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RESEARCH AS A FORMATIVE AND EDUCATIONAL PRINCIPLE IN SCIENCE EDUCATION: contributions to the training of teacher-researchers

A PESQUISA COMO PRINCÍPIO FORMATIVO E EDUCATIVO NO ENSINO DE CIÊNCIAS: contribuições para a formação do professor-pesquisador

LA INVESTIGACIÓN COMO PRINCIPIO FORMATIVO Y EDUCATIVO EN LA ENSEÑANZA DE LAS CIENCIAS: aportaciones a la formación del profesor-investigador

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Abstract

This article critically analyzes the theoretical-epistemological foundations that underpin the perspective of research as an educational and formative principle in science teaching, articulating them with the concrete conditions of its implementation in the Brazilian educational context. It is a theoretical essay of a critical-reflective nature, grounded in the analysis and articulation of contributions from specialized national literature. The analysis was guided by an epistemological and pedagogical axis, considering the relevance of the selected works in the field of teacher education and science teaching, with emphasis on authors who discuss research on pedagogical practice and inquiry-based teaching. The text also addresses the articulation between inquiry-based teaching, socioscientific issues, and scientific literacy, emphasizing their relevance for the education of critical students capable of understanding the relationships between science, technology, society, and the environment. Additionally, the limits of this approach in the Brazilian educational context are problematized, in view of structural challenges such as the precarization of teaching work and the

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real conditions of public schools. The discussions show that incorporating inquiry into science teaching contributes to overcoming traditional teaching models, although its implementation faces tensions and limitations in the contemporary educational scenario. It is concluded that valuing research in initial and continuing teacher education constitutes a fundamental element for strengthening educational practices that promote intellectual autonomy, critical thinking, and civic participation. However, it is highlighted that the consolidation of the teacher-researcher does not depend exclusively on individual initiatives, but results from a complex, situated process shaped by multiple determinants.

Keywords: Teacher-researcher; Research on pedagogical practice; Inquiry-based Science teaching; Teacher education.

Resumo

Este artigo analisa criticamente os fundamentos teórico-epistemológicos que sustentam a perspectiva da pesquisa como princípio educativo e formativo na docência em Ciências, articulando-os às condições concretas de sua implementação no contexto educacional brasileiro. Trata-se de um ensaio teórico de natureza crítica-reflexiva, fundamentado na análise e articulação de contribuições da literatura nacional especializada. A análise foi orientada por um eixo epistemológico e pedagógico, considerando a relevância das obras selecionadas no campo da formação docente e do ensino de Ciências, com ênfase em autores que discutem a pesquisa da prática pedagógica e o ensino por investigação. O texto também aborda a articulação entre o ensino por investigação, as questões sociocientíficas e a alfabetização científica, enfatizando sua relevância para a formação de estudantes críticos e capazes de compreender as relações entre ciência, tecnologia, sociedade e ambiente. De forma complementar, são problematizados os limites dessa abordagem no contexto educacional brasileiro, tendo em vista desafios estruturais, como a precarização do trabalho docente e as condições reais das escolas públicas. As discussões evidenciam que a incorporação da investigação no ensino de Ciências contribui para superar modelos tradicionais de ensino, ainda que sua efetivação encontre tensões e limites no cenário educacional contemporâneo. Conclui-se que a valorização da pesquisa na formação inicial e continuada de professores constitui um elemento fundamental para o fortalecimento de práticas educativas que promovam autonomia intelectual, pensamento crítico e participação cidadã. Todavia, destaca-se que a consolidação do professor-pesquisador não depende exclusivamente de iniciativas individuais, mas resulta de um processo complexo, situado e atravessado por múltiplas determinações.

Palavras-chave: Professor-pesquisador; Pesquisa da prática pedagógica; Ensino de Ciências por Investigação; Formação Docente.

Resumen

Este artículo analiza críticamente los fundamentos teórico-epistemológicos que sustentan la perspectiva de la investigación como principio educativo y formativo en la enseñanza de las Ciencias, articulándolos con las condiciones concretas de su implementación en el contexto educativo brasileño. Se trata de un ensayo teórico de carácter crítico-reflexivo, fundamentado en el análisis y la articulación de contribuciones de la literatura nacional especializada. El análisis fue orientado por un eje epistemológico y pedagógico, considerando la relevancia de las obras seleccionadas en el campo de la formación docente y de la enseñanza de las Ciencias, con énfasis en autores que discuten la investigación de la práctica pedagógica y la enseñanza por indagación. El texto también aborda la articulación entre la enseñanza por indagación, las cuestiones sociocientíficas y la alfabetización científica, enfatizando su relevancia para la formación de estudiantes críticos capaces de comprender las relaciones entre ciencia, tecnología, sociedad y ambiente. De manera complementaria, se problematizan los límites de este enfoque en el contexto educativo brasileño, considerando desafíos estructurales como la precarización del trabajo docente y las condiciones reales de las escuelas públicas. Las discusiones evidencian que la incorporación de la indagación en la enseñanza de las Ciencias contribuye a superar modelos tradicionales de

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enseñanza, aunque su implementación encuentra tensiones y límites en el escenario educativo contemporáneo. Se concluye que la valorización de la investigación en la formación inicial y continua de profesores constituye un elemento fundamental para el fortalecimiento de prácticas educativas que promuevan la autonomía intelectual, el pensamiento crítico y la participación ciudadana. No obstante, se destaca que la consolidación del docente-investigador no depende exclusivamente de iniciativas individuales, sino que resulta de un proceso complejo, situado y atravesado por múltiples determinaciones.

Palabras clave: Profesor-investigador; Investigación de la práctica pedagógica; Enseñanza de las Ciencias por investigación; Formación docente.

1. Introduction

A Teaching is a challenging profession permeated by complexity and specificities, requiring teachers to engage in a continuous process of learning and improvement. Transformations in society always influence different sectors and aspects, and in contemporary times, technological advancement has brought about intense changes in people's lives, altering their interests and ways of communicating, interacting, and even learning, thereby reverberating in changes within school contexts.

However, such transformations do not occur homogeneously; they are shaped by structural inequalities that directly impact teaching work and the conditions of education in Brazilian Basic Education. Therefore, discussing teacher education implies considering not only pedagogical aspects, but also sociopolitical dimensions that condition educational practice.

In this context, current changes have generated demands and the need to (re)adapt teaching practices. Thus, when considering the teaching profession, initial teacher education serves as a key interface, representing the starting point for developing scientific knowledge and teaching expertise, as well as for experiencing different pedagogical situations, among other aspects relevant to the profession. According to Pesce and André (2012, p. 40), "initial education should provide teachers with the knowledge needed to deal with the complexity of the profession, preparing them to understand reality, respond to it, and design actions that promote learning."

Turning our attention to higher education, the Law of Guidelines and Bases of National Education (LDB) (Brazil, 1996) establishes in Article 43 that its purpose

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is to “stimulate cultural creation and the development of a scientific spirit and reflective thinking […] and encourage research and scientific inquiry, aiming at the development of science and technology and the creation and dissemination of culture.”

From this perspective, research has been considered a possibility for improving education, whether in Basic Education or higher education. When understood as a formative principle for the subjects involved, research reveals strong potential to overcome traditional teaching, although its implementation faces structural limitations, such as teacher overload, the precariousness of working conditions, and the insufficiency of public policies to support investigative practices in schools.

In light of this, the objective of this study is to critically analyze the theoretical-epistemological foundations that underpin the perspective of research as an educational and formative principle in science teaching, articulating them with the concrete conditions of its implementation in the Brazilian educational context.

Regarding methodological procedures, this study is characterized as a theoretical essay of a critical-reflective nature, grounded in the analysis and articulation of contributions from specialized national literature. The theoretical foundations supporting the discussion are based on the conceptions of André (2001), Lüdke (2001), Demo (2011), Pimenta and Lima (2005, 2017), and Galiazzi (2014), whose works emphasize the relevance of teacher education guided by research on one’s own pedagogical practice.

Additionally, the reflections developed here engage with Carvalho (2013, 2018), recognizing inquiry-based science teaching as an approach structured around problematization, hypothesis formulation, argumentation, and the collective systematization of knowledge. The selection of these references is justified by the recognized contributions of these authors-especially within the Brazilian context-to advancing discussions on teacher education and investigative practices in science teaching.

The analytical axis adopted articulates epistemological and pedagogical dimensions, with emphasis on formative situations and spaces that enable and

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contribute to scientific research as a formative principle. Beyond the dialogue between different theoretical perspectives, this study seeks to advance by proposing a critical reading of the tensions between the conceptual projection of the teacher-researcher and the real conditions of their practice, making explicit the limits and possibilities of this formative model in the contemporary educational scenario.

The organization of the text is structured into four interconnected sections. This first section presents the introductory aspects of the theme discussed in the theoretical essay, as well as the methodological procedures and delimitations of the critical-reflective analyses. The second section presents the historical milestones that contributed to the emergence of the teacher-researcher as a subject who investigates their own educational context and fosters investigative practice among students. The third section explores contemporary demands in science teaching, highlighting inquiry as a formative pathway in Basic Education. Finally, the fourth section discusses the principles of educating in and through research, emphasizing the potential of the teacher-researcher's role in promoting formative processes committed to social transformation.

2. Historical Aspects of Inquiry as an Educational Principle

The perspective of inquiry in the classroom emerged in the late 19th century, but it was John Dewey, in 1916, who proposed research as a strategy for school education in science (Paula; Harres, 2015). More than a historical milestone, Dewey's proposal represents an epistemological shift by moving the focus of teaching from content transmission to experience and problematization-key aspects that characterize the investigative process based on the scientific method.

For Dewey, learning through inquiry is "an approach to teaching with activities related to the real world, centered on the student, combining scientific content with the domain of human activities" (Batista; Silva, 2018, p. 97). His proposal aimed for students to move beyond merely learning technical concepts without understanding how they were constructed, encouraging instead the development of knowledge that establishes relationships among concepts, objects,

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and human conduct. However, it is important to recognize that this model was linked to a conception of science still strongly influenced by the classical scientific method, which limits its interpretation considering more critical contemporary perspectives on science.

In the first half of the 20th century, the investigative perspective proposed by Dewey was not widely implemented, despite its strong potential contributions to science teaching (Andrade, 2011; Batista; Silva, 2018). This lack of implementation should be understood not only as a pedagogical issue, but also because of political and economic factors that shaped the educational systems of the time.

It is important to clarify that, in that context, inquiry regarded science as neutral and disconnected from social factors, as pointed out by Krasilchik (2000) in studies of curricular projects from the 1950s to the 1970s. This conception has been widely criticized by contemporary epistemological approaches, which highlight the historical, social, and political nature of scientific production, thus requiring revisions in how inquiry is incorporated into teaching.

With the end of World War II and the beginning of the Cold War, science and technology came to be seen as major sources of socioeconomic development in many countries, leading to increased concern for science education at different levels (Krasilchik, 2000). In the mid-20th century, the idea of bringing inquiry into the classroom-specifically into science teaching-was revived both in the United States and in other countries, influenced by the reflections of John Dewey (Andrade, 2011).

At that time, the United States was experiencing a crisis in economic development, which resulted in measures aimed at making school education contribute to a more humanized society. This movement shows that the growing emphasis on science education was largely linked to geopolitical and economic interests, rather than solely to educational concerns.

> [...] in the 1960s, in the United States, there was a movement aimed at improving science education to help students become creative problem solvers and, in doing so, to train scientists capable of competing with the Russians in technological and military terms. [...] These efforts seriously attempted to transform the traditional experimental approach of “cookbook-style” procedures into materials with hands-on engagement and a focus on the development of reasoning skills (Batista; Silva, 2018, p. 97)

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At the same time, in England, a movement led by teachers emerged, culminating in the curricular reform of modern secondary schools (secondary modern schools). For the reform to achieve its goals, curricular content was organized in relation to themes from daily life, thus considering students' everyday experiences (Fagundes, 2016).

In Brazil, during the 1950s and 1960s, efforts were made to overcome the scarcity of raw materials and industrialized products, leading the country to invest in industrialization and to rely increasingly on science and technology, which came to be seen as strategic instruments for development (Andrade, 2011). Science education was also impacted by this scenario, undergoing changes aimed at preparing young people to meet the demand for researchers committed to promoting scientific advancement and, consequently, national progress.

This socioeconomic interest led, in the 1950s, to the curriculum renewal movement in science education in Brazil, which aimed to transform a sector of the curriculum (Nascimento; Fernandes; Mendonça, 2010). At that time, educational proposals in science teaching sought not only to provide students with access to scientific truths, but also to promote the development of scientific thinking and practice.

The scientific inquiry that was prominent in the United States and England also began to be developed in Brazil, through the translation of teaching materials produced in those countries during the 1960s. This initiative "aimed at the development of science teaching and aligned with the growing appreciation of science and technology on the international stage" (Andrade, 2011, p. 125). However, the incorporation of investigative approaches often occurred in an uncritical manner, through the importation of foreign models, disregarding the specificities of the Brazilian educational context.

In this context, Lawrence Stenhouse systematized and organized a curricular plan in which the curriculum is conceived as a set of hypothetical actions to be tested, grounded in reflection on ideas put into practice, assigning the teacher a central role in this construction. From this perspective emerges the idea of the teacher as a researcher, defended by Stenhouse as a "producer of knowledge

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about the situations experienced in their teaching practice" (Fagundes, 2016, p. 287), who "should experiment in each classroom, as in a laboratory, with the best ways to reach their students in the teaching/learning process" (Stenhouse, 1975 apud Lüdke, 2001, p. 80).

Fagundes (2016) clarifies that there is no single action research model structured as a research methodology capable of meeting the needs presented by teachers. Action research is understood not as a ready-made method, but as a process of interrelation between Basic Education teachers and university scholars, aimed at building knowledge for and within education.

Therefore, "action research can be considered a strategy that involves teachers and researchers with the common goal of using it to create new possibilities for teaching and, consequently, for student learning" (Fagundes, 2016, p. 288). From this perspective, Cunha and Prado (2007) conceive action research as a means of strengthening professional learning and the constitution of the teacher as a researcher, assigning them the role of a producer of knowledge derived from their own teaching practice.

Considering this, the movement led by English teachers was fundamental to the constitution of the teacher-researcher and of action research, strengthening teachers' understanding of their own practice. In line with this, science teaching from an inquiry-based perspective, as practiced in the United States, England, and Brazil, supports the strengthening of research on pedagogical practice. However, the idealization of the teacher as an autonomous subject and producer of knowledge needs to be problematized, considering the real conditions of teaching work, often marked by overload, low salaries, and lack of institutional support.

Since the late 20th century, inquiry as an educational principle-especially in science teaching-has come to emphasize the nature of science and the relationships and implications between science and society, considering "scientific activity as a human, historical, and social activity, linked to political and economic interests" (Andrade, 2011, p. 133). This educational paradigm aims to contribute to the formation of individuals who do not take a passive stance toward scientific

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issues that affect their lives, but who mobilize these discussions as a basis for decision-making and for strengthening a democratic and humanized society.

However, it is important to highlight that, although the historical movement points toward the valorization of inquiry, there remains a gap between theoretical assumptions and their effective implementation in school practices, reinforcing the need for analyses that articulate history, theory, and contemporary context.

3. Inquiry-Based Science Teaching and the Practice of the Teacher-Researcher

Initial teacher education is fundamental for the development of meaningful pedagogical practices. However, in the Brazilian context, such education often occurs in a fragmented manner and disconnected from the concrete demands of Basic Education, which limits the incorporation of inquiry-based approaches.

In Brazil, despite numerous discussions and curricular reforms, attempts at meaningful changes in teaching methods, and shifts in didactic-methodological approaches, science education is still frequently guided by traditional models. This persistence cannot be attributed solely to teacher resistance, but must be understood considering structural factors, such as prescriptive curricular policies, standardized external assessments, and precarious working conditions.

These weaknesses and educational deficiencies have their roots in technicism, a model of education that prioritizes technical efficiency, shaping students for the labor market through training and the development of practical skills. Even in the face of contemporary pedagogical trends grounded in dialogicity and in the development of critical thinking, autonomy, student protagonism, and problem-solving abilities, science teaching remains entrenched in an anachronistic formative model.

Comprehensive qualification during teacher professionalization, which combines theoretical-methodological knowledge, practical competencies, and a critical perspective on educational reality, prepares future teachers to face classroom challenges and respond to the demands of a constantly changing society. Depending scientific and pedagogical training is essential so that these

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teachers not only master content but are also able to contextualize and apply it in an interdisciplinary manner, promoting learning that is meaningful to students.

Basic Education, as a pillar of human and social development, requires teachers capable of fostering critical thinking, autonomy, investigative curiosity, and civic education, aligning the teaching of Natural Sciences with contemporary social and environmental issues and with the perspective of scientific inquiry. From this standpoint, the integration of socioscientific issues (SSI) emerges as a relevant alternative in science teaching. However, its implementation requires formative and institutional conditions that are not always available, which may reduce its transformative potential to isolated practices.

In the current scenario of science education, the need to address socioscientific issues in an integrated manner has become increasingly evident. These issues, which encompass complex themes and involve interactions between Science, Technology, Society (STS), and Environment (STSE), play a fundamental role in the formation of critical citizens aware of their role in society. By definition, SSIs represent a set of challenges that transcend the traditional boundaries of scientific disciplines. They arise from the complex interaction between scientific and technological advances and their social, cultural, economic, and ethical implications (Conrado; Nunes-Neto, 2018).

Thus, socioscientific issues have the potential to create conditions for the development of students' citizenship, by fostering a closer relationship between school science and everyday life, in which students can construct knowledge based on experiences from non-school environments (Guimarães et al., 2018).

However, it is important to consider that science teachers face challenges when addressing in the classroom issues related to power, ethical reasoning, and responsible action. This is because, traditionally, science and technology have been taught as bodies of knowledge to be accepted without questioning (Pérez; Carvalho, 2012). The distorted view of the neutrality of science has persisted for decades, finding ways to manifest even today, which hinders teachers' ability to approach SSIs.

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Articulated with SSIs, scientific literacy (SL) has been widely advocated as a goal of science education. Despite its relevance, the concept of scientific literacy is not consensual, being subject to criticism regarding its polysemy and the risk of adopting an instrumental perspective focused solely on the acquisition of knowledge, to the detriment of critical and emancipatory education.

Scientific literacy is grounded in “the civic education of students for the mastery and use of scientific knowledge and its implications in the most diverse spheres of their lives” (Sasseron; Carvalho, 2011, p. 60). According to Aragão (2019), SL is related to the understanding of scientific concepts, the nature of science, and the impacts of human action on socioscientific issues based on scientific knowledge.

In a context of rapid social and technological transformations, scientific literacy becomes essential for individuals to acquire the knowledge and skills necessary to analyze, question, and make informed decisions about scientific issues that affect their lives and the environment (Chassot, 2002; Santos; Mortimer, 2002).

Sasseron and Carvalho (2011, p. 75) observed a growing concern among different authors that the central goal of science teaching should be scientific literacy, finding support for this purpose in the “emerging need to prepare students to act in contemporary society, largely surrounded by artifacts of a scientific and technological society.”

Data on Brazilian education indicate that science teaching, both at the elementary and secondary levels, presents deficiencies that negatively impact the country’s performance compared to other nations (Muline, 2018). This finding highlights the urgency of implementing effective teaching strategies to address the gaps identified in the current scenario and to improve the quality of education offered in Basic Education.

In this sense, it becomes necessary to problematize to what extent scientific literacy, as proposed in certain discourses, effectively contributes to citizenship education or merely reinforces traditional models under new terminology.

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The complexity of concepts and the difficulty of understanding them-requiring greater levels of abstraction from students-represent a significant obstacle in science teaching, affecting the effectiveness of the educational process. Therefore, it is necessary to seek new approaches and teaching resources that can support the teaching and learning process, making it more accessible, engaging, and comprehensible for students. In this regard, inquiry-based science teaching stands out as a methodological perspective capable of addressing these challenges.

Inquiry-based teaching (IBT) emerges as a promising approach. However, its implementation faces concrete challenges, such as large class sizes, lack of teaching resources, reduced instructional time, and insufficient teacher preparation to conduct investigative practices. This model is characterized as a practice in which students engage in problem-solving and participate in situations that foster the construction of scientific knowledge (Castellar; Geraldi; Scarpa, 2016). Thus, it is important to recognize IBT as a didactic approach that brings students closer to key aspects of the nature of science, while also promoting their active role throughout the knowledge construction process.

Carvalho (2018) clarifies that a didactic proposal involving inquiry-based teaching aims to develop scientific content or themes whose investigation can be carried out through different activities. The author defines inquiry-based teaching as the teaching of curricular content in which

> [...] the teacher creates conditions in the classroom for students to "think, taking into account the structure of knowledge; speak, expressing their arguments and constructed knowledge; read, critically understanding the content; and write, demonstrating authorship and clarity in the ideas presented" (Carvalho, 2018, p. 766).

It is worth noting that a person is considered scientifically literate when "their knowledge enables a certain degree of autonomy, a certain capacity for communication, and a certain level of control and sense of responsibility in relation to concrete situations" (Fourez et al., 1994, p. 50 apud Nascimento; Pacheco; Castro, 2024). In this sense, inquiry-based science teaching is an effective method for teachers to foster scientific literacy, which is closely associated with socioscientific issues (SSI), and to provide unique opportunities for students to explore and understand how science relates to the world around them, stimulating

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critical thinking, informed decision-making in the face of real problems, and active participation in society.

Considering the above, discussions about the teacher-researcher emerge. For inquiry to be present in science teaching, it is necessary for teachers to engage in research as part of their professional practice, since, as pointed out by Demo (2011), educating through research requires, as an essential condition, that the teacher be a researcher and adopt research as a daily attitude in the classroom.

At this point, we return to discussions on initial teacher education. The aspects highlighted underscore the urgent need for teacher education programs to encourage academic research among students so that, by practicing research, they can develop investigations into their own pedagogical practice-an intrinsic element of the perspective of educating through research.

In reflecting on the idea that "those who teach do so because they research; otherwise, they have nothing to teach," Santos (2007, p. 42) points to the fragility of teacher education programs in developing investigative capacity-an essential trait of the teacher-researcher-stating that

> [...] the curricular structure practically makes it unfeasible to establish connections between theory and practice, and whose pedagogical processes are often restricted to merely reproductive and disciplinary activities that contribute little to the development of an investigative stance toward teaching among future professionals (Santos, 2007, p. 42).

According to Carvalho (2013), inquiry is not limited to carrying out experiments, but involves creating didactic conditions for students to think, argue, and construct explanations based on evidence, under the intentional mediation of the teacher. Thus, inquiry-based teaching is configured as a formative strategy that articulates scientific content, epistemic practices, and the development of intellectual autonomy, bringing scientific practice closer to the school context.

In this sense, it is essential that teacher education encompasses comprehensive aspects so that, beyond the scientific and practical knowledge inherent to teaching, it also prepares teachers to engage in research on their own pedagogical practice, since "the teacher-researcher has a characteristic that distinguishes them from their peers. They transform their teaching into an

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intellectual activity [...] by reshaping their practice as a function of this activity and, eventually, publishing their conclusions" (Becker, 2007, p. 20).

This represents a pathway for teachers to be prepared to guide their students through an emancipatory formative process that promotes the construction of scientific knowledge aligned with the ability to investigate, interpret, argue, think critically, and make decisions that are aware of the impacts of science and technology on society and the environment, based on the resolution of real-world problems.

In this context, the teacher-researcher is often presented as a central agent of educational transformation. However, this conception must be critically examined, as it may overlook the objective conditions that limit teaching practice, placing the exclusive responsibility for pedagogical innovation on the teacher. Therefore, the consolidation of the teacher-researcher depends not only on individual changes, but also on structural transformations in educational policies, the organization of teaching work, and the conditions of teacher education.

4. The Teacher-Researcher and Educating in and Through Research

Teacher education grounded in the principles of educating in and through research contributes to teachers' professional development insofar as it supports "the construction of their professional identity, theoretical grounding, the valuing of teaching experience, and, consequently, promotes changes in their practice and in the context in which the school is situated" (Cardoso; Araujo; Giroto, 2021, p. 2606). However, its effective implementation requires institutional conditions that ensure time, resources, and the valuing of investigative activity in everyday school life.

Therefore, it is necessary to provide teachers in training with the means to become "capable of analyzing, criticizing, and systematically reflecting on their teaching practice, with the aim of achieving school and social transformation and improving the quality of teaching and innovation" (Imbernón, 1994, p. 50).

The development of teacher autonomy is one of the principles associated with research practice. Research as a teaching methodology moves students from

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the position of passive recipients-who receive everything ready-made from the teacher-to autonomous, critical, and questioning subjects, with the teacher acting as a mediator of knowledge. In educating through research, both teachers and students are active participants in the teaching-learning process (Demo, 2011; Galiazzi, 2014). However, it is important to recognize that autonomy is not constructed solely at the individual level, but depends on public policies that ensure decent working conditions and continuing education.

Educating through research "is the most distinctive feature of school and academic education" and highlights the need to make research a daily attitude of both students and teachers (Demo, 2011, p. 7). The author explains that "becoming and transforming oneself in and through research" (p. 7) is inherent to school education, since other agents and spaces may be educational, but do not educate through research.

For Galiazzi (2014), the teacher who works with education through research is in a constant process of formation, as research involves developing the ability to ask questions and seek answers, building critical and coherent arguments in response to these inquiries.

Thus, research is also advocated on the grounds that it contributes to the qualification of professional training spaces, including teacher education (Maldaner, 2013). Therefore, it is essential that teacher education programs prepare future teachers to use research as a methodological foundation for their didactic-pedagogical practices.

> [...] research can make the teacher-subject capable of reflecting on their professional practice and of seeking ways (knowledge, skills, attitudes, relationships) that help them increasingly improve their teaching work, so that they can effectively participate in the process of human emancipation (André, 2006, p. 223)

Regarding teacher research (or the teacher-researcher), Zeichner (1998) reflects on the practice of research closely connected to the reality of teachers working in schools and/or classrooms. From this perspective, André (2001, p. 22) emphasizes that "if this possibility is not present in teacher education, we will not be able to develop autonomous, research-oriented individuals."

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Lüdke (2001, p. 82), who also advocates for teachers as researchers of their own practice, states that Zeichner was one of those responsible for the "acceptance of teacher research among the types of research recognized as legitimate within the important field of education," due to its significance for the cause he strongly supports, Practitioner Research. The author has also defended the formation of the teacher-researcher, viewing initial teacher education as an opportunity to appropriate a resource that enables teachers to question their practice and the context in which it is embedded; thus, research represents "a resource for professional development" (Lüdke, 2001, p. 51).

Research conducted by teachers on their own practice in schools and/or classrooms has received different designations, the most common being "action research," "inquiry in action," "collaborative research," and "emancipatory praxis" (Diniz-Pereira, 2002, p. 11). In this context, pedagogical research is defined by Cardoso, Araujo, and Giroto (2021, p. 2595) as "the element that aggregates quality and meaning to teacher education and, consequently, to the development of autonomy and teaching work."

For Demo (2011, p. 7), educating through research "is the most distinctive feature of school and academic education" and highlights the need to make research a daily attitude of both students and teachers. Thus, "becoming and transforming oneself in and through research" (p. 7) is inherent to school education, since other agents and spaces may be educational, but they do not educate through research.

Supporting the arguments about the importance of research practice on pedagogical actions, Pimenta and Lima (2005, p. 11) emphasize that "the university is the formative space par excellence for teaching, since preparing for quality teaching is not simple, and research is the methodological path for this formation."

At times, teacher education programs are completed without preservice teachers having the necessary knowledge to become researchers. However, the supervised teaching practicum in licensure programs can constitute a field of knowledge that "is produced in the interaction between teacher education programs and the social context in which educational practices are developed" (Pimenta;

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Lima, 2005, p. 6) and can therefore become a research activity. The authors highlight the supervised practicum as an investigative and reflective process of the educational context and, thus, as a valuable formative space for practicing research on teaching praxis.

Beyond the supervised practicum, research on pedagogical practice can be experienced by preservice teachers in programs focused on scientific initiation and teaching, such as the Pedagogical Residency Program (PRP), the National Program for Teacher Education in Basic Education (Parfor), the Institutional Program for Teaching Initiation Scholarships (PIBID), the Institutional Scientific Initiation Scholarship Program (PIBIC), and the Institutional Voluntary Scientific Initiation Program (PIVIC), among others.

In addition to these programs, teaching and extension projects-also offered by educational institutions as a means of promoting the higher education triad of Teaching-Research-Extension, particularly in teacher education programs-serve as formative spaces that enable research on praxis to be experienced and practiced as a high-quality educational principle.

Students' participation in projects, activities, and curricular components of this nature permeates the formative process as drivers of scientific practice, encouraging the investigation of problems within the educational context. These are spaces that foster writing, reading, communication, and the development of the principles of the scientific method.

Thus, teachers' pedagogical practice through research emerges as a formative and educational principle that contributes to the production and dissemination of knowledge, promoting the development of a more solid and collaborative academic formation. The teacher-researcher, through their constant pursuit of improvement, contributes to enhancing the quality of education, becoming better prepared to innovate and adapt teaching strategies to students' needs by employing more effective teaching-learning methods.

In light of the above, it is undeniable that research as an educational principle strengthens teacher education. However, there is a risk that its institutionalization may occur superficially, being incorporated into pedagogical discourse without

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effective changes in school practices. In this sense, it is argued that educating in and through research should be understood as a situated practice, historically constructed and shaped by social, political, and institutional factors, rather than as a universal solution to the challenges of education.

5. Final Considerations

The analysis developed in this article shows that research as an educational principle holds significant relevance for science teaching and for teacher education. However, throughout the discussion, it became evident that its implementation is permeated by tensions, limitations, and contradictions that cannot be ignored.

The historical trajectory of research on educational practice is linked to movements that sought to overcome teaching models centered on the mere transmission of content. From the early contributions of John Dewey to contemporary developments in science teaching, there has been a consolidation of a pedagogical perspective that values the active construction of knowledge, the development of critical thinking, and the connection between science, society, and everyday life.

Inquiry-based science teaching, articulated with socioscientific issues and scientific literacy, presents relevant formative potential. Such articulation makes it possible to expand understanding of the nature of science and its social, political, and environmental implications, contributing to the formation of individuals capable of critically interpreting scientific and technological phenomena that impact their lives and society. However, its implementation in the Brazilian context faces structural challenges related to teaching working conditions, educational policies, and curricular organization.

The figure of the teacher-researcher thus emerges as central to this process, by taking inquiry as a constitutive part of their pedagogical practice and professional development. By educating in and through research, the teacher not only promotes more meaningful learning for students, but also strengthens their intellectual

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autonomy and their ability to critically reflect on the educational context in which they operate.

Among the formative spaces that enable students in teacher education programs to perceive their practices as opportunities for research, not only the supervised practicum serves as a locus for this process, but also programs aimed at strengthening and consolidating teacher education and scientific initiation. These activities provide opportunities to experience and practice pedagogical research, which is a determining factor in the quality of the education provided. It is therefore essential that teacher education further values research as an educational and formative principle.

Based on what has been presented here, there is evidence and discussion indicating that, given the dynamism of ongoing transformations, training teacher-researchers has been an effective possibility for innovating pedagogical practices. Thus, promoting a research culture in teacher education programs and continuing education enhances teacher qualification, while also strengthening autonomy, commitment, reflection, and critical thinking, contributing to the formation of individuals committed to society and to the factors that transform it through ethical civic participation.

Within Basic Education, investing in formative proposals that value educating in and through research constitutes a fundamental strategy for improving the quality of science teaching and contributing to the formation of citizens capable of actively and responsibly participating in discussions and decisions involving science, technology, society, and the environment.

As a contribution of this study, we highlight the proposal of a critical perspective that integrates three central dimensions: the theoretical-epistemological foundations of the teacher-researcher's formation, inquiry-based science teaching as a driver of education aligned with contemporary demands, and the sociopolitical conditions that shape Brazilian education. This articulation allows for a more consistent analysis of the limits and potential of this approach.

Furthermore, it is proposed that future research advance in the construction of analytical frameworks capable of addressing the complexity of the educational

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context, overcoming idealized perspectives and contributing to the development of more contextualized, critical, and effective pedagogical practices.

Finally, it is reaffirmed that incorporating inquiry into science teaching, combined with the formation of teachers committed to researching their own practice, represents a promising path toward the development of more critical, reflective, and socially engaged educational processes. However, this educational movement must be aligned with educational policies that ensure concrete conditions for its implementation, avoiding placing responsibility on teachers for challenges that are largely structural.

Thus, this study allows us to understand that the consolidation of the teacher-researcher does not depend exclusively on individual initiatives, but results from a complex, situated process shaped by multiple determinants.

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