TEACHER TRAINING AND EDUCATIONAL ROBOTICS: LEARNING IN KNOWLEDGE NETWORKS

FORMAÇÃO DE PROFESSORES E ROBÔTICA EDUCACIONAL: APRENDIZAGENS EM REDES DE CONHECIMENTO

FORMACIÓN DE PROFESORES Y ROBÓTICA EDUCATIVA: APRENDIZAJES EN REDES DE CONOCIMIENTO

Érica Lima Santos QUEIROZ
E-mail: ericabio26@hotmail.com

Marilene Batista da Cruz NASCIMENTO
E-mail: nascimentoolene@yahoo.com.br

Mateus Henrique Silva SANTOS
E-mail: mateus.santos27@hotmail.com

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1 Federal University of Sergipe (UFS), Itabaiana – SE – Brazil. Master's degree in Teaching of Sciences and Mathematics (UFS). Undergraduate student in Pedagogy at the Department of Education of Itabaiana (DEDI/UFS). Member of the Study Group on Higher Education (GEES/UFS).

2 Federal University of Sergipe (UFS), São Cristóvão – SE – Brazil. Doctoral degree in Education (PUCRS). Professor at the Department of Education of Itabaiana (DEDI) and the Graduate Program in Education (PPGED). Tutor at the PET Education - Knowledge Connection Program. Leader of the Study Group on Higher Education (GEES/UFS).

3 Federal University of Sergipe (UFS), São Cristóvão – SE – Brazil. Doctoral degree student in the Graduate Program in Education (PPGED). Teacher at the State Department of Education of Alagoas (SEDUC/AL). Member of the Study Group on Higher Education (GEES/UFS).
ABSTRACT: This research aims to map the scientific productions in the Brazilian Digital Library of Theses and Dissertations database and to categorize the multiple focuses and perspectives on the interrelationships between teacher training and educational robotics. A knowledge state survey was conducted, which involved the identification, registration, and categorization of a specific area and time frame, contributing to disruptions and challenging preconceptions. This qualitative study encompasses contextual, social, institutional, and environmental conditions. The data and information were processed through discursive textual analysis organized into three stages: unitization, categorization, and capturing the emerging news. The findings highlighted the relevance of teacher training supported by the action-reflection-action approach, aiming to overcome knowledge reproduction and fragmentation through robotics, which is considered an interdisciplinary science. The formative experience in robotics involves teaching and research, through the mobilization of students in the field of experimentation and discovery.


RESUMO: Esta pesquisa tem como objetivo mapear as produções científicas na base de dados da Biblioteca Digital Brasileira de Teses e Dissertações e categorizar os múltiplos enfoques e perspectivas sobre as inter-relações entre formação de professores e robótica educacional. Fez-se um levantamento, do tipo estado do conhecimento, que consistiu na identificação, registro e categorização de uma determinada área e espaço de tempo, contribuindo com rupturas e pré-conceitos. Trata-se de um estudo qualitativo que abrange condições contextuais, sociais, institucionais e ambientais. Os dados e as informações foram trabalhados à luz da análise textual discursiva organizada em três etapas: unitarização, categorização e captação do novo emergente. Os achados sinalizaram a relevância da formação de professores apoiada na ação-reflexão-ação, com intuito de superar a reprodução e a fragmentação de saberes por meio da robótica, considerada uma ciência interdisciplinar. A experiência formadora da robótica envolve ensino e pesquisa, via mobilização dos discentes no campo da experimentação e das descobertas.


RESUMEN: Esta investigación tiene como objetivos mapear las producciones científicas en la base de datos de la Biblioteca Digital Brasileña de Tesis y Disertaciones y categorizar los múltiples enfoques y perspectivas sobre las interrelaciones entre la formación de profesores y la robótica educativa. Se realizó un levantamiento del tipo estado del conocimiento, que consistió en la identificación, registro y categorización de un determinado ámbito y periodo de tiempo, contribuyendo con rupturas y prejuicios. Se trata de un estudio cualitativo que abarca condiciones contextuales, sociales, institucionales y ambientales. Los datos y la información se trabajaron a la luz del análisis textual discursivo organizado en tres etapas: unitarización, categorización y captación de lo nuevo emergente. Los hallazgos señalaron la relevancia de la formación de profesores apoyada en la acción-reflexión-acción, con el fin de superar la reproducción y fragmentación de conocimientos mediante la robótica, considerada una ciencia interdisciplinaria. La experiencia formativa de la robótica implica enseñanza e investigación, a través de la movilización de los estudiantes en el campo de la experimentación y los descubrimientos.

Introduction

Teacher education is an ongoing research topic that never exhausts itself in light of the need for continuous improvement in teaching amidst a society undergoing constant change. While progress has been made in certain aspects, it remains insufficient, considering what research in this field has proposed over more than 50 years of scientific production (Nóvoa, 2017). Public policies aimed at enhancing professional development must strengthen formative practices based on overcoming the dichotomy between theory and practice, universities and schools, and scientific and pedagogical knowledge.

One possible approach would involve changes in undergraduate teacher education programs, emphasizing the development of reflective professionals in teaching practice. Nóvoa (2022) asserts that initial education should adopt the principle of integrating theory and practice within an institutional perspective, integrating the triad of teaching (teaching profession), research (universities), and outreach (school networks). Therefore, it is essential to build, particularly at the undergraduate level, a collaborative knowledge network, with the presence, support, and participation of practicing teachers as one of the necessary pillars to transform education.

To envision teacher education from this perspective is to construct collaborative pedagogical practices that transcend the fragmentation of sciences, reconnecting knowledge to produce interconnected and dialogical knowledge spaces for reflection and formation (Morin, 2007). Thus, the praxis of teaching should be guided by the inseparability of theory and practice and grounded in the action-reflection-action cycle of the teacher as a socio-historical subject.

According to Nóvoa (2022, p. 28-29, our translation), "[it is] necessary to build pedagogies that value a diversity of methods and modes of study and work [...]. [The] school day should not revolve around the 'lesson', but rather around 'study'." In other words, pedagogical practices, when part of a cycle of knowledge appropriation, reveal meanings and intentions aimed at mobilizing students to learn how to learn.

According to Matias (2019, p. 171-172, our translation), “[...] in the historical trajectory of education, different technological resources have been employed in pedagogical processes to make classes more engaging for students [...]”. From this perspective, educational robotics presents significant potential to foster learning in educational and interdisciplinary contexts, stimulate creativity, and promote the development of playful and collaborative activities among students.
By integrating programming, electronics, and electrical components, educational robotics serves as a technological interface with educational purposes, meaning it is an “[...] interdisciplinary science capable of attracting students in a playful manner towards knowledge or the realization of new themes” (D’abreu; Aihara, 2019, p. 143, our translation). In this sense, the use of robotics in classrooms can help overcome the fragmentation of knowledge by contextualizing it and giving it new meaning in the learning process.

Therefore, we understand that robotics can be used in educational contexts as long as it is well-planned and intentional. According to Prado and Morceli (2019), educational robotics enables the mobilization of knowledge from science, technology, engineering, arts, and mathematics, aiming to develop students’ logical reasoning and problem-solving skills. It is essential that those involved can create and program their study objects.

In the context of teacher education, we advocate for robotics to stimulate students’ inventiveness in problem-solving, knowledge construction, and skill development, thereby holding significant potential for collaborative pedagogical practices among teachers. This opportunity enables students to learn in networks, shaping them into active citizens capable of making informed decisions.

In this context, this qualitative state-of-the-art knowledge study aims to map scientific productions in the Brazilian Digital Library of Theses and Dissertations (BDTD) database concerning the interrelationships between teacher education and educational robotics from 2016 to 2020. Additionally, it categorizes the various approaches and perspectives addressed in these themes.

Thus, this study is justified by the need for discussions on the development of this field through mapping available works in the BDTD database, aiming to understand how robotics is used by teachers for educational purposes and/or whether there is specific teacher training involved. This direction opens avenues for further research.

Methodological Path of the Research in Question

The present investigation aims to analyze the interrelationships among teacher education, collaborative pedagogical practices, educational robotics, and networked learning, as evidenced in the productions from the BDTD database. This section aims to present the results of this qualitative mapping, organized in a sequence of conceptual and methodological steps.
According to Vosgerau and Romanowski (2014, p. 167, our translation), "[review studies] consist of organizing, clarifying, and summarizing the main existing works, as well as providing comprehensive citations covering the spectrum of relevant literature in a field." These works are categorized into two types: (i) mapping and (ii) evaluation and synthesis, with state-of-the-art knowledge studies falling under mapping reviews.

State-of-the-art knowledge is characterized as the identification and analysis of theoretical frameworks that lead to the reflection and synthesis of a specific theme or area within a predefined time frame and database (Morosini, 2015). Therefore, this type of survey is "[...] a formative and instrumental matter that favors both the reading of reality being discussed in the academic community and the learning of writing and methodological formalization for the development of the research path" (Morosini; Fernandes, 2014, p. 2, our translation).

Thus, these studies become necessary for further research as they gather scientific productions from various authors on a specific topic that underpins the theoretical foundation of subsequent works, besides allowing the identification of gaps, aiming to reaffirm that the state-of-the-art knowledge "[...] is not limited to identifying production, but analyzing it, categorizing it, and revealing multiple approaches and perspectives" (Vosgerau; Romanowski, 2014, p. 172, our translation).

This mapping was carried out based on theses and dissertations available in the BDTD through the creation of a search string to locate the works. The string consists of a sequence of keywords or synonyms related to the research topic. Moreover, boolean operators such as AND and OR were used to establish a relationship between the searched words resulting in the string: ("estado do conhecimento" OR "estado da arte" OR "revisão de literatura" OR "bibliometria") AND ("formação de professores" OR "formação docente") AND ("robótica" OR "robotização" OR "robótica educacional").

Some filters were also applied, including: (i) publication period (2016 to 2020) and (ii) language (Brazilian Portuguese) to select works that determined the focus of the research. In addition, inclusion criteria were established, encompassing studies containing one or more specific keywords, and exclusion criteria for research whose full texts were not available. The results of this survey are presented in Table 1.
Table 1 – Mapping of scientific productions (2016-2020)

<table>
<thead>
<tr>
<th>Title</th>
<th>Type</th>
<th>Author</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construção de tela interativa usando controle de Nintendo Wii e sua utilização por professores e alunos da rede de ensino</td>
<td>Dissertation</td>
<td>CRUZ, Hernani Batista da</td>
<td>2016</td>
</tr>
<tr>
<td>Robótica aplicada à educação: uma análise do pensar e fazer dos professores egressos do curso oferecido pelo município de João Pessoa – PB</td>
<td>Dissertation</td>
<td>SILVA, Jéssica Ferreira Souza da</td>
<td>2017</td>
</tr>
<tr>
<td>Formação em contexto de São José dos Pinhais: robótica sustentável</td>
<td>Dissertation</td>
<td>GREBOGY, Elaine Cristina</td>
<td>2017</td>
</tr>
<tr>
<td>Taghunt School: plataforma web das coisas como ferramenta de apoio à educação</td>
<td>Dissertation</td>
<td>VIEIRA, Pedro Fernandes</td>
<td>2017</td>
</tr>
<tr>
<td>Robótica Educacional e o Ensino de Matemática: um experimento educacional em desenvolvimento no ensino fundamental</td>
<td>Dissertation</td>
<td>GALVÃO, Angel Pena</td>
<td>2018</td>
</tr>
<tr>
<td>A utilização dos laboratórios escolares em instituições de ensino na cidade de Uberaba</td>
<td>Dissertation</td>
<td>GONÇALVES FILHO, Roberto Salgado</td>
<td>2017</td>
</tr>
<tr>
<td>Formação continuada de professores para inovação pedagógica por meio da robótica educacional na Escola Estadual Presidente Kennedy</td>
<td>Dissertation</td>
<td>OLIVEIRA, Denilton Silveira de</td>
<td>2019</td>
</tr>
<tr>
<td>O discurso de professores de ciências relativo ao uso da robótica educacional na cidade do Recife</td>
<td>Thesis</td>
<td>SILVA JUNIOR, Luiz Alberto da</td>
<td>2019</td>
</tr>
<tr>
<td>Análise de projetos de robótica para criança em idade pré-escolar desenvolvidos em escolas da região sul da cidade de São Paulo e em escolas no norte de Portugal</td>
<td>Thesis</td>
<td>RAMOS, Rogeria Campos</td>
<td>2019</td>
</tr>
<tr>
<td>Mapeamento do pensamento computacional por meio da ferramenta scratch no contexto educacional brasileiro: análise de publicações do Congresso Brasileiro de Informática na Educação entre 2012 e 2017</td>
<td>Dissertation</td>
<td>MASSA, Nayara Poliana</td>
<td>2019</td>
</tr>
<tr>
<td>Aplicação de ferramentas pedagógicas para o Ensino de ciências em estudantes de Pedagogia: aprendendo sobre energia e eletricidade</td>
<td>Dissertation</td>
<td>QUINQUIOLO, Natalia Carvalho Rosas</td>
<td>2020</td>
</tr>
<tr>
<td>Robótica pedagógica para o ensino de ciências em Santo Antônio do Tauá-Pará</td>
<td>Dissertation</td>
<td>OLIVEIRA, David Gentil de</td>
<td>2020</td>
</tr>
<tr>
<td>Um olhar sobre a integração de tecnologias digitais e os conhecimentos profissionais do professor durante a ação pedagógica</td>
<td>Dissertation</td>
<td>VALLE, Luciene Angélica Cardoso</td>
<td>2020</td>
</tr>
</tbody>
</table>

Source: Authors’ elaboration (2022).

In total, we found 15 works, however, after applying the exclusion criterion, 13 publications remained, which constituted the corpus of this investigation, comprising 11 dissertations and two theses. The survey was conducted in December 2021. Subsequently, we conducted a floating reading of the abstracts, which consists of organizing the corpus in a way that explores the possibilities of the text under analysis (Bardin, 2011).

Regarding the treatment of collected data, we followed the stages of Discursive Textual Analysis (DTA), understood as a self-organized process that allows understanding the emergence of the new through three procedures: (i) unitarization involves the dismantling of texts; (ii) categorization corresponds to establishing relationships among the units resulting...
from the fragmentation that occurred in the first stage; (iii) construction of the metatext constitutes the capture of the emerging new, involving communication and validation of different understandings about the investigated phenomenon (Moraes, 2003). After going back and forth in this analysis process, the final categories of this study emerged through the interweaving of publications, as depicted in Figure 1.

**Figure 1** – Emerging categories of the study

![Image](image-url)

Source: Authors' elaboration (2023).

The categories involved (re)groupings in the field of education and robotics that allow understanding the interrelations among technologies and digital interfaces with information, communication, and robotics; pedagogical practices and teaching in pedagogical action; construction of knowledge and meaningful learning. Thus, in the following section, we present the metatext resulting from this cycle of DTA.
Formation, knowledge, and learning: perspectives in the field of robotics

This section aims to discuss the analyses carried out in the light of DTA. After selecting and conducting a floating reading of the abstracts of the works mapped in the BDTD, we initiated the categorization process through unitarization and (re)grouping of similar elements, resulting in emerging categories, i.e., categories that emerged from the information contained in the research corpus. These categories evolved from initial to intermediate until reaching the final stages, which were (i) technologies, (ii) pedagogical practices, and (iii) construction of knowledge.

From the discussions addressed in the works, the category of technologies emerged in the educational context of formation. Silva's dissertation (2017, p. 9, our translation) emphasizes that it is "[...] fundamental for teachers, through initial and continuing education, to learn to integrate technologies into school activities." We consider this position obvious yet crucial because there are still educational practices that do not consider digital information and communication technologies (ICT) in the teaching process.

The development of pedagogical practices with technologies in schools is a reality in the educational landscape. This prompts us to reflect on how to meet this demand meaningfully in the educational process, considering that "[...] profound changes are taking place in educational processes, largely due to the digital revolution" (Nóvoa, 2022, p. 10, our translation).

In this context, we highlight Cruz's work (2016), which discusses the use of interactive screens as a technological resource to teach physics, mathematics, and astronomy, aiming to enhance student interactivity in classes. The screen is a digital interface that integrates technologies and enables interaction by allowing students to build knowledge (Lopes, 2020) collectively. Therefore, teachers can use the screen to enhance lessons by executing tasks to solve proposed problems, making the learning process significant.

Another aspect emphasized in this category was the treatment of educational robotics as a technological resource. We find this position misguided because robotics is an interdisciplinary science that mobilizes students' construction of knowledge. Furthermore, we infer that this methodological approach is related to the fact that some authors view technologies as artifacts that enhance human abilities, an idea commonly shared among researchers in computer science and information systems. Let us examine some statements that highlight this finding:
Educators need to change their teaching methodologies to meet the current social context, including new possibilities, such as robotics, a technological resource that can be used in the classroom as a pedagogical and creative alternative, facilitating the learning of concepts and solving challenges involving curriculum components in primary education (Silva, 2017, p. 9, emphasis added, our translation).

Proposes a teaching experiment using robotics for teaching Mathematics, discussing the importance of technology and its contribution to education, the role played by the teacher in using these resources in the classroom, and an analysis of the teacher's training for the use of these tools (Galvão, 2018, p. 6, emphasis added, our translation).

Out of the five teachers from the 4th and 5th-grade classes directly involved in the project, two were able to independently develop the proposal to use educational robotics as an innovative resource in their classes (Oliveira, 2019, p. 8, emphasis added, our translation).

These excerpts indicate that the authors of the cited publications have a limited conception of robotics, not fully understanding its potentialities, placing it in an instrumental position in teaching. According to Bonilla (2005), it is necessary to break away from the idea of ICTs as "tools" for teaching content in schools. This is because these are not resources, but rather structuring devices of a new way of thinking and acting.

The conception of technology as a tool and/or resource places it in a position of dependence on humans (Santos, 2005). Therefore, robotics should not be adopted based on this assumption in the field of education, as it is a science involving mechanics, electronics, and electrical engineering with the potential to enhance pedagogical practices in both school and non-school settings.

Thus, digital and technological interfaces become foundational components of educational units, laden with content rather than merely serving as tools, representing a new way of thinking and feeling (Pretto, 2013). The future lies not in technologies themselves but in the school itself, which, through practices involving technological interfaces, will reinvent itself as a space for the redefinition of knowledge mediated by the teacher.

In this movement, the category of pedagogical practices emerged, highlighting the relationships between technologies in classrooms and educational robotics, as well as the potential for teaching work from an interdisciplinary perspective. For instance, Grebogy's dissertation (2017) discusses the interdisciplinary aspect inherent in robotics, encompassing the mobilization of various curriculum contents. This condition enables students to develop logical reasoning to solve problems, avoiding memorization and facilitating work across diverse
subjects such as Physics, Mathematics, and Sciences. However, it is essential to note that the fragmentation of school curricular frameworks

[...] does not allow for the establishment of the interdisciplinary relationship that robotics provides; nevertheless, what we aim for, in some way, is to change this paradigm. In any educational robotics project, at least three to four reference disciplines (Mathematics, Physics, Portuguese, and Chemistry) may be involved (D’Abreu; Aihara, 2019, p. 157-158, our translation).

In this conjecture, robotics emerges as a possible pathway for conducting pedagogical practices with technologies that enable defragmentation, contributing to the formation of critical citizens aligned with the demands of contemporary society’s Education 4.0. Discussions also underscore the need for instructional planning focused on learning in the field of robotics. The production of experiments and/or educational materials within the realm of ICTs could serve as a strategy to support and guide pedagogical practices involving robotics in interdisciplinary educational contexts.

Vieira’s work (2017) addresses pedagogical practices involving digital games and robotics that enhance student engagement. Prado and Morcelli (2019, p. 40, our translation) argue that "[...] in an educational project, if students do not create and/or build and/or program their study objects, then that project cannot be considered educational robotics." It is essential for students to be engaged in the development of proposed robotics activities to achieve its educational purpose. Gonçalves Filho (2017) draws an analogy between the steps of assembling a robot and laboratory practice protocols, where students follow stages to complete proposed activities.

By making lessons dynamic, engaging, and involving students in the learning process, robotics becomes a strategy employed by educators for conducting practices with technologies. In this regard, Ramos (2019) emphasizes that many teachers have demonstrated a lack of mastery over technologies, especially robotics. This underscores the need for further studies to provide guidance for education in this area.

Thus, teacher education emerges from the literature highlighting the need for theoretical grounding and practical knowledge, both in continuous professional development and initial

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4 “Education 4.0 is part of the logic of systemic development, which is surrounded by a perspective of education mediated by contemporary technologies, a reflection of the information society based on the mold of the Fourth Industrial Revolution, or as it is recognized by some Revolution 4.0. This revolution is felt in different ways, finding in education one of the determining spaces for society to develop in the 4.0 context.” (Kochhann et al. 2021, p. 706, our translation).
training, regarding ICTs aimed at developing pedagogical practices with technologies in school activities. Nóvoa (2022, p. 50, our translation) asserts that

[... ] integrating the digital into teaching is more than incorporating a 'technology'; it is recognizing the reverberations that the new ways of being, acting, and thinking – constituted in the digital age – provoke in schools and being able to integrate them as fundamental references in repositioning teachers.

Teachers are transformative agents in reality through praxis. This reveals that it is not just about inserting technologies into teaching, but about rethinking pedagogical practices with ways of acting and being in a society permeated by ICTs. Therefore, it is not enough for teachers to have a master of scientific knowledge without reflection. The action-reflection-action process allows for finding paths for redefining the profession. According to Freire (2016), teacher education needs to be reflective. Every educator should feel supported by a set of pedagogical and scientific knowledge that certainly does not exhaust itself and is constantly changing.

In this field, the devaluation of teaching work emerges as one of the main factors that undermines the profession, as teachers are subjected to exhaustive work hours. This condition hinders quality education in the face of societal changes and the development of practices involving technologies. These challenges are evident in teacher education, which constitutes "[... ] a key issue for the implementation of an innovative educational project, especially when it involves educational technologies such as educational robotics" (Oliveira, 2019, p. 207, our translation). Thus, reforming thought in initial and ongoing training programs is a necessity for developing pedagogical practices with technologies in basic education, whether formal or informal.

Another aspect noted relates to the lack of autonomy among teachers in carrying out activities. Teacher training with professional authorship, aiming to address social transformations, is relevant and "[... ] constitutes a great challenge, after all, regardless of the methodology, strategies, materials, content, and educational objectives, it is the teacher who actually develops the teaching and learning process with students in the classroom" (Quinquioolo, 2020, p. 9, our translation).

We agree that teacher authorship is not only important but necessary, given that teachers mediate the teaching process. According to Pimenta, Anastasiou, and Cavallet (2001),
information is the first stage of knowledge, and it is the teacher who will guide students in selecting what will become significant knowledge for life.

Regarding the lack of proficiency among teachers in working with technologies and robotics, Ramos' thesis (2019, p. 9, our translation) argues for the need to "[...] have more studies that emphasize the use of robotics in curricula, especially because many teachers have shown no proficiency with technologies, let alone with robotics." Therefore, concerning initial education, undergraduate courses can reconsider their curricula to address the contemporary demands of society.

In this process, the category of knowledge construction emerged from the synergy between teacher education and pedagogical practices with technologies and robotics in teaching. Students begin to reinterpret their prior knowledge and (re)construct new knowledge, as robotics is grounded in Piaget's constructivism (1974) and Papert's constructionism (1991).

According to Prado and Morceli (2019), in constructivism, children create their own learning experiences. These ideas served as the foundation for Papert (1991) to propose constructionism. The latter differs by integrating digital technologies, such as computers, which allow the creation of mechanical and electronic objects through programming. This forms the basis of educational robotics.

The potential of robotics to actively engage students in the knowledge construction process involves different perspectives. Galvão (2018, p. 6, our translation) points out that “[...] the development of knowledge in technological areas encourages students’ learning and contributes to their interest, providing moments of significant learning.” We agree with the ideas of D’Abreu and Aihara (2019), who discuss the playful nature of robotics in sparking students’ interest in science and technology learning. Thus, students experience building models of what surrounds them, placing them in an active role.

The studies also discuss how robotics enables collaborative work among students in problem-solving, fostering the development of reasoning, creativity, communication, critical thinking, autonomy, self-confidence, concentration, and motivation. We observe these potentials, as stated in the studies:

 [...] educational robotics, in pedagogical practice, resulted in participation, development of critical thinking, learning of its student, and the interdisciplinarity between Mathematics and educational robotics (Galvão, 2018, p. 6, emphasis added, our translation).

[Since] robotics is so present in daily life, it can become an ally in the learning process, enabling students to be active, participatory, and thus the subjects
of knowledge construction (Gonçalves, 2017, p. 75, emphasis added, our translation).

[...] Educational robotics has been presented as a resource capable of promoting interdisciplinarity, autonomy, motivation, collaborative group work, fostering creativity for problem-solving, developing concentration, selective observation, logical-mathematical reasoning, self-confidence, among many other characteristics that make it perhaps the most complete example of pedagogical innovation (Oliveira, 2019, p. 207, grifo nossos).

The studies show that involvement in robotics projects enables active learning situations with the creation of tangible objects in the real world. This condition contributes to the mobilization and reinterpretation of knowledge. In this direction, robotics allows students the formative experience that "[...] implies an articulation between activity, sensitivity, affectivity, and ideation" (Macedo, 2015, p. 39, our translation).

The ideas presented in this section aim, succinctly and objectively, to discuss the development of educational robotics pedagogical practices, highlighting its potential in reshaping teaching through interdisciplinarity, and in mobilizing students to promote meaningful learning.

Some considerations

The analyses of the studies allow us to infer considerations about robotics with its potential for educational purposes, enabling students to experience meaningful learning. However, we emphasize that meeting this demand involves planning and studies in the area of teaching practice. Therefore, it is necessary to redefine teachers' pedagogical knowledge and practices, aiming at the development of praxis involving science, technology, and robotics.

In this perspective, there is a need to reconsider the development of educational robotics and thus enable students to learn scientific school contents with meanings and significance, through teaching and research in basic education. In the field of teacher education, studies and investigations are recommended in the field of research intervention with interdisciplinary robotics science in formal and non-formal education contexts.
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**CRediT Author Statement**

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