methods which, although centered on the exposition of

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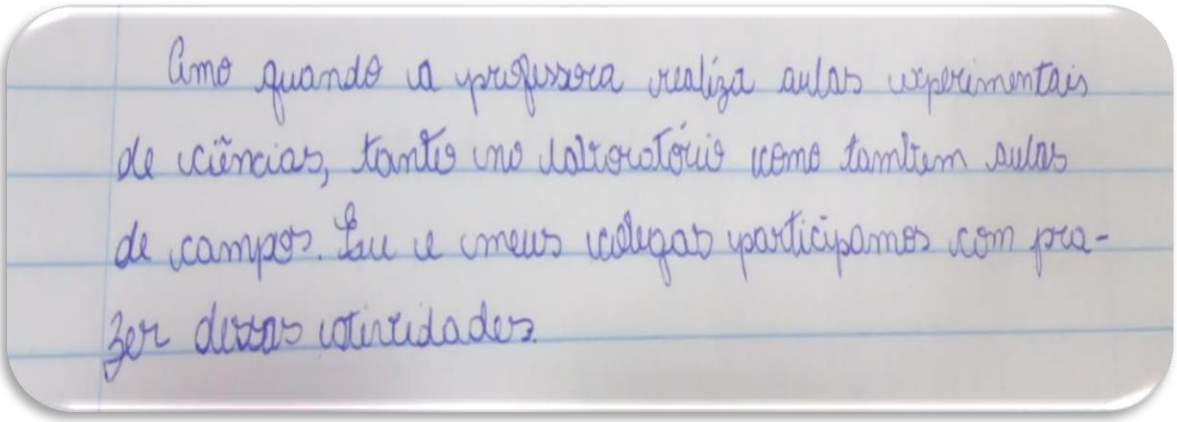
content, transcend pure theory and seek to ensure quality teaching in educational institutions.

Therefore, it is clear that these results support the importance of active and well-planned pedagogical approaches in the teaching-learning process.

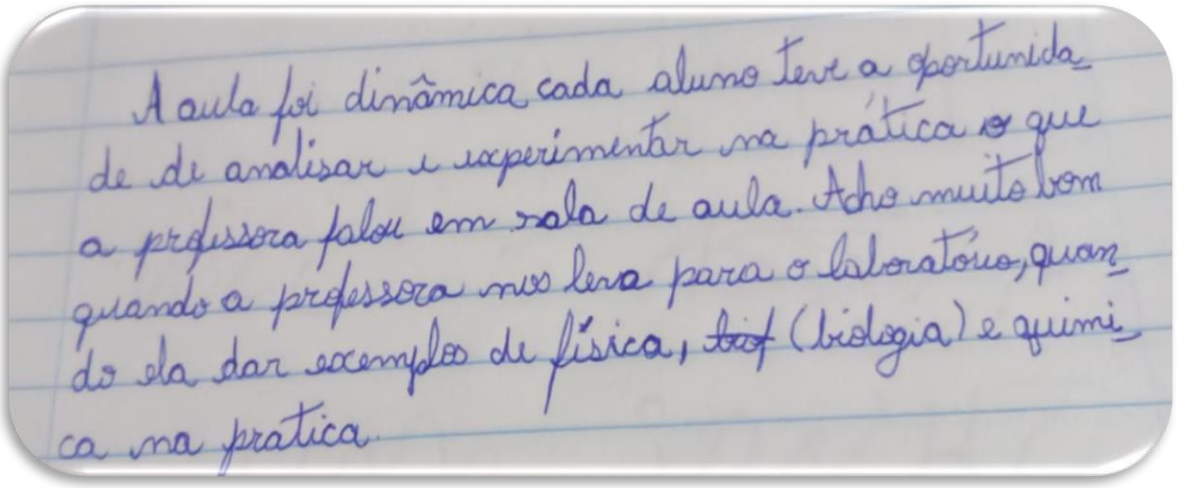
Still on the subject of experimental classes, it can be seen that students in the ninth year of elementary school enjoy activities from this perspective. Let's take a look at the participants' reports:

Figure 3- Reports from student -X



Source: Elaborated by the authors, 2023.

Figure 4- Reports from student -Y



Source: Elaborated by the authors, 2023.

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In practical classes in the natural sciences, carrying out experiments is fundamental to understanding the theoretical concepts discussed in the classroom, establishing a bridge between theory and practice. Andrade and Massabni (2011) argue that these practices enrich student learning, providing knowledge that transcends theoretical instruction, and emphasize the responsibility of educators and educational institutions to offer these training opportunities.

Contextualization is recognized as a valuable methodological technique, facilitating the interpretation and understanding of everyday phenomena and formal academic knowledge. Handling knowledge in a contextualized way promotes meaningful learning, establishing a reciprocal relationship between the student and the object of study, going beyond the mere transmission of concepts.

Table 3. Participation of elementary school students in physical and biological science experiments.

Experiment	**Performed**	**Did not perform**	**Total number of students**
Physics	98,7%	1,3%	25
Chemistry	100%	0%	25
Biology	99%	1%	25

Fonte: Elaborada pelos autores, 2023

Table 3 shows almost universal student participation in practical classes in Physical and Biological Sciences (PBS), with 98.7% taking part in Physics experiments, 100% in Chemistry and 99% in Biology. These high figures reflect the commitment of rural schools to providing practical and interactive education, despite the logistical and resource challenges that often accompany rural institutions. The almost totality of students engaged in the experiments indicates remarkable success in implementing a hands-on approach, suggesting that such methods are not only feasible, but also well received by students in rural educational settings.

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The evaluation of the results obtained with the practices was carried out by means of specific tests that measured the students' understanding of the content covered.

The evaluation parameters included the accuracy of the answers, the ability to apply concepts in practical contexts and the critical thinking skills demonstrated by the students (Table 4).

Table 4 - Student Feedback on Content Review after Social Lockdown

Description	Percentual
Extremely effective when combined with theory	89%
Efficient when dissociated from theory	10%
Inefficient/Just theory is effective	1%
No influence of practice on the quality of education	0%

Source: Elaborated by the authors, 2023

The data in Table 4 shows that 89% of students considered the combination of practical lessons with theory to be 'extremely effective', while only 10% thought that practical lessons were effective even when dissociated from theory. This feedback suggests that students value the integration of theory with practice, reinforcing the idea that learning is deeper and more retentive when theoretical concepts are applied in practical situations. Only 1% of the students thought that theory alone was effective, which highlights the importance of teaching methods that go beyond memorization and promote the practical application of knowledge.

In this way, the students realized the relevance of classes that enable them to reflect on the topic under analysis, encouraging active participation with the content. This aims to develop critical thinking, instigate curiosity and engagement, involving them in the construction of knowledge in a meaningful way, without disregarding the theoretical aspect. This is due to the need to seek meaning, concepts and solutions to their own questions that arise during the teaching-learning process.

This idea is supported by Pimenta (2005), who argues that knowledge does not only arise from practice, but is also enriched by theories, which are essential for education because they provide individuals with different perspectives for

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contextualized action, offering varied approaches, making them critical and builders of knowledge.

This perception is particularly relevant in the teaching of natural sciences, where concepts can seem distant from students' daily experiences. By applying theory to practical experiments, students not only see science in action, but also develop analytical and problem-solving skills that are crucial for active learning. This is especially important in rural schools, where resources may be limited and opportunities for hands-on learning may be less frequent than in urban environments.

This is because meaningful learning implies substantial and non-random interaction between new ideas represented symbolically and the learner's prior knowledge, contributing to a deeper understanding of the object of study (Moreira, 2012). In addition, the integration of theory and practice can be seen as a direct response to the challenges imposed by remote teaching during the pandemic. Students felt the lack of interaction and experimentation during distance learning, which may have led to an even greater appreciation of practical experiences when they returned to the face-to-face school environment.

Therefore, the data in Table 4 not only highlights the students' preference for a more holistic teaching method, but also underlines the need for teaching strategies that align with real-world demands and prepare students to apply knowledge effectively in their lives. The fact that only 1% of students believe that theory alone is enough reinforces the idea that teaching must evolve beyond the transmission of knowledge and move towards a model that favors understanding and practical application.

4 Conclusions

In short, this study looked at the effectiveness of practical lessons in teaching natural sciences in rural schools, a context that has faced unique challenges during the COVID-19 pandemic. The methodology adopted, which integrated action research

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with practical experiments, allowed for a detailed assessment of the barriers to learning, highlighting the resilience and adaptability of practical teaching methods.

The results obtained indicate a significant acceptance of practical classes by students, with a clear preference for combining theory and practice, as demonstrated by participation rates and positive feedback. These findings reinforce the premise that experiential learning is crucial for understanding and retaining scientific knowledge, especially in rural environments where access to educational resources can be limited.

This study contributes to the educational field by providing evidence that hands-on classes can overcome the limitations of remote teaching and enrich students' learning experience. The implications of these findings are significant, suggesting that the implementation of hands-on methods should be a priority for educators and policymakers in order to improve the quality and effectiveness of science teaching.

We conclude that valuing and implementing hands-on pedagogical approaches is essential for advancing education in rural settings and overcoming the challenges posed by distance learning. This study highlights the need to continue exploring and developing teaching methods that are not only theoretically sound, but also practical, engaging and aligned with students' realities.

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