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Teaching sequences based on the STEM approach for the development of inquiry in early childhood education: A systematic review

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Abstract

In light of the growing significance of the STEM (science, technology, engineering, and mathematics) approach in education and the necessity to foster inquiry from an early age, this systematic review was conducted to identify didactic sequences that adopt a STEM approach and facilitate the advancement of inquiry in early childhood education. The results demonstrate that the didactic sequences facilitate disciplinary integration, providing a valuable opportunity to develop inquiry through the resolution of real-life problems and the promotion of interdisciplinary and active learning. Nevertheless, the necessity for additional research and the development of tailored resources to facilitate the effective implementation of these sequences in early childhood education settings is underscored. Concurrently, the significance of specialized and updated teacher training to maximize the impact of these educational practices is emphasized, thereby ensuring the optimal development of inquiry skills in children from an early age.

Keywords: inquiry, STEM approach, early childhood education, didactic sequences

INTRODUCTION

Didactic sequences are regarded as one of the most comprehensive planning strategies, which enables the establishment of a comprehensive methodological route throughout the design and execution of the sequence (Barraza Macías et al., 2020). This procedure entails the organization of a series of learning activities with a hierarchical and sequential structure, designed to foster the acquisition of meaningful knowledge among students (Carmona, 2017, cited in Tobar, 2022). Both students and teachers play a pivotal role in the development of these sequences through a reflective process of interdisciplinary integration. Teachers adapt the content to align with reality and establish structured learning objectives. This approach fosters the development of values, cooperative attitudes, teamwork, and the implementation of innovative activities. These are achieved through a series of phases, including questioning, exploration, production, and application (Barriga, 2013, as cited in Patiño Hernández & Tuta López, 2019).

From a competency-centered perspective, didactic sequences serve as an integrating axis, promoting and evaluating teaching and learning processes while placing students in practical contexts that offer them the opportunity to acquire, adjust, or question relevant knowledge. In this context, the competence of inquiry assumes particular significance. It is understood that research enables the construction of explanations about the natural world and the environmental dimension, employing a range of procedures and methodologies (Instituto Colombiano para la Evaluación de la Educación [ICFES], 2020). The practice of inquiry not only connects curiosity with the learning process but also promotes the development of scientific training from an early age (Del Valle Grisales & Mejía Aristizábal, 2016). Consequently, it is of paramount importance to foster inquiry to stimulate children's natural curiosity, thereby empowering them to comprehend the world in a profound and meaningful manner (Rodríguez Ortiz, 2018).

Research in the field of early childhood education, which is focused on inquiry, seeks to stimulate knowledge and address scientific problems. However, it

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Contribution to the literature

- This systematic review is pioneering in the field of early childhood education, as it focuses exclusively on didactic sequences based on the STEM (science, technology, engineering, and mathematics) approach to promote the development of inquiry.
- The study provides clarity on the structure of STEM-based teaching sequences, demonstrating how inquiry sub-competencies are developed and how STEM disciplines are integrated into the educational process.
- The research underlines the need to create more specific resources and teacher training to support the effective implementation of these sequences in the classroom, as well as highlighting the importance of continuous evaluation of their impact and the development of strategies to improve their effectiveness from the early stages of education.

is necessary to explore practices and contexts based on didactic strategies organized in sequences (Tobón et al., 2010) that are comprehensively structured and involve several disciplines. This approach is designed to foster the development of research, design, and reasoning skills (Campbell et al., 2018) that facilitate experiences that enable children to envision, hypothesize, create, record, communicate, imagine, test, and solve problems (Siemens Stiftung, 2021). This approach is further supported by an interdisciplinary approach that holistically and effectively orients the academic areas (Yepes Miranda & Lee, 2020).

In this context, the STEM approach provides conceptual, procedural, and attitudinal foundations for these disciplines (Perales Palacios & Morales, 2020). The application of scientific and technical knowledge in real-life contexts through hands-on activities based on the STEM approach facilitates the development of critical thinking, inquiry, problem-solving, and creativity skills in children. These skills, in turn, contribute to the strengthening of self-confidence, assertive communication, and collaborative work (Quispe, 2023; Siemens Stiftung, 2021).

The STEM approach, as a research tool (Ortega-Quevedo et al., 2020), can be implemented in an integrated manner through didactic sequences that explore findings, results, and conclusions. These sequences are supported by tools based on problem-solving, collaborative work, and the expression of concepts (Peretti et al., 2019). This approach would not only promote inquiry in early childhood education (Yapurasi Quelcahuanca, 2015) but also facilitate the development of critical thinking skills in students. Furthermore, it is presented as an optimal approach for the comprehensive development of competencies in students at this educational stage.

Given this scenario, it is of paramount importance to conduct a systematic review with the central objective of identifying and analyzing didactic sequences based on the STEM approach that promotes inquiry competence in early childhood education. This review is concerned with the analysis of the methodological structure of didactic sequences, to evaluate their organization and application in facilitating interdisciplinary learning. The objective is to examine how didactic sequences foster key sub-competencies of inquiry, such as hypothesizing, planning, experimenting, communicating, recording, and problem-solving, within the educational context of early childhood children. Additionally, the integration of STEM areas into classrooms will be investigated, with an assessment of how these disciplines combine to provide a learning environment that stimulates inquiry competence in early childhood education.

METHODOLOGY

This study comprises a systematic review of the literature, guided by the PRISMA statement (Page et al., 2021). In the identification phase, the Scopus, Science Direct, Taylor & Francis, and ERIC databases were consulted, as well as the review of two articles found in Google Scholar that met the eligibility criteria. The initial selection of documents was conducted using search equations that combined keywords in English, extracted from the UNESCO Thesaurus. Two search equations were proposed and gradually expanded to improve the selection process. The first equation was (STEM OR inquiry AND childhood education AND teaching), while the second was (Scientific research OR inquiry AND childhood education OR early childhood AND teaching OR didactics OR STEM). Subsequently, the search was refined by limiting the year of publication (2015 to 2023), the subject area (social sciences–education), and the type of document (article).

To ensure the relevance and quality of the studies reviewed in this investigation, the following inclusion and exclusion criteria were established (**Table 1**). In addition, **Figure 1** shows the flow diagram detailing the key phases of the systematic review process.

By the established inclusion and exclusion criteria, 8,782 articles were excluded following an evaluation of their year of publication, subject area, and type of document. Subsequently, a process of deduplication was conducted, whereby records were excluded based on their title and abstract. This resulted in an initial sample of 20 documents. Upon further examination, it was determined that three of the articles were not pertinent

Table 1. Inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Publication type	Articles published between 2015 and 2023	Books, book chapters, conference papers, and systematic reviews
Subject	Implementation of didactic sequences based on the STEM approach, specifically for the promotion of inquiry in early childhood education	Studies involving children under 4 years of age or older than 8 years of age
Age of the participants	Boys and girls ranging in age from 4 to 8 years old	Studies involving children under 4 years of age or older than 8 years of age.
Content	Strategies, methodologies, methods, techniques, and activities related to the STEM approach for the development of inquiry	No content related to inquiry development or STEM focus is specified

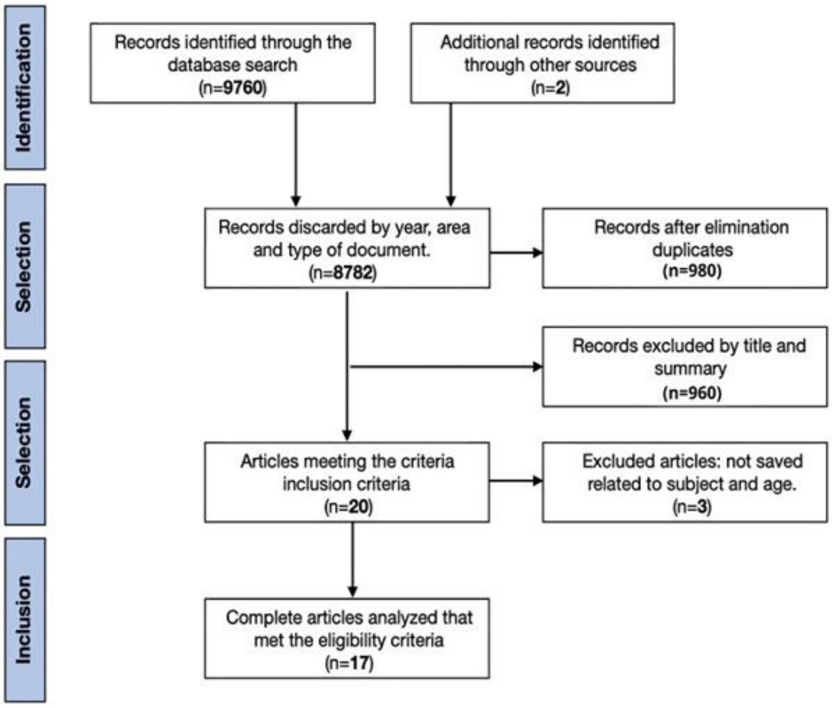

Figure 1. Systematic review flowchart (Source: Authors' own elaboration)

Table 2. Guiding questions

Guiding questions
What is the structure of the didactic sequences based on the STEM approach that have been implemented in the classroom to foster inquiry in children from 4 to 8 years old?
How are the sub-competencies of inquiry addressed?
How is the integration of STEM areas evident?

to the subject matter or age of the students. Finally, a final sample of 17 articles was formed, which were read and analyzed in depth to answer the guiding questions detailed in **Table 2**.

RESULTS

The initial documents derived from the database exploration revealed a considerable number of documents related to the STEM approach and inquiry at early ages. However, the majority of these documents do not focus on the development of teaching sequences based on the STEM approach for the stimulation of inquiry in early childhood education (see **Figure 1**).

The selection of documents about the structure of didactic sequences, the sub-competencies of inquiry, and the integrating areas of the STEM approach are presented in **Table 3**.

Structure of Didactic Sequences Based on the STEM Approach

The 17 papers identified in this study focus on processes of both teaching and learning in STEM activities. The following papers were identified: Dejonckeere et al. (2016), Dufranc et al. (2020), Fridberg and Redfors (2021), Isabelle et al. (2021), Misirli and Komis (2023), and Speldewinde et al. (2023).

Table 3. Structure of didactic sequences

Article	Author	Didactic strategy	Sub-competencies of inquiry	Integrating areas STEM approach
1. Exploring the classroom: Teaching science in early childhood	Dejonckeere et al. (2016)	The sequence was divided into three intervention phases. Fifteen activities were performed; 2 to 4 activities were selected in each session. Each activity was chosen at least twice. The activities were presented in a separate corner of the classroom and could be chosen by the child as a free-play initiative. **Phase 1:** Introduction (present problem situation). **Phase 2:** Exploration (free play). **Phase 3:** Activation (exploratory questions).	Initial questions, exploratory behavior, probing (activation) questions, problem-solving, and informative actions	Science, technology, engineering, and mathematics
2. Child-identified problems and their robotic solutions	Cherniak et al. (2019)	The activities started with experiments and interactions with the Cubelet robot so that the children could learn how it works and understand its functions. **Week 1:** Exploration of three basic Cubelets (a sensor, an actor, and a battery). **Week 2:** Experimenting with sensors. **Week 3:** Building Cubelets robots to solve given problems. **Week 4:** Building Cubelets robots to solve problems identified by the children.	Identifying a problem, generating possible solutions, and selecting the most effective solution	Science, technology, engineering, and mathematics
3. Preschool teachers' role in establishing joint action during children's free inquiry in STEM	Fridberg and Redfors (2019)	The activities were designed based on the theory of joint action in didactics. **Concept 1:** Joint attention (sharing attention on the same objects). **Concept 2:** Joint affordance (participants in the same joint action, recognizing the same affordances in a given environment). **Concept 3:** Common ground (shared preconceptions and understanding of a common background).	Observe, experiment, and discuss	Science, technology, engineering, and mathematics
4. Children's engineering design thinking processes: The magic of the ROBOTS and the power of BLOCKS (electronics)	Kewalramani et al., 2020	The sequence is structured in pedagogical steps. These steps are based on the creation of a robot city for the Botley family, in which children build electronic prototypes in interaction with their peers, under the guidance and direction of the teacher. **Step 1:** Planning (interaction with robotic toys). **Step 2:** Scaffolding (building the robot city). **Step 3:** Development of inquiry skills (questioning techniques). **Step 4:** Interaction (teacher, children, peers). **Step 5:** Evaluation (review, discussion).	Entry questions, Experimentation, sequence of questions, checking, and sharing results	Technology and engineering
5. Robotics and early-years STEM education: The botSTEM framework and activities	Dufranc et al. (2020)	The sequence is organized into phases that follow the inquiry process and the engineering design process. **Phase 1:** Observe and inquire. **Phase 2:** Play and discover. **Phase 3:** Design, experiment, and program. **Phase 4:** Engineering design process. **Phase 5:** Evaluate and share.	Propose hypotheses, experiment, evaluate, share, and discuss	Science, technology, engineering, and mathematics
6. 'You have 25 kids playing around!': Learning to implement inquiry-based science learning in an urban second-grade classroom	Isik-Ercan (2020)	The sequence was organized into three levels based on the 5E model (engage, explore, explain, elaborate, evaluate). **Level 1:** Individual (researching the topic). **Level 2:** Group work (sharing findings with peers). **Level 3:** Group and teacher meetings (the teacher guides each work group and leads them to reflection).	Observe, describe, formulate questions, explore, test, acknowledge, share, and demonstrate	Science, technology, engineering, and mathematics

Table 3 (Continued). Structure of didactic sequences

Article	Author	Didactic strategy	Sub-competencies of inquiry	Integrating areas STEM approach
7. Exploring steam teaching in preschool using Fred Rogers approach	Awang et al. (2020)	The sequence was organized in three steps according to the postulates of Fred Rogers. **Step 1:** Talking STEAM (prior knowledge) **Step 2:** Finding STEAM Everywhere (guiding boys and girls to act as explorers) **Step 3:** STEAM in the future (encouraging interest in becoming an inventor).	Active conversation, exploration, asking questions, posing solutions, and sharing information	Science, technology, engineering, and mathematics
8. Preschool children's science motivation and process skills during inquiry-based STEM activities	Dilek et al. (2020)	The sequence was structured based on the skills of the scientific process (observe, compare, classify, measure, communicate, conclude, predict). Each skill was worked from the 5E model (engage, explore, explain, elaborate, evaluate). **Skills.** Children engage in the process, explore scientific concepts, explain the concept, use the concept in new situations, and evaluate.	Implication, exploration, explanation, elaboration, and evaluation	Science, technology, engineering, and mathematics
9. Teachers' and children's use of words during early childhood STEM teaching supported by robotics	Fridberg and Redfors (2021)	The botSTEM teaching model consists of three phases based on the inquiry and engineering design process. **Phase 1:** Selection of a real-world problem in a playful way, **Phase 2:** Guided inquiry focused on science or technology. **Phase 3:** Solving a problem that requires the design or implementation of a technological solution.	Propose hypotheses, experiment, evaluate, share, and discuss	Science, technology, engineering, and mathematics
10. Sinking or floating: An inquiry-based STEM activity for children	Park and Park (2021)	The sequence was structured according to the 5E didactic model, which promotes children's active participation in STEM activities **Phase 1:** Engage (ask questions). **Phase 2:** Explore (plan and carry out investigations) **Phase 3:** Explain (construct knowledge) **Phase 4:** Elaborate (investigate new problems) **Phase 5:** Evaluate (demonstrate knowledge, understanding, skills).	Engagement, exploration, explanation, elaboration, and evaluation	Science, technology, engineering, and mathematics
11. Using the engineering design process (EDP) to guide block play in the kindergarten classroom: Exploring effects on learning outcomes	Isabelle et al. (2021)	The sequence was structured around three premises: teach, review, and reinforce. Before beginning, the children walked around the neighborhood to observe different structures and buildings. **Day 1:** Introduction (presentation of the engineering design process). **Day 2:** Building (first day of building blocks, conversation, and reflection). **Day 3:** (second day of block building, conversation, and reflection) **Day 4:** (third day of block building, conversation, and reflection. New block shapes are introduced). For the test group, the engineering design process was reviewed before beginning).	Ask, imagine, plan, create, and improve	Science, engineering, and mathematics
12. Project-based inquiry in STEM teaching for preschool children	Chen and Tippett (2022)	Theme-based model related to problems children encounter in their daily lives. Some themes are blowing bubbles, water, and sinking and floating, paper airplanes. The sequence is structured according to the stages of inquiry. **Stage 1:** Observe and ask questions. **Stage 2:** Interest. **Stage 3:** Predict. **Stage 4:** Investigate. **Stage 5:** Synthesize data. **Stage 6:** Communicate findings.	Observe, ask, predict, investigate, summarize data, and report findings	Science, technology, engineering, and mathematics

Table 3 (Continued). Structure of didactic sequences

Article	Author	Didactic strategy	Sub-competencies of inquiry	Integrating areas STEM approach
13. The role of imagination in science education in the early years under the conditions of a *Conceptual PlayWorld*	Fleer (2023)	The sequence is structured according to the project "The scientific conceptual play world–PlayWorld". The project foregrounds imagination. It begins with reading a book. **Feature 1:** Imaginary space. **Feature 2:** Children enter the imaginary space. **Feature 3:** Confronting problems and finding solutions through concepts. **Feature 4:** Pupils and teachers enter a character. **Feature 5:** They experience the issues and design solutions.	Imaginary situation, choice of roles, problem statement, imagining solutions, make solution plans, collect data, and problem-solving	Science, technology, engineering, and mathematics
14. Beyond the preschool gate: Teacher pedagogy in the Australian 'bush kinder'	Speldewinde et al. (2023)	The activities are in an outdoor educational environment, in a small grove with trees, vegetation, and a stream with a bridge. First, the children participate in free games individually or in groups. The teachers go around and observe them. One group gathers around a large fallen tree trunk, which they imagine as an ice cream parlor, taking on roles and using resources such as sticks and leaves to simulate ice cream and money. Other groups can join in the work of another group. The activities are concluded with a class discussion, or a song related to the imaginary games.	Free play, discover, experiment, imaginative play, involuntary inquiries, and risk taking	Science, technology, engineering, and mathematics
15. Qualifying the science experiences of young students through dialogue–A Norwegian lesson study	Munkebye and Staberg (2023)	The instructional sequence considered the following phases. **Phase 1:** Student dialog (asking questions). **Phase 2:** Scientific dialog (use of scientific vocabulary) **Phase 3:** Consolidation (the student develops his ideas). **Phase 4:** Reflection (deep connection with other experiences).	Planning, first implementation, evaluation, redesign, second implementation, and final evaluation	Science and mathematics
16. Development of an inquiry-based module with scientific equipment to facilitate primary school students learning the force concept	Herwinarso et al. (2023)	The didactic sequence is structured by a module according to the 4D model (define, design, develop, disseminate) to address issues of strength. **Phase 1:** Orientation (introduction to the topics). **Phase 2:** Conceptualization (raising questions). **Phase 3:** Investigate (experiment, explore). **Phase 4:** Conclusion. **Phase 5:** Discussion (sharing the results with the class). This module will be distributed to various schools in Indonesia with a multimedia kit of science materials.	Watch, participate in discussions, suggest and search for evidence, construct arguments, connect arguments with theories, and communicate results	Science, technology, engineering, and mathematics
17. Computational thinking in early childhood education: The impact of programming a tangible robot on developing debugging knowledge	Misirli and Komis (2023)	The sequence is structured according to a scenario-based design for teaching and learning, together with the tangible robot Bee-Bot. **Part 1:** Identification of the instructional topic. **Part 2:** Children's prior mental representations and knowledge of the topic. **Part 3:** Learning objectives. **Part 4:** Teaching activities. **Part 5:** Artifacts and materials **Part 6:** Children's prior mental representations and knowledge of the topic **Part 7:** Documentation. This model builds a linear model for designing a complete robotics-based didactic intervention and presents different instances of planning and implementation.	Try, evaluate, identify errors, represent, locate, correct, and solve problems	Science, technology, engineering, and mathematics

In addition, the papers identified in this review address learning in STEM activities (Awang et al., 2020; Cherniak et al., 2019; Fleer, 2023; Isik-Ercan, 2020; Munkebye & Staberg, 2023).

The findings led to the identification of four key emphases in the design and development of didactic sequences. The first group of sequences is based on robotics, which encourages exploration, experimentation, and the construction of robots (Cherniak et al., 2019). This group also includes the use of tangible robots, such as the Bee-Bot (Misirli & Komis, 2023), as well as the creation of interactive scenarios (Kewalramani et al., 2020). Furthermore, the utilization and assessment of online tools are observed within the context of the botSTEM project (Dufranc et al., 2020; Fridberg & Redfors, 2019, 2021).

The second group addresses the engineering design process. It is pertinent to note that two of these works are previously related to robotics and seek to enhance play, hands-on learning, technological design, and collaborative work (Dufranc et al., 2020; Fridberg & Redfors, 2021). Additionally, a study that guides play with blocks to improve learning outcomes is highlighted (Isabelle et al., 2021).

The third group presents models or programs that serve as a foundation for the implementation of didactic sequences. The 5E model, engage, explore, explain, elaborate, evaluate (Dilek et al., 2020; Isik-Ercan, 2020; Park & Park, 2021), the PlayWorld scientific concept game world (Fleer, 2023), and the Fred Rogers approach (Awang et al., 2020) are among the most prominent models or programs in this category. Finally, in the fourth group, science activities (Dejonckeere et al., 2016) are recognized as meaningful in different educational settings (Speldewinde et al., 2023) and focused on topics related to problems encountered by children in their everyday lives (Chen & Tippett, 2022; Herwinarso et al., 2023).

Sub-Competencies of Inquiry

Concerning the sub-competencies of inquiry, there is a clear commitment to promoting scientific development in early childhood education. This approach is manifested through the stimulation of curiosity (Awang et al., 2020; Chen & Tippett, 2022; Dejonckeere et al., 2016; Fleer, 2023; Herwinarso et al., 2023; Isabelle et al., 2021; Kewalramani et al, 2020; Park & Park, 2021), as well as in promoting critical thinking (Awang et al., 2020; Chen & Tippett, 2022; Cherniak et al., 2019; Herwinarso et al., 2023; Isabelle et al., 2021; Isik-Ercan, 2020; Kewalramani et al., 2020; Munkebye & Staberg, 2023), computational (Cherniak et al., 2019; Dilek et al., 2020; Dufranc et al., 2020; Fridberg & Redfors, 2019, 2021; Misirli & Komis, 2023), creative (Awang et al., 2020; Cherniak et al., 2019; Isik-Ercan, 2020), engineering design (Dilek et al., 2020; Isabelle et al., 2021; Kewalramani et al., 2020), and scientific (Fleer, 2023; Herwinarso et al., 2023) from the early stages of the research process. These sub-competencies are supported by carefully designed activities that encourage initial questioning and active exploration of relevant information (Chen & Tippett, 2022; Dejonckeere et al., 2016; Dilek et al., 2020; Dufranc et al., 2020; Isabelle et al., 2021; Kewalramani et al., 2020; Park & Park, 2021), which lay the foundation for meaningful learning and deep understanding of scientific concepts.

Consistent with the principles of scientific inquiry, educational programs, and practices in early childhood education emphasize problem identification and analysis (Cherniak et al., 2019; Fleer, 2023) and the generation of creative and workable solutions (Cherniak et al., 2019; Dejonckeere et al., 2016; Fleer, 2023; Misirli & Komis, 2023). Experiments (Dufranc et al., 2020; Fridberg & Redfors, 2019, 2021; Kewalramani et al., 2020; Speldewinde et al., 2023) and active observations (Chen & Tippett, 2022; Fridberg & Redfors, 2019; Herwinarso et al., 2023; Isik-Ercan, 2020) are posited as essential tools for exploring the natural world, enabling children to engage in authentic scientific processes and develop critical thinking and problem-solving skills from an early age (Chen & Tippett, 2022; Cherniak et al, 2019; Dilek et al., 2020; Dufranc et al., 2020; Fleer, 2023; Fridberg & Redfors, 2019, 2021; Herwinarso et al., 2023; Isabelle et al., 2021; Isik-Ercan, 2020; Kewalramani et al., 2020; Misirli & Komis, 2023; Munkebye & Staberg, 2023; Park & Park, 2021).

Effective communication also emerges as a central aspect of teaching inquiry subskills in early childhood education. Through interactive and collaborative activities, children learn to express their ideas clearly and accurately, and to share and discuss their findings with peers and educators (Awang et al., 2020; Chen & Tippett, 2022; Dejonckeere et al., 2016; Dufranc et al., 2020; Fridberg & Redfors, 2019, 2021; Herwinarso et al., 2023; Kewalramani et al., 2020). This process fosters an inclusive and participatory learning environment (Dufranc et al., 2020), where diverse perspectives are valued and the development of oral and written communication skills is encouraged (Awang et al, 2020; Chen & Tippett, 2022; Cherniak et al., 2019; Dilek et al., 2020; Dufranc et al., 2020; Fridberg & Redfors, 2019, 2021; Herwinarso et al., 2023; Isik-Ercan, 2020; Misirli & Komis, 2023; Munkebye & Staberg, 2023).

Integration of STEM Disciplines

Regarding the disciplinary integration of the STEM approach, it is clear that it can take different forms depending on the needs and objectives of each study. From a holistic perspective that encompasses the four STEM domains to more specific approaches that explore the intersections between particular disciplines. First, it is noteworthy that 14 of the analyzed studies implement full integration of STEM by making disciplinary connections that focus on solving students' real-world problems (Awang et al., 2020; Chen & Tippett, 2022; Cherniak et al, 2019; Dejonckeere et al., 2016; Dilek et al., 2020; Dufranc et al., 2020; Fleer, 2023; Fridberg & Redfors, 2019, 2021; Herwinarso et al., 2023; Isik-Ercan, 2020; Misirli & Komis, 2023; Park & Park, 2021; Speldewinde et al., 2023).

In terms of integrating specific disciplines, one study focuses on the practical application of technology in engineering contexts, including designing and building prototypes, programming devices, and using digital tools to solve real-world engineering problems in early childhood education (Kewalramani et al., 2020). Another study raises the connection between science, engineering, and mathematics by demonstrating the development of mathematical and scientific concepts within the engineering design process (Isabelle et al., 2021). Finally, the connection between science and mathematics establishes activities that solve scientific problems supported by mathematical principles (Munkebye & Staberg, 2023).

DISCUSSION

Structure of Didactic Sequences Based on the STEM Approach

The records found in the initial database search are abundant. However, those that focus specifically on the structure of the didactic sequences, the sub-competencies of inquiry, and the integrative domains of the STEM approach are scarce. In terms of the structure of the instructional sequences, we first identify remarkable advances in the way children interact with robots, learn, and develop skills in exploring and experimenting with complex concepts in a hands-on and tangible way. This promotes active, experiential learning from an early age (Cherniak et al., 2019; Dufranc et al., 2020; Fridberg & Redfors, 2019, 2021; Kewalramani et al., 2020; Misirli & Komis, 2023). However, Espinosa Moreno and Gregorio Olivares (2018) emphasize that robotics should not be assumed lightly and be part of extracurricular activities; on the contrary, it should be integrated into the curriculum and adapted to different courses and age groups. Just as children are taught to read and write, it is crucial to teach them coding and programming, as these skills are the pillars of 21st century literacy (Mims, 2012 cited in Sánchez Vera, 2020).

This means recognizing the critical role of technology in education. The integration of robotics and programming into the school curriculum represents an invaluable opportunity to improve student learning in an increasingly digitalized world. As stated by Otero and Ortega (2020), technology must contribute to every teaching process to transform education into an inclusive, open, and sustainable activity that enhances the natural environment, revitalizes urban areas and holistically promotes digital innovation. In line with the manifestations of Ruiz-Rey et al. (2018), robotics creates an educational environment that fosters meaningful learning experiences and transforms the classroom into a space for experimentation and exploration, inviting students to question themselves about the how and why of the phenomena around them.

However, to ensure an effective and noteworthy implementation of these technologies, this integration implies the responsibility of educational institutions and educators. This requires not only the availability of adequate resources but also careful planning and continuous training for teachers. According to Parra Sarmiento et al. (2015), the introduction of technology in the classroom entails a process of pedagogical innovation that is reflected in the transformation of the roles of both teachers and students, the modification of the physical space, the adjustment of teaching methods, the adaptation of assessment methods, and new ways of employing available resources.

Second, the engineering design process fosters creativity and critical thinking at an early age. Through design, children learn to identify problems, propose solutions, and build prototypes, which allows them to develop problem-solving skills, teamwork, leadership, creativity, and persistence of effort (Dufranc et al., 2020; Fridberg & Redfors, 2021; Isabelle et al., 2021). Along the same lines, González-González (2018) adds that the design process in engineering is directly related to the computational thinking employed in programming and leads to the development of computer literacy and technological skills. This means that minors should not only think as scientists or mathematicians but also as active and creative engineers (Isabelle et al., 2021).

Programs such as the 5E model, which provides a solid structure for teaching scientific concepts (Dilek et al., 2020; Isik-Ercan, 2020; Park & Park, 2021), the scientific conceptual game world PlayWorld (Fleer, 2023), and the Fred Rogers approach (Awang et al., 2020) are other fundamental elements in the structure of didactic sequences. These programs represent interesting and enriching experiences, as Bastida Izaguirre (2019) states, they contribute significantly to the creation of didactic sequences, and they consider the constant interaction of children with their environment. In addition to the incorporation of social and emotional skills (Rivadeneira, 2023) through the use of technological tools and video games, it is proposed to design dynamics that address problem-solving based on real situations of students (Torres, 2015).

Sub-Competencies of Inquiry

Regarding the sub-competencies of inquiry, Kewalramani et al. (2020) argue that there is a close relationship between curiosity and thinking. In line with these approaches, Barragán et al. (2016) agree that using carefully designed procedures stimulates and promotes thinking, which in turn helps to rescue children's curiosity and wonder, thus fostering their intellectual development within a community of inquiry. This enriched community or environment prepared for inquiry should create opportunities for scientific activities as students explore, play, and acquire knowledge (Dejonckeere et al., 2016). The sub-competencies of inquiry promote children's active and reflective participation in the world around them from an early age. In addition, they develop their ability to argue a personal position based on empirical and scientific evidence on ethical dilemmas related to science and technology (Ministerio de Educación Perú [MINEDU], 2015). However, it is appropriate to mention, as stated by Alcalá and Maqueda (2022), the fundamental role played by the teacher in the stages of inquiry, where students are protagonists, and the teacher is the guide of the process.

Therefore, it is essential to promote inquiry in early childhood education, allowing students to play an active and participatory role in their educational process. This leads to the creation of a school environment that fosters their confidence and autonomy, giving them the freedom and responsibility to explore, question, and discover for themselves. As Romero-Ariza (2017) points out, inquiry is a skill that prepares children for life. More than simply acquiring knowledge, this skill helps to consolidate and deepen their experience of their context, encouraging them to take a stand and think critically.

Integration of STEM Disciplines

Finally, consistent with STEM integration, it is noteworthy that fourteen of the reviewed studies implement full integration of STEM. These studies make disciplinary connections that focus on solving students' real-world problems (Awang et al., 2020; Chen & Tippett, 2022; Cherniak et al., 2019; Dejonckeere et al., 2016; Dilek et al., 2020; Dufranc et al., 2020; Fleer, 2023; Fridberg & Redfors, 2019, 2021; Herwinarso et al., 2023; Isik-Ercan, 2020; Misirli & Komis, 2023; Park & Park, 2021; Speldewinde et al., 2023). Nevertheless, Bogdan and García-Carmona (2021) highlight the imprecision in planning and implementing the real contribution of the STEM approach due to the lack of clarity in disciplinary integration in curricula, as well as in teaching practices, since it goes beyond the simple grouping of content from different fields under the same name.

This finding underscores the need to pay more attention to and delve deeper into this particular area of education (Dejonckeere et al., 2016). However, it is important to recognize that the origins of the STEM approach are relatively recent, roughly from the beginning of the 21st century (Barbaran et al., 2022). For this reason, Mazo and Cano (2023) suggest that countries must face social changes by investing resources to ensure the presence of qualified, competent, and specialized personnel in STEM fields to generate new knowledge. Therefore, it is necessary to promote the understanding of concepts related to STEM from the early stages of education and prepare young people to face a society in constant change and evolution (Jurado et al., 2020).

However, this lack of clarity about how to integrate the disciplines into curricula and educational practices poses significant challenges that still need to be overcome to realize the full potential of the STEM approach to education. These challenges include the need for specialized teacher training, updating curricula, implementing innovative methodologies that promote interdisciplinarity and critical thinking, and ensuring adequate resources, both material and human, to provide an enriching and equitable educational experience for all students.

CONCLUSIONS

Based on the results obtained, this systematic review provides a comprehensive understanding of the structure of didactic sequences based on the STEM approach to promote inquiry in early childhood education. It highlights the prominent role of robotics as an innovative pedagogical tool that promotes hands-on learning and problem-solving. In addition, there is evidence of the widespread adoption of recognized educational models such as the 5E model, the Fred Rogers approach, and the Play World conceptual game world, which, characterized by their interdisciplinary approach, actively promote student participation in the learning process and represent a significant advance in STEM education.

Nevertheless, there is an urgent need to redouble efforts in the research and development of specific resources that support the effective implementation of STEM didactic sequences for the development of inquiry in early childhood education. Despite the identification of several promising sequences, a considerable challenge remains due to the lack of adequate materials and tools for their practical application in the classroom. Therefore, it is essential to focus on the development of innovative and accessible educational resources that support the development of scientific inquiry in the learning process through STEM education.

It is important to emphasize the importance of ongoing evaluation of the effectiveness of these practices in real early childhood settings. This includes not only measuring their impact on children's learning but also identifying and addressing challenges and barriers to implementation. It is also critical to develop teacher training strategies that facilitate the successful integration of these sequences to promote a deep understanding of how to effectively use the STEM approach to promote inquiry from an early age.

Finally, investment in research and development, as well as specialized teacher training, represents an invaluable opportunity to improve learning opportunities, holistic STEM education, and the development of inquiry skills in children from the earliest stages of education. This investment will not only prepare the child population for an increasingly science- and technology-oriented future but will also help to cultivate a generation of critical, creative, and scientifically literate students from an early age.

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