THE USE OF ACTIVE METHODOLOGIES FOR THE PROCESS OF INCLUSIVE EDUCATION IN NATURAL SCIENCE CLASSES

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ABSTRACT
This qualitative study aimed to evaluate the use of active methodologies in experimental Science classes associated with inclusive education from an investigative perspective with characteristics similar to the Problem-Based Learning (PBL). To do so, three Science experiments were adapted for students with visual impairments in basic education. Results indicate that school and social inclusion are possible by means of active assistive activities. It is concluded that students with visual impairments achieved learning objectives through the development of adapted teaching materials, with active participation from the students in this process. This confirms the effectiveness of the methodology used in these activities and highlights the need for successful active practices to overcome the inherent obstacles of inclusive education.

Keywords: Active methodologies. Inclusive education. Teaching natural sciences.

RESUMO
Este estudo qualitativo teve como objetivo avaliar o uso de metodologias ativas em aulas experimentais de Ciências associadas à educação inclusiva a partir de uma perspectiva investigativa com características semelhantes à Aprendizagem Baseada em Problemas (ABP). Para tanto, foram adaptados três experimentos de Ciências para alunos com deficiência visual da educação básica. Os resultados indicam que

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a inclusão escolar e social é possível por meio de atividades assistivas ativas. Conclui-se que os alunos com deficiência visual alcançaram os objetivos de aprendizagem por meio do desenvolvimento de materiais didáticos adaptados, com a participação ativa dos alunos nesse processo. Isso confirma a eficácia da metodologia usada nessas atividades e destaca a necessidade de práticas ativas bem-sucedidas para superar os obstáculos inerentes à educação inclusiva.

**Palavras-chave:** Metodologias ativas. Educação inclusiva. Ensino de ciências naturais.

1 **INTRODUCTION**

In Brazilian education, the use of expository classes identified as "classical" or "traditional" is recurrent, where the teacher takes on the role of the protagonist in the educational process and is the sole holder of knowledge, while the students, in a passive manner, act as mere spectators and are expected to reproduce the knowledge that has been constructed. Therefore, the application of innovative teaching practices that can transform this process is necessary. These practices are known as active methodologies.

The didactic context centered on learning and the way teaching activities are developed, involving students in practical and participatory activities, characterize these activities as active methodologies. For this purpose, actions should be guided by constructivist assumptions and a contextualized approach that holds meaning for the students.

Active methodologies present themselves as instruments for knowledge construction, using analytical and dialogical procedures that contribute to clarifying doubts and finding answers to challenges. Strategies that facilitate and stimulate a broad student participation in their own learning process in a critical and reflective manner, considering their reality and the challenging situations of daily life, are essential.

Active teaching methodologies involve a wide range of educational practices that are dynamic and interactive, providing students with active participation in their own learning. These methodologies transform the learner from a mere participant into a protagonist of the learning process, leading to greater responsibility in constructing scientific, affective, and attitudinal knowledge.

Among the recognized approaches of active methodologies are: Flipped classroom, Project-based learning, Problem-based learning, Gamification, Peer
learning, Maker culture, Field studies, Case studies, and Storytelling. All these strategies aim to enable students to recognize a methodology that is most suitable for their learning, in a process known as metacognition. Metacognition involves self-awareness of cognitive actions and practical attitudes to achieve goals, while respecting students' prior knowledge as an educational resource and focusing on the development of competencies and skills.

According to Quintilhano and Tondato (2019, p. 7), modern pedagogical praxis should be transdisciplinary, centered on the student as an active subject of learning, resulting in new interactionist practices that use resources provided by information and communication technology (ICT), such as active methodologies like Flipped classroom, PBL, station rotations, multiple representations, among others.

Considering that remote teaching requires autonomy, discipline, commitment, and participation from students, active methodologies are recommended in these times of pandemic and social distancing that our society is currently experiencing. These methodologies are suitable for both in-person and distance or non-face-to-face learning, as well as hybrid models. The virtual environment provides the essential conditions for implementing these teaching strategies, helping to overcome the physical distance between teachers and students. It fosters a digital relationship where all actors in the educational system become protagonists of teaching and learning, with a shift in attitudes where the teacher is no longer the center of the process.

This research on inclusive education in Natural Science classes utilized the perspective of 'Science Teaching through Investigation' (EnCI), which, according to Zompero et al. (2019, p. 222), shares points of convergence with the active methodology ‘Problem-Based Learning’ (PBL) used in the pedagogical practice of educators. The authors state that both approaches have common theoretical and methodological foundations, aiming to promote autonomous thinking among students and teachers, thereby fostering effective learning and enhancing the spirit of investigation. According to Zompero et al. (2019), active methodologies are subject of debates and reflections among educators and teacher trainers due to their alignment with educational proposals that address the knowledge demands of the modern society we live in.
Problem-Based Learning (PBL), mainly used in undergraduate courses in health-related fields. Both Inquiry Teaching and Problem-Based Learning are rooted in the ideas of Dewey, who proposed teaching based on authentic problem-solving that stimulates critical thinking and allows students to take an active role in their learning (ZOMPERO et al., 2019, p. 224).

The definition of Inquiry Teaching in Science encompasses various meanings associated with the term "investigation," leading to polysemous formulations of this concept. Among several definitions, Jorde (2009) as cited by Scarpa and Silva (2013, p. 132) points out four characteristics that, in his conception, define Inquiry Teaching in Science: "1) Learning activities based on authentic problems; 2) experiments and practical activities, including information seeking; 3) self-regulated activities that prioritize students' autonomy; 4) communication and argumentation."

Both in Inquiry Teaching and Problem-Based Learning, students construct knowledge through solving real challenges and engaging in academic investigations, dynamically using various educational resources such as books, videos, digital technologies, posters, etc. These methodologies foster critical and interdisciplinary reflection by connecting theory with practice.

Nonato, Sales, and Sarly emphasize the "disruptive and knowledge-building potential centered on the student" character of active methodologies in "developing pedagogical solutions adapted to the context, needs, and interests of the individuals involved."

These characteristics use active methodologies with the support of educational technologies able to promote inclusive education effectively within the school system. Essentially, this becomes possible if we utilize assistive technologies that can provide functional abilities for People with Disabilities (PwD).

Assistive Technology is a new concept, with a range of resources and services that contribute to providing, expanding, and facilitating certain functional abilities of people with disabilities, consequently promoting greater independence and inclusion. Examples of assistive technology in schools include accessible school and teaching materials, alternative communication tools, accessibility features for computers, resources for mobility and location, signage, and furniture that meets postural needs, among others (ABREU et al., 2017, p. 3).

Santos and Trindade Souza (2020, p. 3) assert that it is necessary to develop pedagogical proposals that guide teachers and students with specific needs to achieve the proposed objectives in the educational process. However, the authors state that many teachers encounter difficulties, which become even more complex in
subjects that require specialized language, such as Sciences, Chemistry, and Physics. There is a lack of adequate material in these knowledge areas in Brazilian Sign Language (Libras) and in the Braille reading system, hindering learning, and leading to discontinuity of studies or school and social exclusion. Moreover, when images, tables, graphs, and diagrams are not adequately adapted, they can become obstacles to accessing related information, negatively impacting students' learning.

According to Sousa and Silveira (2011, p. 38), "the specificity of language and chemical terms – atom, electron, mole, ion, proton, among others – which are not included in Libras dictionaries, can hinder the construction of meanings for chemical concepts and, consequently, their translation from Portuguese to Libras."

Given the observation above, this qualitative study aimed to evaluate the use of active methodologies in experimental Science classes associated with inclusive education from an investigative perspective with characteristics similar to the Problem-Based Learning (PBL).

2 THE OBJECTIVE OF THE CLASS AND THE DEVELOPED COMPETENCE

The objective of the planned and implemented didactic experimental activities was to promote the investigative dimension of Natural Sciences and equip students with investigative procedures, such as identifying problems, formulating questions, developing arguments and explanations, planning, and conducting experimental activities, among others.

It is evident that "access to knowledge and its benefits is not available to all individuals in society to the same extent, as the school, in general, and particularly, fails to promote education that is accessible to all" (SOUSA; SILVEIRA, 2011, p. 37-38). Therefore, the aim of this didactic action is to build mechanisms that overcome these didactic and epistemological obstacles related to inclusive education.

The specific intention was to verify the possibility of students constructing explanations of the physical reality through adapted investigative experiments, using their senses, inquiries, and research to form hypotheses. In this context, the teacher's role was to guide and ensure autonomy in information-seeking.

In this activity, the aim was to ensure the development of competencies associated with attitudes that promote respect, equality, and acceptance of individual differences concerning the inclusion of students with special needs. It enabled access to science and technology for all and contributed to the construction of a just,
democratic, and inclusive society. As a result, pre-service teachers recognized the need for inclusive pedagogical practices and curriculum differentiation, as proposed by the document of the Brazilian National Common Curricular Base (Base Nacional Comum Curricular, BNCC).

3 ACTIVE METHODOLOGY USED AND ITS JUSTIFICATION

The development of this research is justified by the observation that some schools accommodate students with disabilities without the necessary inclusion adjustments, including the lack of appropriate training for some teachers and the absence of infrastructure for this inclusive process. Thus, we used an active assistive methodology to observe how the learning of these students can progress.

This study is based on qualitative research as it sought to understand the context of the situation. It is also a case study as it represents an empirical investigation that encompasses a study of specific and delimited individual case events. Researchers used observation as the data collection instrument. This research was conducted by applying three Science experiments associated with inclusive education from an investigative perspective. The experiments were designed by Chemistry and Natural Sciences teaching degree students and applied to visually impaired students in Basic Education, from public and private schools in the state of Pará, Brazil.

The methodology used in this study was the perspective of Inquiry Teaching in Science, which presents convergences with the Problem-Based Learning. According to Zompero et al. (2019, p. 236), both "propose methodological directions that aim for students' autonomy in a way that leads them to seek knowledge and develop reasoning skills that would hardly be fostered by traditional teaching."

Both Inquiry Teaching in Science and Problem-Based Learning can enable pedagogical transformations, allowing teachers to work in line with a critical discourse that promotes innovation and opportunities to monitor the cognitive creation and development process of students (ZOMPERO, 2019, p. 236).

The choice for the perspective of Inquiry Teaching in Science for the development of this educational experience is justified by the fact that with this methodology, students can build autonomy, identify priorities, and what is relevant to their learning. They can also seek explanations for observed phenomena, inclusively considering their prior knowledge.
In the document of the Brazilian National Common Curricular Base (BNCC), the process of inquiry teaching is highlighted in various parts of the text as an object and learning strategy, as it can promote autonomy, the development of logical and critical reasoning, stimulate the discovery of answers to observed phenomena, and develop skills and investigation procedures inherent of the construction of scientific knowledge (SANTOS; TRINDADE SOUZA, 2020, p. 1).

The second general competence of basic education proposes that the student should "exercise intellectual curiosity and use the specific approach of sciences, including investigation, reflection, critical analysis, imagination, and creativity, to investigate causes, develop and test hypotheses, formulate and solve problems, and create solutions" (BRASIL, 2018, p. 9). Thus, investigation provides the assimilation of the dynamics of scientific and technological procedures, and the specific language of scientific research, necessary to address everyday situations and school-related issues of interest to society.

Regarding the field of Natural Sciences, which is committed to the "development of scientific literacy," it must guide the "development of the capacity to act in and on the world." Thus, it is necessary to ensure "practices and procedures of scientific investigation" (BRASIL, 2018, p. 321). Therefore, it is not sufficient to merely present scientific knowledge to students. It is essential to provide investigative learning opportunities that enable the exercise of curiosity and observation, logical reasoning, and creativity, with more collaborative approaches, and structure their "first explanations about the natural and technological world, and about their body, health, and well-being, with reference to the knowledge, languages, and procedures specific to Natural Sciences" (BRASIL, 2018, p. 331).

In this perspective of scientific education, there is the possibility of developing skills such as identifying problems, formulating questions, planning experimental activities, among others. Thus, the use of inquiry teaching creates an opportunity to promote social and school inclusion of people with disabilities (PwD), justifying the choice for this active methodology in this study.

4 ASSESSMENT OF LEARNING

The evaluation process of the applied inclusive didactic activities occurred through the observation of the cognitive progress presented by the visually impaired students in relation to the achieved objectives.
5 RESULTS

5.1 EXPERIENCE REPORT

The first experiment was conducted with a visually impaired student in the 3rd year of high school, attending a private school in Ananindeua (Pará, Brazil). The student's performance was monitored in Physics classes. An experiment was conducted with the student using a nearsighted lens and another for farsightedness so that the student, through the sense of touch, could identify the shape and utility of a convex-concave lens and a concave-convex lens (Figure 1).

![Figure 1 - Convex-concave and concave-convex lenses.](source: The authors.)

In terms of cognition, results indicated that the student demonstrated difficulties with the teaching subject "optics" (colors, mirage, and types of lenses) and content involving the use of graphs. Regarding the experiment, the student was able to identify and understand the shape of the lenses and their uses, stating that the concave-convex surface curves inward, being thinner at the edges than in the middle (converging lens), and the convex-concave curves outward, being thinner in the middle than at the edges (diverging lens).

This observation demonstrates the need for educators to develop activities that can be shared with both visually impaired (VI) and non-visually impaired students. Regarding this aspect, De Paula, Guimarães, and Silva (2017, p. 860) mention that "there are adapted materials and technological resources developed to assist students with disabilities in carrying out educational activities."

In this regard, several authors presented adapted materials and technological

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8 This report was also presented, online, at the II Encontro de Ensino de Ciências por Investigação (EnECI), in 2020.
resources that can help students with disabilities in educational activities. Thus, teachers should propose and use materials with investigative aspects and accessible resources for visually impaired students that address their specific needs.

The second experiment consisted of developing an educational software, which we named "Quilivoz," by students in a specialization course in computer science applied to Chemistry teaching. The software interacts with visually impaired students through audio recordings in Portuguese and was designed for teaching and learning about electronic distribution. Through simple commands, activated by pressing keys on the computer, visually impaired students from the third year of high school at a public school in Belém city (Pará, Brazil) had access to information on this subject through an interactive audio menu. In addition to learning about atomic structure and interacting with the program, students could practice the electronic distribution of some chemical elements from the periodic table.

The third experiment was applied to the same visually impaired students from the second experiment and consisted of using a Braille periodic table constructed by students in the Chemistry teaching degree course at UFPA. The table was built on a base of styrofoam, with the identification of chemical element symbols, their respective atomic numbers, and atomic masses, created with different textured materials. Colored rounded headpins were also used. Differentiation of elements such as metals, non-metals, and noble gases required the application of textured paints, enabling tactile reading of the table.

Immediately after the completion of the third experiment, the students investigated the use of adapted materials and, with the knowledge built with the help of the Quilivoz software on electronic distribution, they were able to identify elements that can undergo a chemical reaction in a thermodynamically favorable process.

It was possible, thus, to verify that the students were able to develop explanations of the physical reality in science education through the construction of theories and evidence and by becoming aware of the process of scientific investigation. This result aligns with the affirmation by Maia and Silva (2018, p. 84) that "inquiry-based science teaching starts with the construction of a problem in the classroom, and not just the elaboration of a well-structured statement that instigates students' curiosity," and also with the comments by Zompero and Laburú (2016, p.22) about the proposal of inquiry teaching where students must develop cognitive skills, hypothesis formulation, argumentation, observation, and problem-solving, and with
Andrade et al. (2004), who advocate for science teaching that encourages students to question.

6 DIFFICULTIES ENCOUNTERED

It was observed that resistance from teachers in basic education and from teacher educators in Undergraduate Institutions presents itself as one of the main obstacles for the implementation of active methodologies in teaching, particularly for accelerating the process of school and social inclusion.

According to Sousa and Silveira (2011, p. 38), science and chemistry teachers, lacking adequate qualifications to "work with hearing-impaired individuals, face significant difficulties in dealing with the construction of scientific concepts for this particular group, which, in turn, results in exclusion and alienation of deaf students in classes on this content."

As stated by Santos and Trindade Souza (2020, p. 23), the mechanisms of Inclusive Education require the inclusion of students with disabilities in regular schools and that they receive equal learning opportunities. For that purpose, teachers must receive appropriate training and develop instructional materials suitable for including students with specific needs in classes, aiming their full integration into society.

In this investigation, the teacher did not have specific training to support visually impaired students (VI) but sought methodological alternatives to overcome obstacles that hinder learning in conditions that do not fit in the inclusion process. Regarding infrastructure, the school has tactile flooring to facilitate the movement of the student. These physical conditions are favorable to the inclusion process since, according to Oliva (2016, p. 493), "physical establishment, cultures, policies, curriculum, teaching method, seating arrangement, and forms of interaction are some examples of barriers that can hinder the school life."

It was also observed that the obstacles encountered by VI- students stem from the process of constructing knowledge in Chemistry and Physics, which is naturally and methodologically dependent on visual aspects. Thus, it is necessary to implement inclusion programs to overcome these obstacles and give meaning to this constantly changing reality.

Furthermore, it was found that there is a certain difficulty in establishing communication with schools, students, and their guardians who have some form of disability.
7 FINAL REMARKS

The teaching of Natural Sciences can be improved through the training of teachers with an interdisciplinary vision and active teaching and learning methodologies. Citizens educated in this context will be able to fully exercise their citizenship, and the school will contribute concretely to the formation of conscious, critical, economically, environmentally, socially, and inclusively responsible citizens. Therefore, the teaching of Natural Sciences should seek didactic-pedagogical environments and spaces for the scientific method, where students experience knowledge through observations, formulation of hypotheses, tests, refutation of them when necessary, and adaptation of educational resources for students with disabilities towards comprehensive inclusive education.

In this teaching activity, it was observed that active methodologies can promote school inclusion with autonomy and that the needs of students with special educational needs can be addressed through creative practices that enable their full participation in the process of constructing their own knowledge. The educational context, the type of content taught, and, above all, the way teaching practices are developed are essential for effective participation and inclusion of students with disabilities. However, the process of training teachers should focus on practices that better meet the needs of inclusive education from an investigative perspective.

Active assistive methodologies can facilitate the learning process and the autonomy of students; however, it is essential for teachers to understand how to address each student's specific disabilities by using adapted educational materials that aim to achieve the educational goals established and demanded by contemporary society.

In conclusion, the visually impaired students who participated in the research achieved good learning outcomes, reaching the objectives proposed in this study. This highlights the importance of constructing adapted educational materials for students with disabilities and developing practices that encourage students to investigate observed phenomena. The development of investigative activities confirmed the hypothesis that blind individuals can construct explanations of physical reality and that visually impaired students can effectively participate in the process of science education through investigation.


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