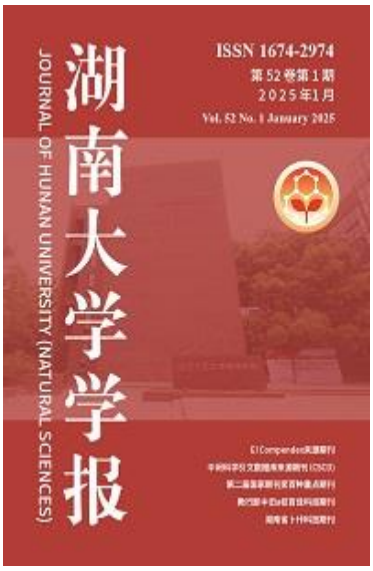

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Characteristics of Teacher Training in Educational Robotics: A Systematic Review

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Abstract: Educators must prepare for the Fourth Industrial Revolution and its impact on technology-enhanced learning. They must learn skills to engage with students in areas such as educational robotics. This study reviews the literature on teacher training in educational robotics. A qualitative analysis of the literature was conducted to identify potential areas of improvement. The review was conducted in accordance with PRISMA methodology using the Scopus, ERIC, and WOS databases. To be included in the review, the studies had to deal directly with teacher training in educational robotics at the school level. Eighty-four articles were identified from 2018 to 2023, and 84 articles were identified. These articles were filtered through three stages, resulting in a final set of 16 articles. The findings revealed several noteworthy aspects, including the relatively brief duration of the training courses, lack of coherence between the initial and ongoing training, considerable diversity in the training objectives and structure, and necessity of positioning robotics as a mediator. Regarding procedural and conceptual elements, there is a clear need to deepen the pedagogical and philosophical aspects of training. With respect to these conclusions, it is evident that there are multiple avenues for strengthening teacher training in educational robotics.

This can be achieved by addressing the aspects observed in the results, including extending and consolidating training periods, refocusing objectives, integrating foundational work into structures, and establishing connections between initial and continuing training.

Keywords: educational robotics, teacher training, research, PRISMA methodology

教育机器人教师培训特点：系统评价

摘要：教育工作者必须为第四次工业革命及其对技术增强学习的影响做好准备。他们必须学习与学生在教育机器人等领域互动的技能。本研究回顾了有关教育机器人教师培训的文献。对文献进行了定性分析，以确定潜在的改进领域。审查是根据 PRISMA 方法使用 Scopus、ERIC 和 WOS 数据库进行的。要纳入审查，研究必须直接涉及学校层面的教育机器人教师培训。从 2018 年到 2023 年，共确定了 84 篇文章，最终确定了 84 篇文章。这些文章经过三个阶段的筛选，最终确定了 16 篇文章。研究结果揭示了几个值得注意的方面，包括培训课程持续时间相对较短、初始培训和持续培训之间缺乏连贯性、培训目标和结构存在相当大的差异，以及将机器人技术定位为中介的必要性。关于程序和概念要素，显然需要深化培训的教学和哲学方面。关于这些结论，显然有多种途径可以加强教育机器人教师培训。这可以通过解决结果中观察到的方面来实现，包括延长和巩固培训期、重新调整目标、将基础工作整合到结构中以及建立初始培训和持续培训之间的联系。

关键词：教育机器人；教师培训；研究，PRISMA 方法论

1. Introduction

The advent of educational robotics as an emerging technology characteristic of the Fourth Industrial Revolution has introduced significant challenges to the field of education [1]. However, the focus has been on the outcomes of robotics interventions in students [2] or the utilization of a specific robotics kit [3], which has resulted in partial neglect of a crucial aspect: the training of educators to effectively integrate educational robotics into their teaching practices. The aforementioned situation is further complicated by the observation that university faculty of education in countries such as Colombia lack training programs in educational robotics, with many teachers learning to work with it on their own [4]. A systematic review of the literature on teacher training in educational robotics reveals a similar phenomenon, with the majority of studies focusing on aspects of educational robotics other than teacher training itself [5-7].

A systematic review was conducted to identify the specific characteristics of the selected teacher-training processes in educational robotics. These were analyzed qualitatively and reflexively to determine the potential areas for enhancement or transformation. To this end, a systematic review was conducted using the PRISMA methodology, and the following characteristics were identified in the selected studies: duration, participants, type of training (initial or continuous), objective, structure, and conceptual and/or procedural elements.

Because of the preceding exercise, the duration of the training processes was markedly reduced if it could be quantified in days or hours. The number of participants may be either minimal, comprising 10 or fewer teachers, or considerable, involving one or more teachers. The orientation of the training was that both initial and continuous training were provided, but no points of connection between the two were identified. The structures are heterogeneous and generally focus on learning how to handle a particular robotics kit without considering foundational work in the field of educational robotics. The TPACK model and computational thinking are presented as conceptual and procedural elements. In terms of conclusions, it can be observed that there are aspects of teacher training that have made varying degrees of progress, which can be further strengthened with considerations such as the following. The procedural and conceptual elements can be reinforced with components of a philosophical nature that enable the teacher to adopt a more expansive perspective on educational robotics.

The duration of the training processes should be structured around a work plan that allows for more time and continuity, even with the understanding that in addition to continuous training, educational robotics can be addressed in the initial training of future teachers. It is not advisable to limit the structure of

teacher-training processes to the utilization of a specific robotics kit. Instead, it would be more beneficial to adopt a flexible approach that enables adaptation to any type of kit. Procedural and conceptual elements should be reinforced through instruction in disruptive pedagogies and philosophical components that foster a more critical stance among teachers. This, in turn, facilitates the sentimental training of students regarding robotics and technology in general.

2. Materials and Methods

The process and criteria for selecting articles that were part of this document review are presented below. In relation to this process, the methodology known as PRISMA was adopted because of its replicability and wide acceptance in the academic world. This methodology has been applied in a variety of fields, including political science, education, and numerous other disciplines, as evidenced by the extensive literature on the subject [8-9].

2.1. Eligibility Criteria

The following three eligibility criteria were considered in this systematic review: (i) articles directly related to teacher training in educational robotics at the school level, (ii) articles in English, and (iii) full- and open-access articles. Similarly, a time window between 2018 and 2023 was utilized, which coincided with the period during which doctoral research, upon which this documentary review is based, was developed as one of its specific objectives.

2.2. Search Strategy

The search process was conducted using three highly relevant academic and educational databases: i) Scopus, ii) Web of Science (WOS), and iii) Education Resources Information Center (ERIC). The keywords were defined in accordance with the objectives of the research and with consideration of UNESCO Thesauri: i) Educational Robotics, ii) Teacher Training, and iii) Teacher Development. A logical AND and OR connector were employed to construct the following search equation: "educational robotics" AND ("teacher training" OR "teacher development"). Subsequent application of the search equation to the aforementioned databases yielded the following numbers: i) Scopus: 52, ii) ERIC: 9, and iii) WOS: 20.

2.3. Description of the Process Used to Select Research Articles for Review

The selection of articles focused on in this review sequentially followed the four-stage methodology proposed by PRISMA: i) Identification, ii) Eligibility, iii) Screening, and iv) Inclusion.

In the initial stage, designated as the "identification stage," 81 articles were identified by applying the search equation to the three aforementioned databases. In the subsequent stage, referred to as the "eligibility stage," eligibility criteria were employed, resulting in the exclusion of 31 articles and a retention of 50. In the third stage, known as the "screening stage," duplicate articles were eliminated, 23 articles were discarded, and 27 articles were retained. In the fourth stage, known as the "inclusion stage," full-text articles were identified, with 11 discarded and 16 retained. Figure 1 shows a summary of the stages of the selection process described above, including details of the number of articles retained from one stage to the next as well as the number of documents excluded.

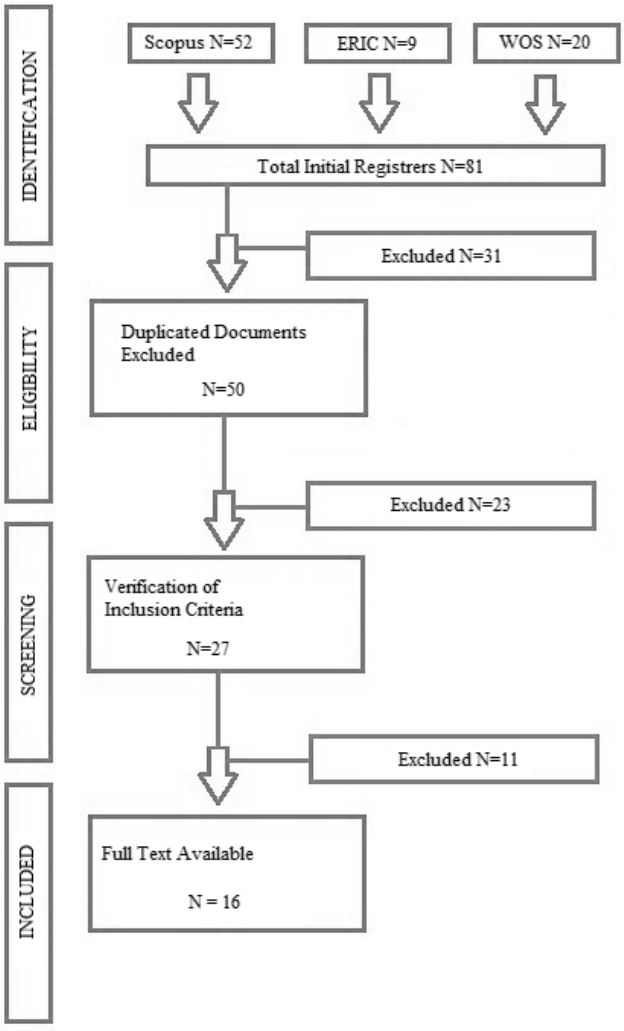

Figure 1. Systematic review process (developed by the authors)

3. Results and Discussion

This section presents 16 articles that were ultimately included in the systematic review in detail. It then develops each characteristic identified in the articles as a foundation for suggesting potential improvements and enhancements in the processes of teacher training in educational robotics.

3.1. Selected Research Articles and their

Characteristics

After carrying out the four stages of the systematic review according to the PRISMA methodology described in the previous section and listed in Figure 1, it is time to present in detail the 16 articles that were finally included in the review, which are organized in Table 1 according to the five characteristics of interest to be considered for this research: i) duration and participants, ii) type of training (initial or continuing), iii) objective, iv) structure, and v) conceptual and/or procedural elements.

3.1.1. Duration and Participants

A review of the literature revealed that the duration of teacher training processes in educational robotics is generally relatively short. This is evidenced by the timescales of the experiences described by [10], which comprise three six-hour sessions, and those described by [11], which entail a similar time commitment of four four-hour sessions. Therefore, it is essential to highlight the necessity for teacher training processes to be more extensive in duration, thereby affording teachers the opportunity to develop the subject matter in greater depth. Based on the aforementioned evidence, it is reasonable to expect that teacher training processes would encompass more consistent timescales, as exemplified by those considered in [12]. It is noteworthy that the number of participants in these initiatives varied considerably. One particularly noteworthy example is [13], a teacher-training initiative in educational robotics that has been running for over a year and has reportedly impacted hundreds of teachers.

3.1.2. Type of Training

A review of the articles revealed that over 50% of training processes occur within the context of continuing education. This is exemplified by the work of [14], which focuses on the training of early childhood education teachers to facilitate their integration of educational robotics in their classrooms. In the domain of initial training, the study in [15] merits particular attention. This study engaged over 200 prospective teachers, with a particular emphasis on inclusive education. It is also noteworthy to mention the initial training experience of [16], in which future teachers were all women and were integrated through robotics, art, and programming. From these experiences, it is evident that there is a clear opportunity for improvement, in the sense that both initial and continuing teacher education are part of the same process. This implies that there should be a bridge between these two forms of education that articulates them as a unified process rather than as isolated subjects of study.

This is theoretically supported by the considerations presented in one of the classic books entitled "Initial and Continuing Teacher Training as Two Stages of the Same Process," which provides guidelines related to teacher training [17].

3.1.3. Objective

Regarding the objective, the articles comprising the systematic review exhibited varying degrees of complexity. For instance, in [18], the object was situated at a fundamental level of complexity by orienting teacher training to a limited group of teachers, thereby providing them with the requisite elements to introduce educational robotics into the classroom. Conversely, [19] has a more expansive scope, encompassing not only a greater number of participating teachers but also the objective of influencing teachers from multiple elementary schools. This is achieved through the concurrent implementation of pilot tests of a curriculum and the training of teachers in educational robotics. Additionally, research such as that presented in [20] proposed that teachers engage in educational robotics processes within virtual environments that emulate those imposed by the 2019 pandemic. In conclusion, the aforementioned objectives demonstrate a clear vision of educational robotics, which is perceived as either a means or an end. This aligns with the theoretical stance of [21], who views educational robotics not as an end in itself but as a means to an end, based on the premise that it is a tool that facilitates teaching and learning processes.

3.1.4. Structure

A review of the articles reveals that, regarding the structure of teacher training processes, a further degree of heterogeneity is evident. For example, [22] structured the teacher training program into four modules: (i) the Theoretical Framework of Educational Robotics, (ii) Practice with Robots, (iii) Construction of a Project with Robotics, and (iv) Feedback and Exchange of Experiences Among Teachers. In contrast, [23] does not explicitly mention modules but does provide insight into their structural elements, which include: (i) what-if experiments, (ii) half-baked solutions, (iii) going beyond trial and error, and (iv) placing oneself in the role of the robot. In addition to the aforementioned approaches, [24] proposed a curriculum structure for teacher training in educational robotics comprising the following elements: (i) introduction to the course; (ii) introduction to educational robotics, programming, and constructionism; (iii) approaches and challenges of programming in educational robotics; (iv) classroom discussion and digital storytelling; (v) games in schools; and (vi) final tests and conclusions.

The heterogeneity observed in the different teacher-training structures developed in the reviewed research is partly explained by the fact that educational robotics is an emerging field of knowledge and still lacks standardized structures

validated by the academic community, as evidenced by the review [25] of emerging technologies related to the STEM approach, such as educational robotics. A common element that should be considered in all teacher training processes in educational robotics is the foundational work of the field [26], as it would allow teachers to approach elements of Papert's constructionist theory and his early vision of putting technology at the service of education.

Table 1. Characteristics of the articles analyzed (compiled by the authors)

Ref	i)Duration ii)Participants iii)Type of training	Objective	Structure	Conceptual and/or Procedural Elements
[10]	i) Approximately 3 sessions with 6 hours per week between virtual and face-to-face sessions. iii) Initial training	Develop training to motivate teachers toward the future use of Educational Robotics in their classrooms.	i) Introduction to Educational Robotics and resources for early childhood education, ii) Introduction to programming, iii) Experimentation with robots, iv) Classroom activities with robots, v) Recommendations to the activities, vi) Brainstorming on project with robots, vii) Presentation of final projects, viii) Presentation of final projects.	Includes familiarization and activities with additional programming resources and Educational Robotics, for example, could include sessions with other resources suitable for early childhood education. The technology acceptance model (TAM) was used to measure the impact of the intervention. Teachers' perception of Educational Robotics before and after the training is assessed.
[11]	i) 4 sessions of 4 hours ii) Students pursuing a bachelor's degree in pedagogy iii) Initial training	Enable them to integrate Educational Robotics resources into educational contexts by exploring the potential of Educational Robotics resources as learning tools in all disciplines.	In each session, students were introduced to a new Educational Robotics proposal or resource, and the training was conducted in a lab format, rather than an exhibition.	Educational Robotics is related to the United Nations Sustainable Development Goals. Digital competence for teachers Technologies such as Educational Robotics could help make up for some of the educational backlog generated in the pandemic.
[12]	i) 13 weeks ii) 120 Future graduates of the Bachelor's Degree in Primary Education iii) Initial training	Developing STEM skills and vocations in future elementary school teachers through Educational Robotics.	Sessions: 1-3 were introductory to the material and the project; 4-9 development; 10-13 focused on experimentation and working with the robotics materials.	Educational robotics practical sessions A robotics and programming project was developed in groups of 5 students. They used Scratch software and the Lego Spike Essential physical robot.
[13]	ii) 100 Future graduates of the Bachelor's Degree in Primary Education for the study, but in existence 1400 iii) Initial training	Motivation of future teachers through training in Educational Robotics.	Assessment of teachers' pedagogical knowledge to teach computational thinking through programming.	To train future teachers in Educational Robotics with an inclusive digital teaching perspective.
[14]	i) 4 weeks, 18 hours. ii) Early childhood education teachers iii) Continuing Education	To train future teachers in Educational Robotics with an inclusive digital teaching	2 stages: a training in which teachers are trained and another in which they must design a learning path for kindergarten students.	Teachers are expected to be able to introduce Educational Robotics to their curricula. Use of learning paths and elements of inclusive education.

		perspective.		Use of robots: Cody Roby, Cody Pies, Cody Color, Abeja-Bot and Blue-Bot;
[15]	i) 1 month ii) 200 teachers with a master's degree in education and 50 teachers with a specialization in early childhood education. iii) Continuing education	Introduce coding tools and methodologies and Educational Robotics, focusing on kindergarten.	Synchronous and asynchronous training.	Training with elements of inclusive education, starting with the first levels of education and then moving to higher levels in subsequent years, with a view to continuity and verticality.
[16]	ii) 7 Future graduates of the Bachelor's Degree in Primary Education iii) Initial training	Development of educational robotics through processes associated with the narrative.	Using Ozobot and bee-bot physical robots Didactic design: counting, drawing, and coding. Courses comprised theoretical lectures and practical activities.	Educational Robotics is proposed as a didactic for computational thinking in elementary school (Tpack support). Tell, Draw and Code strategy. Storytelling as a method for teaching robotics.
[18]	i) 16 sessions of approximately 1 hour ii) 4 Elementary school teachers. iii) Continuing education	Training a small group of teachers to introduce Educational Robotics in the classroom.	Six phases: i) Workshop ii) Presentation of the curriculum iii) Adaptation of the curriculum iv) Classroom implementation v) Application of questionnaires vi) Dissemination of the work done	Training with classroom accompaniment by a university-trained support teacher for developing curricular materials and evaluation of student and teacher learning. Educational Robotics to promote soft skills and STEM learning. Physical robotics platform used (KIBO).
[19]	ii) 350 teachers from the 1st to 4th grade of elementary school iii) Continuing education	Integrate Educational Robotics and computer science in a pilot study in elementary schools through curriculum adaptation and teacher training.	i) Offline Computer Science ii)Offline Robotics iii)Connected Robotics with tangible programming iv)Connected Robotics with visual programming v)Visual programming vi)Computer Science.	The teacher training initiative is articulated with the inclusion of Computer Science and Educational Robotics in the curriculum. Computer Science is worked offline and educational robotics without screens, but with physical robots.
[20]	ii) 10 primary school teachers in the first and second grades iii) Continuing education	Possibility for teachers to work in Educational Robotics in virtual conditions such as a pandemic.	There is no teacher training per se, but it poses a scenario for educational robotics that needs to be considered in terms of teacher training.	Educational Robotics as a didactic strategy to work gamification in the classroom. Use of a low-cost modular platform for teaching Educational Robotics.
[22]	i) 32 hours distributed over several months ii) More than 200 teachers iii) Continuing education	To offer a group of teachers a course on Educational Robotics based on pedagogical knowledge and discuss its impact.	4 modules: i) The theoretical framework of Educational Robotics. ii) Practicing with robots iii) Development of an Educational Robotics didactic project. iv) Feedback.	Didactic method: evidence-based education. The proposal was based on the teachers' experience supported by the TPACK model.
[23]		Train teachers in RE through a curriculum to reduce dropout	The training curriculum incorporates some innovative mechanisms such as: "What if?" experiments, active reflection on the task, half-baked	The teacher must have technical and pedagogical skills in Educational Robotics. The training curriculum

		risk rates, under the ROBOESL methodology (iterative design, tool selection, play and share.)	solutions, going beyond trial-and-error strategies, and embodiment or "playing the robot".	methodology was designed to support interdisciplinary robotics projects in schools. Based on the well-known axiom that "teachers teach how they are taught, not how they are told to teach". Learning methodologies based on constructivism and the elements of project-based learning.
[24]	ii) 184 in-service teachers. iii) Continuing education	Propose a methodology for teachers to introduce educational robotics, coding and tinkering in the classroom.	i) Introduction to the course. ii)Introduction to Educational Robotics, coding and constructionism. iii) Educational Robotics: programming approaches and challenges iv) Classroom discussion and digital storytelling. v) Playing at school. vi)Test and conclusions	Combination of notions of educational robotics with coding and thinking. Skills for the 21st century prioritized by the European Union. A total of 15 hours was dedicated to the introduction of 5 different methodologies. During the 4 workshops the teachers addressed theoretical aspects and practical activities. Curricular content
[27]	i) 36 h ii) 6 elementary and 6 high school teachers. iii) Continuing education.	Evaluate robotics work focused on the development of computational thinking.	Training and evaluation stages with the trainer's accompaniment and follow-up in class moments.	Use of the TPACK model. Evaluated by observing teachers' work with their students and reviewing their lesson plans. Use of virtual robots for lower cost.
[29]		To assess teachers' knowledge to teach computational thinking via programming.	Three-stage model (at the beginning of the course, during the course and outside the course) with increasing order of difficulty.	Educational robotics for the development of computational thinking. Use of the TPACK Model (PK, CK and PCK). Use of virtual robots VER and CODE environment.
[31]	iii) Continuing education.	Synchronous and asynchronous training processes in various topics associated with Educational Robotics.	A virtual community of Educational Robotics with a platform called Roteco, which has forums, material repositories, training cycles and other resources in this area.	Constructionism and Competencies for the the 21st Century. The results show that, in order to help teachers implement Educational Robotics activities, the focus should not be on the robot itself, but rather on supporting teachers with training and didactic materials that have been previously planned and tested, as well as providing them with the tools to design open-ended activities with their classes.

3.1.5. Conceptual and Procedural Elements

In this final observation, the research subject demonstrates significant contributions from each component, with the following examples being particularly noteworthy: [27] From a procedural standpoint, the deployment of virtual robots for teacher training is a notable contribution, largely because of their comparatively low cost relative to physical robots. This aligns with the work of [28], which highlights the crucial task of classifying simulated robots according to the proficiency stage of the teacher. Consequently, [29] provided a conceptual contribution in the form of the TPACK model, which serves as a reference framework for educators to develop their practices in educational robotics.

This model is therefore a crucial element in the process of teacher training. This aligns with the approach taken by [30], who based his proposal for robotics teacher training on the TPACK model. Furthermore, [31] offers procedural contributions, providing teachers with the option of designing open activities for their classes. From a conceptual standpoint, he linked the concepts of computational thinking, constructionism, and 21st-century competencies to the aforementioned training.

This procedural contribution is aligned with the emphasis placed on the design of resources by teachers, as highlighted by [32], through an evaluation rubric for the qualification of these resources. Regarding the conceptual contribution, the proposal is reinforced by works such as that of [33], which suggests that educational robotics is a highly suitable avenue for the advancement of computational thinking.

The previously discussed aspects suggest that there are procedural and conceptual elements in the reviewed research that could be strengthened by the integration of innovative teaching strategies, as well as philosophical elements that could allow teachers to adopt more critical positions regarding the use of educational robotics.

3.1.6. Articulation of the Theoretical Elements in the Reviewed Articles.

This section synthesizes the results and their discussion, summarizing the characteristics of interest previously observed and corresponding to the articles under review. First, it is essential to acknowledge that, given the duration of the educational robotics teacher training processes, they should provide the necessary extension to ensure that teachers' learning is truly meaningful for them and, consequently, for their students, as previously mentioned [34]. Similarly, it is imperative that teacher training in educational robotics be conceptualized in a manner that allows educators to engage with it irrespective of their foundational training discipline. This approach has been explored in previous studies [12], which demonstrated that approaches such as STEM can serve as a preliminary avenue for multidisciplinary integration. With respect to the nature of training, whether initial or ongoing, it is anticipated that a comprehensive proposal for teacher training in educational robotics will be formulated, considering the continuous training needs of educators throughout their professional careers. This approach is consistent with the integrative visions of these two training modalities. As exemplified by the contributions of [35] with regard to the objective, it is imperative that teacher training be grounded in foundational works in the domain of educational robotics. This approach has already been implemented rudimentally in works such as [36].

Conversely, with respect to the structure of the processes of teacher training in educational robotics, it is necessary to establish fundamental guidelines to support the diversity of orientations that may emerge. Efforts in this regard are evident in proposals such as those of [37], which already demonstrate the intention to develop preliminary guidelines for this particular type of teacher training. In conclusion, regarding the integration of conceptual and procedural components, it is imperative to incorporate the principles of computational thinking, as proposed by [38], into teacher training in educational robotics. In addition, active incorporation of theoretical frameworks is crucial. This involves the integration of theoretical references, such as the TPACK model proposed in [39], when using this model for developing rubrics. Additionally, it is crucial to consider the development of skills or competencies for the 21st century, as proposed by [40].

3.2 Comparison with Other Studies

This systematic review, conducted as part of the present research, offers a more extensive scope than prior studies, particularly those focusing on secondary education [41]. In contrast to these studies, this review encompasses the primary and secondary school levels, thus providing a more comprehensive perspective. With regard to its focus, the present research emphasizes teacher training, building upon the findings of studies such as [6], which explore educational robotics in the context of student engagement. Conversely, the systematic review by [42] addressed the topic of inclusion, a significant contribution to the present research due to the pertinence of this topic in school environments.

4. Conclusions

4.1. Research Summary

This systematic review represents a significant contribution to the field of teacher training for educational robotics. It identifies various characteristic elements that facilitate an overview of trends and interests that can guide the academic community associated with this field.

With regard to the duration and participants, the challenge for teacher training in educational robotics is to be open to teachers with diverse training profiles, including those in STEM+ areas, while also presenting development times that make the training appear more systematic than arbitrary.

In relation to the type of training, it is crucial to foster a unified approach to robotics education, integrating initial and ongoing teacher training to provide a comprehensive and coherent understanding of robotics among educators. This training should encompass foundational knowledge and skills, with updates and enhancements through ongoing professional development.

With regard to the objective of teacher training in the field of educational robotics, it is evident that different levels of complexity can be observed, which serves to enrich the nature of teacher training. However, for such training to be effective, it is essential that it is based on a conception of robotics that places it as a means rather than an end capable of contributing to a diversity of school educational scenarios.

A considerable degree of heterogeneity is evident in the structure of teacher-training processes, which serves to

illustrate the nascent state of the field. However, this heterogeneity contributes to the development and consolidation of this field. Some common elements have been identified, including the necessity of training structures to equip teachers with foundational knowledge specific to the field of educational robotics.

With respect to the procedural and conceptual elements, the presence of concepts such as the TPACK model, computational thinking, simulated robots, and others is observed. While these concepts are undoubtedly important, they would be significantly enhanced if teachers were trained in disruptive pedagogies and a philosophical component linked to it. This would enable teachers to adopt a critical stance toward educational robotics, thereby fostering in their students an attitude of engagement with robotics and technology in general.

4.2. Implications of the Study

The culmination of this systematic review suggests the potential of teacher training in educational robotics to become a progressively established area of research within the broader field of educational robotics. Concurrently, this systematic review constituted a component of a doctoral research initiative, encompassing the development of a teacher training model in educational robotics and integrating methodological components from the *"Ondas"* education program of Minciencias in Colombia. This contribution represents a significant advancement in the realm of educational modernization and development in Colombia.

4.3. Strengths and Limitations

Among the strengths are the fact that the documentary review was carried out in high-impact databases; also, the fact that it was possible to choose an updated time window for the development of the doctoral research; likewise, characteristics that were key for the development of the teacher training model for the *"Ondas"* of Minciencias program could be evidenced.

With regard to the limitations encountered, it was determined that the inclusion of certain articles in the systematic review was precluded by their lack of open access. Another potential limitation pertains to articles from low-impact or non-indexed databases, which despite their potential relevance to the research, were not included because of their restricted accessibility.

4.4. Recommendations and Future Research

Subsequent research endeavors may encompass a more expansive temporal scope in documentary reviews, thereby facilitating a more comprehensive perspective on the evolution of teacher training. Additionally, it is imperative to approach teacher training in educational robotics in conjunction with computational thinking and programming concepts that have witnessed a marked resurgence in educational and technological domains.

Future studies should explore how gender and inclusion issues are addressed during teacher training in educational robotics. Additionally, research should examine the relationship between teacher training in educational robotics and artificial intelligence, given the exponential growth of AI in recent months across all fields, particularly in the educational field.

Declarations

Author Contributions

Conceptualization, L.W.R.P, S.L.C., and S.R.A.; Methodology, L.W.R.P, S.L.C., and S.R.A.; software, validation, L.W-R.P., and S.L.C.; formal analysis, L.W.R.P, S.L.C., and S.R.A investigation, L.W.R.P, S.L.C., and S.R.A.; data curation, S.R.A.; writing—original draft preparation, L.W.R.P, S.L.C., and S.R.A.; writing—review and editing, L.W.R.P., and S.R.A.; supervision, L.W.R.P, S.L.C., and S.R.A.; project administration, L.W.R.P.; funding acquisition, L.W.R.P. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

The data presented in this study are available on request from the corresponding author.

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Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of the Universidad Santiago de Cali.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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