

COMPLEXITY, TRANSDISCIPLINARITY, AND ECO-FORMATION IN TEACHER TRAINING: A SCOPE REVIEW

COMPLEXIDADE, TRANSDISCIPLINARIDADE E ECOFORMAÇÃO NA FORMAÇÃO DE PROFESSORES: UMA REVISÃO DE ESCOPO

COMPLEJIDAD, TRANSDISCIPLINARIEDAD Y ECOFORMACIÓN EN LA FORMACIÓN DOCENTE: UNA REVISIÓN DE ALCANCE

Aline Lima da Rocha Almeida¹ 0000-0003-0821-3556

Marlene Zwierewicz¹ 0000-0002-5840-1136

Verónica Violant-Holz³ 0000-0003-2464-6845

¹University of the Upper Rio do Peixe Valley - Caçador, Brazil; linerocha5@yahoo.com.br; marlene@uniarp.edu.br

²University of Barcelona - Barcelona, Spain; vviolant@ub.edu

Abstract: Teacher training proposals guided by epistemological frameworks that encourage the articulation of the curriculum with territories and its connection to global demands constitute alternatives for addressing the challenges of contemporary reality. This article analyzes the influence of the epistemology of complexity, transdisciplinarity, and eco-formation on teacher training and its impacts on pedagogical practice, identifying possibilities for improving educational policies. Through a qualitative scoping review, a search was conducted in the Web of Science, followed by the screening of 15 out of 142 identified articles using Rayyan. The analysis was supported by VOSviewer and Elicit. The results indicate that this epistemological framework influences teacher training by fostering closer connections between knowledge and real-world problems, the reconfiguration of curricular boundaries, the strengthening of collaboration, and a commitment to sustainability. Regarding contributions to educational policies, the findings highlight the need for more flexible and integrated curricula, greater articulation between initial and continuing teacher education, and stronger collaborative arrangements between schools and universities in response to territorial and global challenges. It is concluded that the articulation of this conceptual triad offers a promising basis for reorienting teacher education and enhancing pedagogical practice in the face of contemporary challenges.

Keywords: teacher training; educational policy; pedagogical practice; epistemology of complexity; transdisciplinarity.

Resumo:

As propostas de formação de professores orientadas por referenciais epistemológicos que estimulam a articulação do currículo com os territórios e sua conexão com demandas globais constituem alternativas para responder às exigências da realidade contemporânea. Para abordar essa questão, este artigo analisa a influência da epistemologia da complexidade, da transdisciplinaridade e da ecoformação na formação de professores e seus impactos na prática pedagógica, identificando possibilidades de aprimoramento das políticas educacionais. Por meio de uma revisão de escopo de natureza qualitativa, realizou-se uma busca na Web of Science, seguida da triagem, com o uso do Rayyan, de 15 dos 142 artigos identificados. A

análise foi desenvolvida com o apoio do VOSviewer e do Elicit. Entre os resultados, observa-se que esse referencial epistemológico influencia a formação de professores ao favorecer a aproximação entre saberes e problemas reais, o tensionamento das fronteiras curriculares, o fortalecimento da colaboração e o compromisso com a sustentabilidade. Quanto às contribuições para as políticas educacionais, evidenciou-se a necessidade de currículos mais flexíveis e articulados, de maior aproximação entre a formação inicial e a continuada e do fortalecimento de arranjos colaborativos entre escolas e universidades, como resposta aos desafios territoriais e planetários. Conclui-se que a articulação entre a tríade conceitual abordada oferece uma base promissora para reorientar a formação docente e qualificar a prática pedagógica diante dos desafios contemporâneos.

Palavras-chave: formação de professores; política educacional; prática pedagógica; epistemologia da complexidade; transdisciplinaridade.

Resumen: Las propuestas de formación docente guiadas por marcos epistemológicos que fomentan la articulación del currículo con los territorios y su conexión con las demandas globales constituyen alternativas para responder a las exigencias de la realidad contemporánea. Este artículo analiza la influencia de la epistemología de la complejidad, la transdisciplinariedad y la ecoformación en la formación docente y sus impactos en la práctica pedagógica, identificando posibilidades para mejorar las políticas educativas. Mediante una revisión de alcance de carácter cualitativo, se realizó una búsqueda en la Web of Science, seguida de la selección de 15 de los 142 artículos identificados mediante el uso de Rayyan. El análisis se desarrolló con el apoyo de VOSviewer y Elicit. Entre los resultados, se observa que este marco epistemológico influye en la formación docente al favorecer la articulación entre el conocimiento y los problemas reales, la reconfiguración de los límites curriculares, el fortalecimiento de la colaboración y el compromiso con la sostenibilidad. En cuanto a las contribuciones a las políticas educativas, se evidenció la necesidad de currículos más flexibles e integrados, una mayor articulación entre la formación inicial y continua, y el fortalecimiento de arreglos colaborativos entre escuelas y universidades, como respuesta a los desafíos territoriales y globales. Se concluye que la articulación de esta tríada conceptual ofrece una base prometedora para reorientar la formación docente y mejorar la práctica pedagógica ante los desafíos contemporáneos.

Palabras clave: formación docente; política educativa; práctica pedagógica; epistemología de la complejidad; transdisciplinariedad.

Introduction

Education has among its challenges to meet the demands of a society in accelerated transformation, which includes the need to offer alternatives for students to face challenges that are difficult to predict (Tan; Chua, 2023). This panorama highlights the need to resignify teacher training, reducing the distance between the academic discourse on training initiatives and the concrete working conditions in schools (Nóvoa, 2017).

As possibilities, Nóvoa (2019) suggests initiatives in which teachers themselves collectively analyze the demands of their performance, share knowledge and build new possibilities in constant dialogue between universities and schools. It is a process of co-

construction that is particularly relevant in a dynamic world, in which trends continually arise, requiring education to respond to current needs and, simultaneously, to anticipate future challenges (Tan; Chua, 2023).

In this process, the recursive potential of teacher education stands out, which manifests itself when teachers resignify their practice during the training process itself and, articulately, mobilize transformations that can influence educational policies, constituting a spiral movement that materializes in new training conditions, which feed back and expand the possibilities of action. This recursiveness intensifies when the formation is anchored in the epistemology of complexity, linking theory and practice in itineraries that approach curriculum, territory and global emergencies.

In the meantime, what Morin (2011) defines as pertinent knowledge, enhanced by transdisciplinary dynamics, which integrates different levels of reality, is strengthened (Nicolescu, 2018). It is this process that drives the development of eco-forming practices aimed at improving intrapersonal and interpersonal relationships, as well as the preservation and regeneration of the environment.

In light of these considerations, this study aims to analyze, at an international level, the influence of epistemology of complexity, transdisciplinarity and ecoformation on Teacher Training and its impacts on pedagogical practice, identifying contributions to the formulation and improvement of educational policies.

Methodologically, a qualitative scope review was carried out, guided by previously defined inclusion and exclusion criteria. The analysis was guided by two questions: i) How has the epistemology of complexity, transdisciplinarity and eco-training been articulated to teacher training in the international literature and how does this articulation affect pedagogical practice? E; ii) What contributions do the mapped initiatives offer to the formulation or improvement of educational policies aimed at teacher training? To answer them, the study examines teacher education demands in different countries and discusses contributions to streamline training processes aligned with the territories of action and planetary emergencies.

Teacher education: tensions, trends, and the obsolescence of models

The training of teachers faces challenges accentuated by the transformations that have occurred both in the territory of operation and in the global scope. These challenges are related to technological advances, professional demands in the face of an accelerating reality and crises that require teachers to practice in which the curriculum is linked to reality.

As for issues involving technologies, Ashrafova Allahverdi *et al.* (2025) examine a reality marked by asymmetries of access and training weaknesses, in which teachers face challenges conditioned by structural inequalities and the impacts of curricular fragmentation, resource limitations and training weaknesses. It is, therefore, a reality that exposes structural tensions and demands an epistemological change that critically integrates technology, curriculum and context.

With regard to transformations in the world of work, lifelong learning plays a central role in professional contexts marked by constant changes and challenges. Therefore, Rodrigo-Segura, Méndez-Cabrera and Hernaiz-Agreda (2024) argue that initial training needs to be articulated with continuous processes of professional development, favoring reflective and critical thinking, creativity, autonomy and the ability to articulate knowledge built at the university to teaching practice.

For the authors, it is a perspective that favors dialogue with real problems of a world in permanent transformation. In addition, it should be considered that the accelerated changes currently experienced expose the limits of linear and content-focused teaching training, emphasizing the relevance of an epistemological resignification capable of recognizing complexity as an organizing principle.

Articulated to technological and labor demands, the environmental, social and ethical crises that cross contemporary societies position teachers in the face of unprecedented challenges, intensified by the acceleration of environmental catastrophes, the increase in violence and other manifestations increasingly present in school daily life, which requires training processes aimed at developing the ethical, aesthetic and ecological sensitivity of teachers. In this sense, Bernaschina (2023) defends initiatives that promote the conscious use of technology, the articulation between science, art and life, the connection between school and territory, and the strengthening of environmental responsibility.

This defense reinforces that the current reality raises new alternatives for teacher training, driving the overcoming of fragmented curricula disconnected from territorial and planetary contexts. Such pressures also affect educational policies, as they demand the development of conditions to face the adversities experienced in school daily life.

In this scenario, education needs to contribute so that teachers critically link the curriculum to concrete demands, stimulating projects guided by pertinent knowledge that, according to Morin (2011), articulates the local and the global, recognizes the multidimensionality of contemporary problems and overcomes fragmented readings of reality. It is necessary, therefore, the pedagogical resizing of the formative proposals based on an

epistemology capable of integrating multiple dimensions of reality and of facing, in a critical and creative way, the uncertainties of the current time.

Complexity, transdisciplinarity, and eco-education in teacher training

The challenges currently faced by teachers require urgent investments in initial and continuing training. Among the alternatives pointed out in the literature, Ashrafova Allahverdi *et al.* (2025) highlight, from the pedagogical point of view, the need for a collaborative curriculum design, capable of involving teachers in the collective construction of training proposals, in convergence with Nóvoa (2019), which defends the collaborative analysis of reality, the sharing of knowledge and the joint construction of possibilities.

Bernaschina (2023), in turn, proposes the integration of art, science, technology and biology in teacher training, favoring an education oriented to sustainability, environmental sensitivity, and critical reflection on the ethical implications of technoscience. Together, these approaches offer subsidies to reframe curriculum, planning, and pedagogical practices from an ethical, ecological, and planetary perspective.

In the same direction, Rodrigo-Segura, Méndez-Cabrera and Hernaiz-Agreda (2024) defend the incorporation of the Sustainable Development Goals (SDGs) as a structuring axis of teacher training, for enabling the problematization of complex social issues, such as inequalities, exclusion and socio-environmental vulnerabilities. According to the authors, this approach favors the development of reflective and critical thinking and contributes to future teachers being able to transpose the knowledge built in the university context to concrete situations of professional practice, such as the elaboration of projects that promote the articulation between curriculum and territory and the making of pedagogical decisions sensitive to social and environmental contexts, conditions that reinforce the permanent, dynamic and unfinished nature of training.

This perspective contributes to facing what Morin (2018, p. 13) characterizes as the “[...] increasingly broad, deep and serious inadequacy between separate, fragmented, compartmentalized knowledge between disciplines and, on the other hand, increasingly transversal, multidimensional and global realities or problems.” By problematizing this inadequacy, complex thinking places teacher training in accordance with the complexity of the contemporary world and stresses training models based on linear and simplifying approaches.

Due to its articulating potential, complex thinking enhances an integrated reading of reality, differentiating itself from paradigms that, for Conceição and Molina Neto (2017),

simplify the educational process by not considering the multiple relationships that cross it. In this direction, transdisciplinarity expands the possibilities of reconnecting knowledge by proposing an understanding of knowledge that is built between, through and beyond disciplines (Nicolescu, 2018), favoring pedagogical practices that articulate different areas of knowledge around real and socially relevant problems (Santos, 2009). Marquesi, Rodrigues and Passarelli (2023) even argue that teacher training needs to adopt transdisciplinary perspectives capable of avoiding simplifying reductions in knowledge.

In this process, ecoformation plays a crucial role in a formation that stimulates the care of oneself, the other, and the environment (Silva, 2008), mobilizing, in this path, pertinent knowledge (Morin, 2011). These are initiatives in which the approximation between areas such as biology and art is nourished by sustainability and ethical sensitivity (Bernaschina, 2023), calling teachers to a critical, creative, and supportive action capable of strengthening links between school, territory, and the world.

Methodology

Constituting itself as a qualitative scope review, the research involved the survey of scientific production in the Web of Science database, at the beginning of the second semester of 2025, through advanced research, using the following equation: (“epistemology of complexity” OR “complexity theory” or transdisciplinarity OR “eco training”) and (“pedagogical practice” or “teacher training”). To support the stages of screening, organization and analysis of the studies, Rayyan software was used, an online platform for screening studies, available at <https://www.rayyan.ai>; VOSviewer, version 1.6.20 (Van Eck; Waltman, 2023), bibliometric analysis software available at <https://www.vosviewer.com>; in addition to Elicit, used as a tool to support the identification, organization and synthesis of evidence from the scientific literature.

Selection criteria

The inclusion and exclusion criteria were previously defined to guide the team’s work in the selection process. Empirical articles were included, published in English, Portuguese, Catalan or Spanish, located in the fields of education and / or health, addressing teacher training articulated to the epistemology of complexity and / or transdisciplinarity and / or eco-training,

and describing practices proposals for communities, educational institutions or public and/or private Basic Education schools.

Duplicates were excluded; reports, opinion polls, essays, comments, reviews, books, book chapters and annals of events; theoretical articles and systematic reviews; studies with unrecoverable data (full text unavailable); studies published in languages other than English, Portuguese, Catalan or Spanish; studies that did not deal with teacher training linked to the epistemology of complexity and/or transdisciplinarity and/or eco-training; and studies that did not present practices linked to communities, educational institutions or schools of Basic Education.

During the selection process, themes or contexts considered not relevant emerged based on the aforementioned criteria, which were analyzed by the team of authors before exclusion. For example, searches that combined the terms “teacher education” and “epistemology of complexity” or “transdisciplinarity” or “eco-education” often retrieved studies whose practices were restricted to Higher Education.

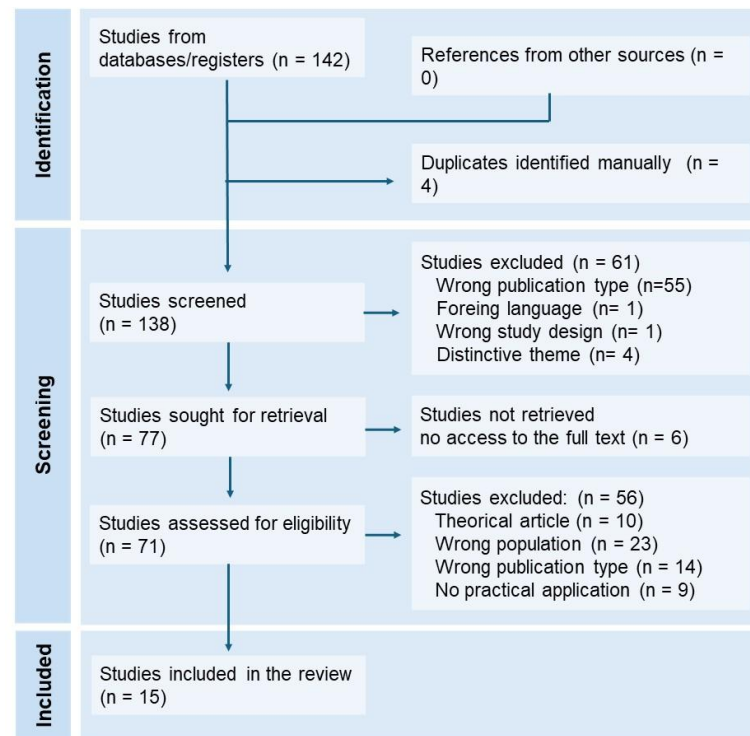
To ensure the necessary consensus in the selection of the 142 records, systematic procedures aimed at increasing agreement among the researchers were adopted. For this purpose, the tools made available by Rayyan were used, starting the analysis with a sample of 10% of the productions, with the participation of all the researchers of the team.

After the review of this percentage, a consensus meeting was held, in which conceptual specificities and eligibility criteria were clarified. At this meeting, it was also decided to review another 10% of the articles, with the aim of resolving residual disagreements. After obtaining a high degree of consensus among the evaluators, the remaining 80% of the productions were screened.

Throughout this sequence, composed of three stages of analysis, 61 articles were excluded. Subsequently, after reading the full text, another 56 articles were excluded, 6 of them due to the unavailability of the full text. Thus, the process resulted in the inclusion of 15 articles for the final analysis.

This whole process, carried out in different stages, is illustrated in the diagram based on the PRISMA method (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*), shown in Figure 1, which describes the selection flow of studies (Page *et al.*, 2021).

Figure 1 – Flow diagram of the study selection process



Source: research data (2026)

Data analysis

The literature analysis process prioritized evidence on the articulation between the conceptual triad that guides research and teacher training, evidencing impacts on pedagogical practice and contributions to educational policies. Initially, the bibliometric analysis in VOSviewer enabled the visualization of co-occurrence relationships between terms, identifying thematic nuclei highlighted in the literature. In addition, Elicit was used to support the organization, comparison and synthesis of the evidence, contributing to the systematization of the findings and to the identification of convergences, gaps and implications of the analyzed initiatives, especially regarding the impacts on pedagogical practice and contributions to the improvement of teacher training policies.

Results

Considering the objective of the study, Table 1 presents specificities that were the focus of analysis of the 15 selected articles, including identification data, country of publication, objective, concepts addressed, the practice presented and the place of development. Based on

the interface between epistemology and the analyzed practices, possibilities for the formulation and improvement of educational policies were identified.

Table 1 – Characterization of selected articles

Authors	Country	Objective	Concepts	Practice	Place of practice
Álvarez Monsalve, Ruano and Orefice (2023)	Colombia	Improve the professional profile of teachers from complex thinking, in order to strengthen the processes of citizen training in public schools	Complexity Transdisciplinarity	Pilot training with teachers, based on complex thinking and developed from a transdisciplinary approach	Public schools
Alves <i>et al.</i> (2021)	Brazil	To analyze creative and inclusive pedagogical practices that configure the school as a space for democratic human formation.	Complexity Transdisciplinarity	Formative practice based on creative, inclusive and transdisciplinary pedagogy	Third-sector institution (school or other educational space)
Amaral <i>et al.</i> (2025)	Brazil	Analyze violence in the school context and obstacles to teacher training, considering the ambiguity between practices and discourses.	Transdisciplinarity	Shared teaching to promote transdisciplinary knowledge	Public schools
Eça (2010)	Portugal	Explore the role of arts education in promoting creativity, innovation and critical thinking for a sustainable future	Transdisciplinarity	Training with transdisciplinary projects integrating different areas of knowledge through art.	Communities
Endlich and Sá (2021)	Brazil	Investigate how creativity manifests itself in the pedagogical practices of teachers who work in the creation spaces of the Faróis do Saber e Inovação (FSI)	Complexity Transdisciplinarity	Teacher training in spaces for creative learning (maker culture)	Creation spaces attached to public schools
Ovenden-Hope and Kirkpatrick (2024)	England	To analyze the experience of early career teachers and mentors in the Early Career Framework in England, considering its practical functioning and the influence of the school context.	Complexity	Continuing training for early career teachers (ECTs), organized into five areas: behavior management, pedagogy, curriculum, evaluation, and professional conduct	Public schools

Paige (2017)	Australia	To analyze the impact of the pedagogical practice of environmental pledges on the personal and professional lives of teachers in initial training and early career teachers, in the context of science and mathematics teacher training	Transdisciplinarity	Proposal for teacher training oriented by education for sustainability, based on transdisciplinary, experiential, and reflective approaches	Basic Education schools
López (2023)	Brazil	Analyze the proposal for training Indigenous teachers in the Takinahaky nucleus of UFG, focusing on intercultural and transdisciplinary education to value local knowledge and promote the improvement of living conditions in indigenous villages	Transdisciplinarity	Proposal for intercultural and transdisciplinary training, based on contextual themes of villages, which articulates indigenous knowledge and academic knowledge, alternating between university training and work in communities	University and Indigenous communities
Saito (2013)	Brazil	Analyze how teachers, in a public school, discursively construct their positions—technophilic or technophobic—in relation to the use of technologies	Transdisciplinarity	Training focused on the use of Information and Communication Technologies (ICTs)	Public schools
Sobral, Matos and Suanno (2022)	Brazil	Identify in transdisciplinarity ways for an inclusive education practice	Complexity Transdisciplinarity	Transdisciplinary and inclusive pedagogical practice in swimming lessons.	Swimming schools
Silva <i>et al.</i> (2020)	Brazil	Present a study and promote reflections on the contributions and challenges of The Pedagogy of Alternation in a Degree Course in Field Education (LEdoC), focusing on Natural Sciences	Transdisciplinarity	Formative practice based on the alternation between activities at the University and experiences in the community	Communities
Silva and Espíndola (2016)	Brazil	To investigate representations of Brazilian elementary school teachers in professional reflective writing (field notes and reports) produced by Master students, to	Transdisciplinarity	Training practice based on written reflection on the internship experience	University and Basic Education school

		understand what they reveal about Initial Teacher Education and the University–School relationship			
Ulbrich <i>et al.</i> (2025)	Austria	Analyze whether the use of modeling and 3D printing in the training of future teachers favors the skills of the “4 Cs”—creativity, critical thinking, collaboration and communication	Transdisciplinarity	Training with the creation and analysis of pedagogical projects with modeling and 3D printing.	Basic Education schools
Yüzlü and Dikilitas (2022)	Turkey	To investigate the impact of a continuing education oriented by translanguaging pedagogy on the reconstruction of the professional identity of teachers of English as a Foreign Language (EFL), analyzing this process in the light of complexity theory	Complexity	Continuing training of English teachers (EFL) guided by the pedagogy of translanguaging, conceived from the epistemology of complexity	Basic Education schools
Zwierewicz <i>et al.</i> (2021)	Brazil	To analyze the proximity between master’s research on Teacher Training and the perspective of a “science with conscience,” which underlies the international network of Creative Schools (RIEC)	Complexity Transdisciplinarity and Ecoeducation	Diversified training practices, partly prioritizing critical analysis, collaboration, pedagogical co-creation and the development of teaching projects.	Basic Education schools

Source: research data (2026)

The selected studies show a diversity of training initiatives, such as shared teaching, transdisciplinary projects via art, maker spaces, training for sustainability, and intercultural training by alternation, among others. Overall, there is a clear predominance of transdisciplinarity as a reference axis, followed by a relevant presence of complexity, while ecoeducation appears much more punctual, with low adherence among the mapped works.

Regarding the origin of the studies, in continental terms, the investigations are mainly distributed in South America, in addition to records in Europe, Asia and Oceania, which indicates a diverse international scope. In these continents, there is the presence of research in seven countries, with a strong predominance of Brazil, which concentrates most of the work, as evidenced in Figure 2.

Figure 2 – Geographical distribution of studies included in the review

Source: research data (2026)

Epistemological influence and impacts on teaching practice

Regarding the articles that address complexity, it is observed that some of the authors use the expression complex thinking while others opt for complexity theory. Despite this specificity, there is a convergence in conceiving the interdependence between educational phenomena, linking territorial situations to broader contexts. Zwierewicz *et al.* (2021), for example, emphasize the potential of complex thinking to understand reality as a fabric of relationships, in which everything is interconnected. Complementing this view, Álvarez Monsalve, Ruano and Orefice (2023) highlight their contributions to the study of the interactions of a system in connection with nature and the cosmos, reinforcing that phenomena can only be understood in relation to the broader environments of which they are part.

Yüzlü and Dikilitaş (2022) indicate that complexity theory is characterized by aspects such as self-organization, suggesting that systems can produce patterns, adjustments and changes from their own internal interactions, without a central command. In this direction, by adopting a complexity lens, it is recognized that the effects of a system tend to occur nonlinearly, through feedback loops that continuously reconfigure the system itself, as evidenced by Ovenden-Hope and Kirkpatrick (2024).

In addition, part of the articles shows that complexity manifests itself in different conditions, recognizing that educational phenomena are dynamic, relational and crossed by multiple dimensions: at the institutional level, the school is understood as a living system, in which actions trigger effects that return to the context itself and continuously transform it (Alves

et al., 2021); at the level of pedagogical processes, creativity is conceived as a systemic phenomenon, resulting from interactions between subjects and variables, capable of producing patterns and emerging reorganizations in educational practices (Endlich; Sá, 2021); at the human level, complexity appears in the integral constitution of subjects throughout life, integrating rational, emotional and bodily dimensions (Sobral; Matos; Suanno, 2022).

Based on the analyzed articles, convergent impacts of the epistemology of complexity on the epistemology of complexity applied in teacher training. By understanding educational reality as an interdependent and relational system, studies suggest that teacher education shifts from linear and prescriptive models to reflective, contextual processes that are open to uncertainty (Zwierewicz *et al.*, 2021; Álvarez Monsalve; Ruano; Orefice, 2023), strengthening the ability to read and interpret the complexity of school contexts. In addition, by incorporating self-organization and nonlinearity as formative principles, it is recognized that professional development does not occur in fixed stages, but emerges from the interactions between people, practices, policies, and institutional contexts (Yüzlü; Dikilitaş, 2022; Ovenden-Hope; Kirkpatrick, 2024), valuing situated learning, pedagogical experimentation, and continuous adaptation through feedback processes. By considering the complexity at the institutional, pedagogical and human levels, the articles broaden the scope of the teachers training by understanding the school as a living organism, practice as a space of creative emergency and the teacher as an integral subject (Alves *et al.*, 2021; Endlich; Sá, 2021; Sobral; Matos; Suanno, 2022).

Regarding transdisciplinarity, Paige (2017) understands it as an educational approach capable of crossing disciplinary boundaries to face real problems in an integrated way. Sobral, Matos and Suanno (2022), in turn, highlight that it broadens the understanding of the human being by integrating reason, emotion and corporeality, a fundamental condition for mobilizing a posture that relinks knowledge, cultures and experiences.

In the school and training context, this perspective contributes to teacher training by sustaining practices that tension curricular boundaries and strengthen a dialogued, emancipatory and socially committed education, as shown by shared teaching and training anchored in situated knowledge, including the Afrodiasporic ones described by Amaral *et al.* (2025). In this direction, Silva *et al.* (2020) present The Pedagogy of alternation as a possibility to promote an inter- and transdisciplinary science education oriented to the integral formation of educators in the field, while Eça (2010) emphasizes education through art for its systemic character and for the ability to reconfigure the curriculum through transdisciplinary projects,

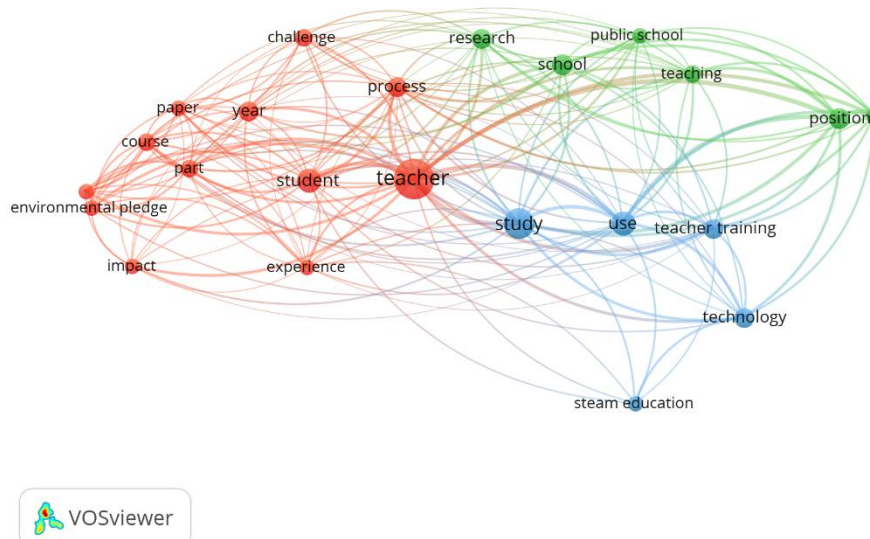
breaking with disciplinary fragmentation and creating integrated learning spaces focused on citizenship and sustainable development.

As for ecoeducation, although it appears less frequently in the studies analyzed, its presence allows us to highlight ethical and socio-environmental dimensions fundamental to the reconfiguration of Teacher Training. Discussed exclusively in the article by Zwierewicz *et al.* (2021), ecoeducation is conceptualized as a formative perspective articulated to transdisciplinarity and complex thinking, guided by a science with consciousness. In addition, by emphasizing the relevance of overcoming fragmented training approaches, the study links ecoeducation to training interventions that mobilize schools and teachers in processes of co-creation of teaching projects, with repercussions on the transformation of pedagogical practice.

In general, the studies denote the impact of complexity on the teacher training, highlighting its potential for stimulating reflective processes and contextualized, capable of conceiving school as a living system. Transdisciplinarity is understood as a way to tension curricular boundaries and favor socially committed practices, while ecoeducation is positioned as an alternative to articulate ethics, sensitivity and planetary responsibility, stimulating practices committed to sustainability. In this way, the literature analyzed reinforces that the incorporation of complexity, transdisciplinarity and ecoeducation has a direct impact on pedagogical practice, favoring initiatives that are more articulated, reflective and aligned with contemporary challenges.

Bibliometric mapping by co-occurrence of terms (VOSviewer)

In order to deepen the understanding of how scientific production has addressed complexity, transdisciplinarity and ecoeducation in teacher education and its impacts on pedagogical practice, the VOSviewer software was used, due to its potential to build and visualize bibliometric networks. In this study, we prioritized the analysis of term co-occurrence - that is, the frequency with which two or more terms appear together in a set of documents - a strategy that allows us to identify semantic and thematic relationships between concepts (Van Eck; Waltman, 2023). The visualization of the nodes made it possible to recognize groupings and the strength of the established associations; in this mapping, 23 items were identified organized into three clusters, represented by distinct colors, bringing together terms in greater proximity and evidencing correlated themes, as shown in Figure 3.

Figure 3 – Co-occurrence map of terms generated with VOSviewer 1.6.20 software

Source: research data (2026).

The interdependence between the thematic nuclei (clusters) supports the objective of this study, showing that, in the set of 15 articles analyzed, there are convergences around the epistemological base and its developments for Teacher Training. This finding converges with Álvarez Monsalve, Ruano and Orefice (2023), who highlight the need to strengthen teacher training from a complex and transdisciplinary perspective, highlighting its potential to face the socio-environmental challenges of the twenty-first century and to have repercussions both on the organization of pedagogical work and on the citizen formation of students.

The red cluster, with a central character, brings together terms with a higher degree of co-occurrence such as teacher, student, process, experience and impact, indicating that the literature focuses on teacher training articulated to pedagogical practice, with emphasis on training processes, experiences and impacts on teaching. This centrality is consistent with the understanding of training as an articulation between theory and practice and between the subjects involved, as explained by Silva *et al.* (2020) by stating that, from the perspective of complexity, the Pedagogy of Alternation allows to reconnect scientific and everyday knowledge, university and community, teachers and students.

The green cluster presents greater co-occurrence between terms such as school, teaching and research, which evidences the institutional and epistemological dimension of the debate. This is a link that is related to relevant knowledge (Morin, 2011) by linking training to the analysis of reality conditions.

The blue cluster is marked by the co-occurrence of terms such as Teacher Training, Technology and STEAM, pointing to strategies and technological mediations in teacher education, often associated with integrative proposals. This perspective is corroborated by Ulbrich *et al.* (2025), highlighting that the integration of emerging technologies in STEAM contexts favors cohesive and transdisciplinary learning experiences, with direct impacts on training practices.

As for the approaches, the clusters show a literature committed to approaching teacher training in an interdependent way. And, even with a less direct presence of ecoeducation, the association with terms such as environmental commitment and impact, signal concerns with socio-environmental responsibility and the transformation of pedagogical practice, coinciding with Eça (2010) when it highlights the role of education in promoting a responsible social consciousness.

Discussion and implications for educational policies

Considering the contributions of the authors that theoretically support this study, the results indicate that the literature analyzed denounces the exhaustion of traditional models of teacher training and highlights the need for an epistemological change with the potential to face problems that are interdependent and, at the same time, multidimensional and marked by uncertainty. These are conditions for confronting the tensions associated with technologies, transformations in the world of work and social, environmental and ethical crises, highlighting the relevance of Ashrafova Allahverdi's *et al.* (2025) reflections on structural and formative problems affecting teachers and Rodrigo-Segura, Méndez-Cabrera and Hernaiz-Agreda (2024) on the need to undertake efforts for a lifelong formation that connects to contemporary problems.

In this context, the findings related to the epistemology of complexity confirm the centrality of pertinent knowledge, capable of articulating the local and the global and of overcoming the fragmentation of knowledge (Morin, 2011; Morin, 2018). By evidencing that teacher training shifts to reflective, recursive and contextualized processes, the results dialogue with the criticism of the simplifying paradigm and linearity in the understanding of teaching and school culture (Conceição; Molina Neto, 2017).

By evidencing the potential of transdisciplinarity for the articulation between knowledge and between areas of knowledge, as well as formative experiences and real

problems, the analyzed literature offers clues for curricular reconnection, strengthening an epistemological option built between, through and beyond disciplines without denying the relevance of curricular content, as Nicolescu (2018) argues. As a result, the valorization of pedagogical practices based on collaboration, dialogicity and approximation to situational conditions reinforces the defense of training processes based on collective analysis of reality, knowledge sharing and joint construction of possibilities (Nóvoa, 2019), as well as the need to overcome reductionist and simplifying initiatives to strengthen educational responses committed to sustainable development (Marquesi; Rodrigues; Passarelli, 2023).

In addition, even if in the literature analyzed ecoeducation is less recurrent, its presence denotes an ethical and socio-environmental commitment. By characterizing a formative orientation mobilized by commitment to people, society and nature, stimulating the care of oneself, the other and the environment, as defended by Silva (2008), it has direct implications for pedagogical choices, teaching projects and forms of relationship in school daily life, dialoguing with proposals that emphasize teacher training oriented to sustainability and environmental sensitivity (Bernaschina, 2023).

Therefore, the findings of the review position the conceptual triad that guides the research as a way to displace the training traditionally offered to teachers for a deeper epistemological resignification. This resignification has direct repercussions on pedagogical practice by stimulating curricular integration, collaboration, contextualization, and commitment to the defense of life, approaching the propositions of Morin (2011) and Bernaschina (2023).

In this horizon, the conceptual triad constitutes an epistemological reference to resize teacher training policies. By recognizing teaching as a continuous, contextualized, and relational process, policies that align with this framework can favor more flexible curricula that are compatible with territorial and planetary demands.

Final considerations

With an international scope, the study sought to understand how the epistemology of complexity, transdisciplinarity and ecoeducation have been articulated to teacher training, its impacts on pedagogical practice, and contributions to the redirection of educational policies. Among the convergences observed, the criticism of the offer of traditional teacher training alternatives stands out, usually characterized by linearity, curricular fragmentation and distance from the curriculum in relation to local and global realities.

As alternatives, complexity stands out as a structuring axis for the resignification of training processes by understanding education as an interdependent and dynamic system. This framework shifts the focus from formations marked by technical prescriptions to reflective processes, contextualized and open to uncertainty, stimulating pedagogical practices with a more expressive openness to social and environmental issues.

In the analysis, transdisciplinarity occupies a central place for this process due to its potential to reconnect knowledge and bring curriculum and real problems closer. Practices involving shared teaching and integrative projects are examples of reconnecting initiatives with significant impacts on pedagogical practice, especially in the sense of strengthening collaborative work, integrating different areas of knowledge and stimulating dialogical and socially committed initiatives.

Ecoeducation, in turn, emerges as a way of articulating ethics, sensitivity and socio-environmental responsibility. Among the findings, we observed their contributions to enhance the impacts of complexity and transdisciplinarity in the consolidation of a transformative and sustainable education.

As a reference of practices that converge with this perspective, Brazil stands out for its theoretical and empirical production linking the conceptual triad that guides this research to teacher training, contributing both to the advancement of the debate and to the development of innovative practices. Likewise, productions in other countries show a scope with international capillarity.

From the educational policies' perspective, the results suggest that the articulation between complexity, transdisciplinarity and ecoeducation offers consistent foundations to overcome reforms centered on isolated competencies or instrumental solutions, pointing to policies that encourage integrated and flexible curricula, the articulation between initial and continuing education and the strengthening of collaboration between universities and schools.

As a limitation, it should be noted that the study did not directly analyze current teacher education policies, and, although it was not its objective, it understood the relevance of an international review that expands the understanding of the results of this research. In addition, longitudinal studies are recommended to evaluate the impacts of epistemology of complexity, transdisciplinarity, and eco-training in pedagogical practice and its relevance to the field of public policies for Teacher Training.

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About the Authors

Aline Lima da Rocha Almeida. Ph.D. candidate in Basic Education in the Graduate Program in Basic Education (PPGEB) at Universidade Alto Vale do Rio do Peixe (UNIARP), within the research line Culture, Teaching, Health, and Teacher Education. Holds a Master's degree in Basic Education from the Professional Master's Program in Basic Education (PPGEB) at UNIARP.

Author contributions: conceptualization, methodology, investigation, and writing – original draft.

Currículo Lattes: <http://lattes.cnpq.br/0370535143822555>

Marlene Zwierewicz. Ph.D. in Psychology from the Federal University of Santa Catarina (2013) and Ph.D. in Education from the University of Jaén (2012). Holds a Master's degree in Education from the Universidade do Contestado (2002).

Author contributions: conceptualization, methodology, investigation, and writing – original draft.

Currículo Lattes: <http://lattes.cnpq.br/2338653915538065>

Verónica Violant-Holz. Ph.D. in Psychology from the Universitat Ramon Llull (2001). She has experience in the field of Education, with emphasis on the interdependence between education and health.

Author contributions: conceptualization, methodology, investigation, and writing – original draft.

Currículo Lattes: <http://lattes.cnpq.br/9184353476452366>

How to Cite

ALMEIDA, Aline Lima da Rocha; ZWIEREWICZ, Marlene; VIOLANT-HOLZ, Verónica. Complexity, transdisciplinarity, and eco-formation in teacher training: a scope review. **Revista Práxis Educacional**, Vitória da Conquista, v. 22, n. 53, 19602, 2026. DOI: 10.22481/praxisedu.v22i53.19602