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Review

Fostering computational thinking and environmental awareness via robotics in early childhood education: A scoping review

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Abstract: The COVID-19 pandemic has been proven to be an important vector in humanity's behavioral reshaping, reflecting on people's value systems regarding sustainable consumption, and environmental awareness. At the same time, the inevitable lockdown brought out the demand for designing innovative educational and assessment strategies, oriented toward digital technology. However, even before the COVID-19 pandemic, digital technology had already been infused in contemporary educational settings, while its undeniable effect on the future of the forthcoming generations had already entailed the necessity of developing today's students' digital competencies and computational thinking (CT) skills in order to equip them for a new reality in the job arena. Especially in early childhood, implementing interdisciplinary education, exploiting state-of-the-art technological tools, and adopting engaging educational practices, like robotics, support the cultivation of core 21st-century skills, such as CT and environmental awareness. Directly responding to these considerations, we provide the results of a scoping review conducted in April of 2023, following the PRISMA statement, aiming at bringing out studies regarding educational practices in early childhood education that concurrently cultivate CT and environmental awareness via robotics. The findings of the literature indicate that this field remains direly underinvestigated.

Keywords: Computational thinking, Environmental awareness, Early childhood education, Robotics

Introduction

Nowadays, CT is considered a valuable set of skills for all citizens in modern societies, since it is applicable to everyday solving activities (Hsu et al., 2018; Yang et al., 2020). It involves defining problems, providing solutions to difficult or complicated issues, and exercising scientific reasoning (Wing, 2006). It is also a metacognitive process that combines skills and dispositions for regulating complex problem-solving and modeling unobservable phenomena (Dwyer et al., 2014). The value of cultivating CT, even from kindergarten, has already been recognized worldwide, considering its inclusion in contemporary curricula, implemented in formal educational settings (Buitrago-Flórez et al., 2021), or in after-school programs (Yang et al., 2021). Robotics is an excellent way to cultivate CT skills, especially in early childhood education (Yang et al., 2020), since it involves hands-on tools and activities that trigger curiosity, and motivate children to get involved and feel in control of the learning process (Witt & Kimple, 2008).

In the broader context of supporting scientific schooling during early childhood, which involves formal and informal education provided to children from birth up to the age of

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eight (Kalogiannakis & Kanaki, 2022), exploiting robotics promotes the development of STEM (Science, Technology, Engineering, and Mathematics) education (Chaldi & Mantzanidou, 2021). Besides the so-called core sciences (e.g. mathematics and physics), there are STEM branches, such as Environmental Science and Technology (Glänzel & Schubert, 2003), that are crucial to be introduced in compulsory education, starting from the early years (Cruz et al., 2021). Indeed, well-designed environmental education creates environmental literal citizens that do not distinguish themselves from nature (Quinn & Cohen, 2021), and are capable to establish environmental and resource sustainability (Ardoin & Bowers, 2020). Well-designed robotics activities provide unique learning experiences, engaging young children in STEM fields in novel ways that target environmental issue awareness (Phamduy et al., 2015). Indicatively, we refer to the Interactive Robotic Fish, a tool for boosting informal science learning and environmental awareness (Phamduy et al., 2015), and the robotics system "Smart Trashcan Brothers" that empowers the environmental consciousness of young children attending primary school (Arnett et al., 2021). At this point, it is important to discuss the absence of a generally accepted definition for environmental awareness, although the concept is intuitively clear to most people. Nevertheless, it can be broadly defined as the attitude regarding the environmental consequences of human behavior (Ham et al., 2016). It is a part of social awareness concerning an aspect of an individual's system of values and beliefs, and the predisposition to confront environmental issues in a specific way (Ham et al., 2016).

The case of the concurrent cultivation of CT and environmental awareness in early childhood settings has recently been addressed, exploiting a novel programming schema of visual and text-based programming techniques (Kanaki & Kalogiannakis, 2022a, 2022b; Kanaki et al., 2022a, 2022b). We applaud this innovative idea of the contemporaneous development of 21st-century competencies, such as CT and environmental awareness, since they are necessary for the upcoming generation to confront current challenges. We endorse the cultivation of CT as a requisite set of skills in all facets of work and life (Wei et al., 2021), not in unilateral technical contexts, but in educational environments that encourage the cultural and aesthetic development of young students (Aryabkina et al., 2021). We support moving away from raising technocrats that are unenlightened of crucial global socio-environmental issues, with the main goal of improving humanity's attitude towards nature and, thus, preserving the future of the planet (Boluda et al., 2021). We focus on early childhood as a formative period of developing attitudes and establishing a connection to nature (Beery et al., 2020).

Triggered from the availability of contemporary teaching and learning contexts, such as robotics, that could serve the parallel enhancement of CT skills and the boosting of environmental awareness in early childhood education, we undertook a scoping review in order to bring out relevant educational approaches. More precisely, this research study aims to conduct a preliminary assessment of the potential size and scope of the available research literature (Grant & Booth, 2009). This way, we address state-of-the-art teaching and learning practices that support the novel idea of concurrently cultivating environmental awareness and CT in early childhood education, via a very promising, appealing, and engaging technological teaching and learning tool i.e., robotics. The findings about the body of evidence on this particular topic highlight the relevant research gap and indicate the emerging need of conducting pertinent empirical research (Grant & Booth, 2009). As far as the uniqueness of this study is concerned, it lies in the absence of scoping reviews on the subject under consideration.

Theoretical framework and relevant research fields

Researchers and scholars have already highlighted the many-faceted benefits of cultivating CT skills (Tzagkaraki et al., 2021), and developing environmental literacy (Ardoin & Bowers, 2020) in early childhood education. Capitalizing on young children's natural tendency to explore STEM challenges (Foti, 2021), developmentally appropriate STEM educational activities are employed in order to foster CT (Chevalier et al., 2020; Wang et al., 2022), and improve students' environmental awareness (Helvaci & Helvaci, 2019). Robotics, with its multi-disciplinary character, is considered a valuable tool in STEM education (Barker et al., 2012) that enhances CT skills (Chevalier et al., 2020), supports students to understand scientific and nonscientific disciplines (Khanlari, 2013), and develops mathematical literacy and social competences (Smyrnova-Trybulska et al., 2016).

Environmental education

In the Anthropocene epoch (Laurance, 2019), people exercise intense pressure against planetary boundaries in ways that could indelibly influence sustaining life on Earth (Ardoin et al., 2020). The cultivation and enhancement of developmental-friendly attitudes, values, knowledge, and skills are unidirectional and demand flourishing environmental education, preparing people to take informed and responsible actions to improve and protect the environment (Ardoin et al., 2020). Towards this end, environmental education addresses wicked problems (Lönngren & Van Poeck, 2021), such as climate change and biodiversity loss, focusing on cultivating prosocial and environmental norms, in order to establish environmental awareness, and develop action-related skills on meaningful issues, foregrounding attitudes, dispositions and behaviors at individual, societal and ecosystem level (Ardoin et al., 2020).

The verifiable advantages of providing infants and children with environmental education impelled researchers and practitioners to define early childhood as the starting point for developing environmental literacy (Ardoin & Bowers, 2020). Engaging young children in meaningful environmental learning experiences and applying effective play-based nature-rich pedagogical approaches cultivate ecologically literate individuals, and, at the same time, advocate their cognitive development, social and emotional development, social interaction, physical development, and language and literacy development (Ardoin & Bowers, 2020).

Computational thinking

In 2006, Wing defined CT as a process that encompasses providing solutions to problems posed, designing systems, and comprehending human behavior, based on the core concepts of informatics (Wing, 2006). In the modern digital era, CT is seen as a set of competencies that are essential for the productive citizenry (Hsu et al., 2018), as it is estimated that by the end of the century, it will have evolved into a fundamental set of skills, such as reading, writing, and arithmetic (Wing, 2006). At the same time, CT skills are critical for successfully operating in contemporary complex technology-driven societies (Kale et al., 2018). The undeniable impact that technology will have on the future of today's students arouses the interest in introducing CT as soon as possible in compulsory education in order to equip posterity with 21st-century skills and prepare it for a new reality regarding the job market (Kanaki & Kalogiannakis, 2022a, 2022b; Kanaki et al., 2022a, 2022b; Silva et al., 2021).

Until recently, CT skills were typically being cultivated in Computer Science contexts or via out-of-school activities (Lytle et al., 2019). Nevertheless, the multi-facet nature of CT transcends programming and computer science (Li et al., 2020), since it does not exclusively focus on creating future scientists or engineers. On the contrary, CT is a model of thinking that is important to every student (Li et al., 2020). It supports the development of a plethora of cognitive and intellectual skills, such as spatial ability, reasoning ability, problem-solving ability, and creative thinking (Román-González et al., 2017; Xu et al., 2022), facilitating people to deal with everyday problems (Kanaki & Kalogiannakis, 2022a, 2022b; Kanaki et al., 2022a, 2022b; Wei et al. 2021).

Nowadays, there is an emerging trend of integrating computing and, thus, CT into disciplinary education, especially in STEM fields (Lee et al., 2020; Li et al., 2020). Blending CT with creative STEM activities can empower students' STEM learning, because of the dominant role of computation in modern STEM disciplines (Wang et al., 2022). At the same time, infusing CT in STEM education might reduce potential inequities in terms of CT learning, since STEM courses are more widely offered and are more likely to be compulsory than computer science courses (Wang et al., 2022; Weintrop et al., 2014).

Robotics

The technological revolution remodeled the educational scene, and introduced modern learning opportunities, by employing state-of-the-art technological tools such as robots (García-Valcárcel-Muñoz-Repiso & Caballero-González, 2019; López-Belmonte et al., 2021). Nevertheless, the advent of technology in education is not a panacea. On the contrary, it has to be carefully infused in teaching and learning processes, towards their enhancement (López-Belmonte et al., 2021). Robotics is one of the most appealing and effective educational practices that is appearing at an increasing rate in modern curricula, especially in developed countries (López-Belmonte et al., 2021). Educational robotics exploit contemporary technology, achieving the cultivation of various cognitive skills, the comprehension of complex scientific concepts, the advancement of social and communication skills (Caballero-Gonzalez et al., 2019; Chaldi & Mantzanidou, 2021; Kubilinskienė et al., 2017), and the development of literacy and CT skills (Caballero-Gonzalez et al., 2019; Chaldi & Mantzanidou, 2021; Papadakis, 2020).

Educational robot kits have physical artifacts that make learning less abstract but more direct (Benitti, 2012; Eteokleous, 2019), and advocate the motivational aspect for children to engage with STEM activities, even from kindergarten (Sullivan & Bers, 2016). The integration of robotics in early childhood education takes advantage of the fact that, in this period, the generation of new ideas and the acquisition of knowledge are based mainly on experiences and concepts previously learned (García-Valcárcel-Muñoz-Repiso & Caballero-González, 2019). Hence, learning arises when children, employing information gathered with their senses, exchange ideas, test their limits, and obtain feedback. In these actions, imagination and creativity have a key role in producing new knowledge (Buitrago et al., 2017). However, the proper introduction of robotics is a complicated task that should be accompanied by developmentally appropriate techniques and approaches, that would capture the attention of preschoolers (Papadakis, 2020).

Early childhood education

Experiencing high-quality early childhood education and care has multiple benefits both at a personal and societal level. In fact, the years from birth to age five are considered a pivotal period for establishing the basis for thinking, behaving, and emotional well-being (Bakken et al., 2017). During these sensitive years, children develop linguistic, cognitive, social, emotional, and regulatory skills that predict their later functioning in many domains (Bakken et al., 2017; McCoy et al., 2017).

Early childhood education and care services need to be child-centered. Indeed, children learn best in engaging environments that are based on their participation and interest in learning. High-quality early learning settings follow children's interests, enhance their well-being and seek to meet the unique needs and potential of each individual child, including those with special needs or in a vulnerable or disadvantaged situation (The Council of the European Union, 2019).

Method

Scoping review design

The process and methodology adopted to conduct the present scoping review is the internationally recognized PRISMA model (Moher et al., 2009; PRISMA, 2023). The steps followed were (Kitchenham, 2004):

- Stating the research questions
- Searching on databases
- Specifying inclusion/exclusion criteria
- Selecting studies
- Extracting and analyzing data
- Summarizing and interpreting findings
- Writing the review report

Research questions

To examine the literature on the synergistic cultivation of CT and environmental awareness via robotics in early childhood education, we set up seven research questions (RQ), organized around three axes (Table 1):

(a) The conceptual framework toward the synergistic cultivation of CT and environmental awareness via robotics in early childhood education (RQ1, RQ2).

(b) The documentary framework i.e., the research methodologies employed, the sample size used, the publication details, and the active countries in conducting relevant research (RQ3, RQ4, RQ5).

(c) The pedagogical framework i.e., the areas of knowledge, the grade levels involved, and the didactic tools employed (RQ6, RQ7).

Concepts employed in searching on databases

The databases searched were Science Direct, Eric, Wiley Online Library, SpringerLink, Sage Journals, Taylor & Francis Online, and JSTOR. We also searched Google Scholar, as the currently most comprehensive academic search engine (Gusenbauer, 2019).

The core search terms used were: (a) Computational thinking, (b) Environmental awareness, (c) Robotics, and (d) Early childhood education. In order to maximize the amount of information gathered when conducting the present scoping review (Cronin et al., 2008), we identified alternative search terms from the database thesaurus, constructing four search terms sets (Table 2), that correspond to each one of the core search terms. The four search terms sets were included in the final search string. The search terms within each set were separated by the operator "OR" and the four search term sets were combined using the operator "AND" (Cronin et al., 2008).

The search string we ended up with was: "computational thinking" AND ("robotics" OR "robotic") AND ("early childhood education" OR "preschool education" OR "nursery

Table 1. Research questions

Scope	Research Questions
Conceptual Framework	RQ1. What are the main axes of the research studies used in the current scoping review?
	RQ2. What is the conceptual framework for the cultivation of environmental awareness?
Documentary Framework	RQ3. What are the research methodologies and sample sizes used?
	RQ4. Where and when were the items published?
	RQ5. What are the most active countries in conducting relevant research?
Pedagogical Framework	RQ6. What are the grade levels and areas of knowledge involved?
	RQ7. What are the didactic tools employed?

Table 2. Core concepts and synonyms – relevant terms

Core concepts	Synonyms – Relevant terms
Computational thinking	-
Robotics	robotic
Early childhood education	early childhood education, preschool education, nursery school education, infant school education, preprimary education, primary education
Environmental awareness	environmental awareness, environmental problems, environmental challenges, environmental concerns, environmental issues, environmentally conscious, environmentally aware, environmentally responsible, ecological challenges, ecological issues, ecological problems, going green, green issues

school education" OR "infant school education" OR "preprimary education" OR "primary education") AND ("environmental awareness" OR "environmental problems" OR "environmental challenges" OR "environmental concerns" OR "environmental issues" OR "environmentally conscious" OR "environmentally aware" OR "environmentally responsible" OR "ecological challenges" OR "ecological issues" OR "ecological problems" OR "going green" OR "green issues").

In the case of Science Direct and JSTOR, which have restrictions in the Boolean connectors (max 8), and the number of characters in the search string (200 characters max), we ended up with the search string: "computational thinking" AND "robotics" AND ("early childhood education" OR "preschool education" OR "primary education") AND ("environmental awareness" OR "ecological challenges").

In the case of Google Scholar, which has a 256-character limit for searches, we conducted three search rounds. The first search was conducted with the search string: ”computational thinking" AND ("robotics" OR "robotic") AND ("early childhood education" OR "preschool education") AND ("environmental awareness" OR "environmental challenges" OR "ecological challenges " OR "green issues"). The second search was conducted with the search string: "computational thinking" AND ("robotics" OR "robotic") AND ("early childhood education" OR "preschool education") AND ("environmental problems" OR "environmental concerns" OR "environmental issues" OR "environmentally responsible"). The search string of the third search was: "computational thinking" AND ("robotics" OR "robotic") AND ("early childhood education" OR "preschool education" OR "primary education") AND ("environmentally conscious" OR "environmentally aware" OR "ecological issues" OR "ecological problems" OR "going green").

Inclusion and exclusion criteria

We searched for studies without setting time criteria, since the concurrent cultivation of CT skills and environmental awareness is a novel area of research interest (Kanaki & Kalogiannakis, 2022a, 2022b; Kanaki et al., 2022a, 2022b), and, thus, it was expected that a manageable amount of articles would emerge. Besides this, we adopted the following inclusion and exclusion criteria:

Inclusion criteria

1.The study was conducted in early childhood educational settings.
2.The study was related to cultivating and/or assessing CT skills.
3.The study was related to cultivating and/or assessing environmental awareness.
4.Robotics tools and educational techniques were exploited.
5.The article was a peer-reviewed or a conference paper.

Exclusion criteria

1.The study was not written in English.
2.The study was listed in another database.
3.The study was only published as an abstract.

Review process

The outcome of the initial search in all databases was 89 findings (Table 3). Following the PRISMA review process, we excluded 10 records in the identification stage, and 66 records in the screening stage for the reasons listed in Figure 1. The remaining 13 articles were thoroughly reviewed regarding their research objectives and the educational tools/approaches employed. Each author studied the articles separately and the information gathered was compared and discussed.

Extracting and analyzing data

In order to provide validity and credibility to the data extracted in the context of the present scoping review, the investigator triangulation process was adopted, according to which the authors documented their observations and conclusions (Carter et al., 2014). At first, a thorough review and analysis of the trends of the relevant studies, theories, methodologies, and purposes were conducted. Thence, to ensure the convergence and verification of the findings, we proceeded to document analysis, completing the triangulation process (Bowen, 2009).

In line with the research questions of the study, the attributes coded and analyzed were:

Table 3. The outcomes of the search in all databases

Databases	Records
Google scholar	84
Wiley	4
SpringerLink	-
Sage Journals	-
Taylor and Francis Online	1
Eric	-
JSTOR	-
ScienceDirect	-

a)The main axes of the objectives of the research studies used in the current scoping review.
b)The conceptual approach to cultivating environmental awareness.
c)The research methodology (qualitative, quantitative, or mixed methodology).
d)The sample size.
e)The year of publication.
f)The journal/proceedings in which the studies were published.
g)The areas of knowledge.
h)The grade levels.
i)The didactic tools.

Findings

In Table 4, we provide evidence regarding the conceptual framework of the articles included in the scoping review, documenting if its main axes are included in each one of them. Thus, we answer the RQ1 for the dataset reviewed.

Maintaining the enumeration of the articles in Table 4, in order to answer RQ2, we list the conceptual approach to cultivating environmental awareness for each study (Table 5).

Answering the research questions RQ3, RQ4, and RQ5, Table 6 provides evidence regarding the documentary framework of the articles reviewed i.e., the research methodologies employed, the sample size of the participants, the year of publication, the journal/proceedings in which the study was published, and the county in which each study was conducted.

In Table 7, we provide evidence regarding the pedagogical framework of the articles reviewed, answering the research questions RQ6 and RQ7, the areas of knowledge employed, the grade levels involved, and the didactic tools employed.

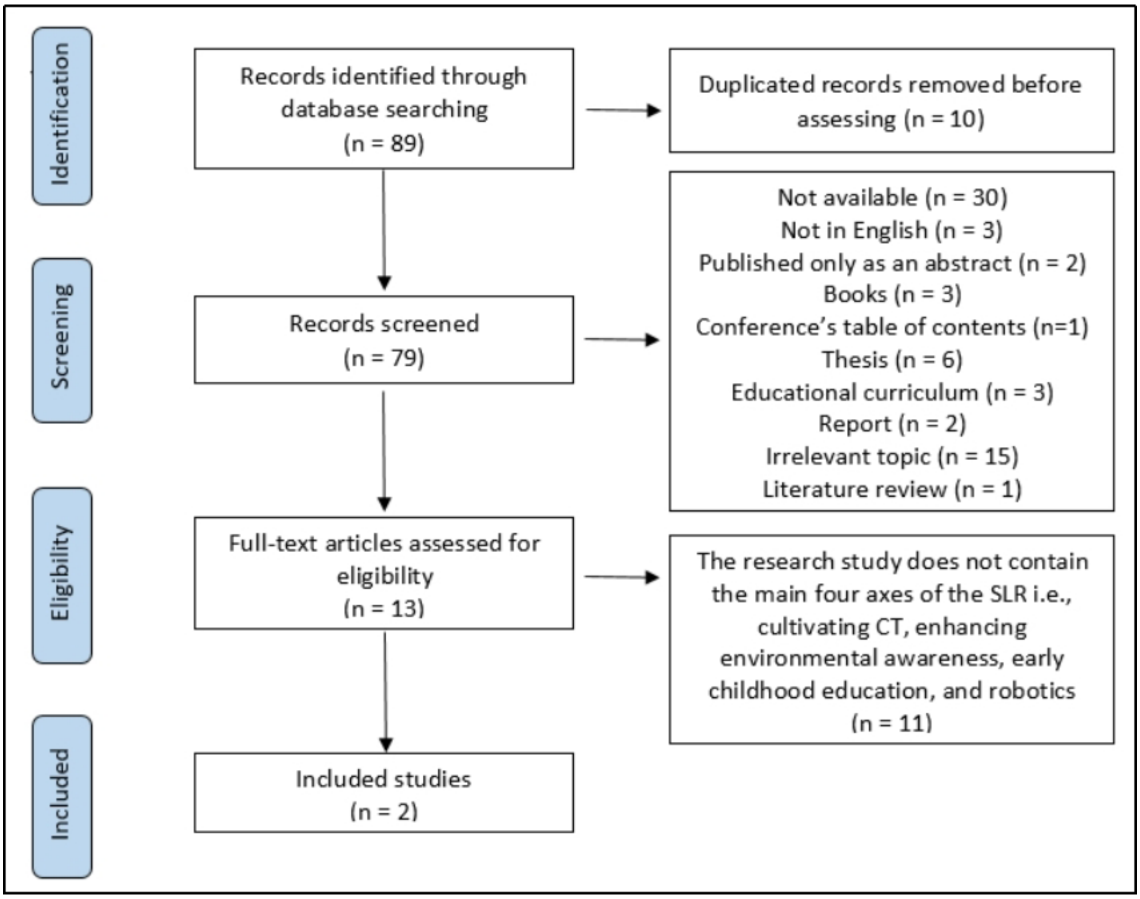

Figure 1. PRISMA review process

Table 4. The conceptual framework of the articles included in the present scoping review

No	Authors	CT skills	Environmental awareness	Robotics	Early childhood education
1.	Silvis et al., 2022	✓	✓	✓	✓
2.	Tan-a-ram et al., 2022	✓	✓	✓	✓

Table 5. The conceptual approach to cultivating environmental awareness

No	The conceptual framework for cultivating environmental awareness
1.	Establishing responsibility for technologies and cultivating a technological ethic of care
2.	Implementing dust monitoring device exploiting KidBright's Internet of Things capabilities

Table 6. The documentary framework of the articles included in the present scoping

No	Research methodology	Sample size	Year of publication	Journal -proceedings	Country
1.	Qualitative	84 children	2022	International Journal of Child-Computer Interaction	Intermountain West region of the US.
2.	-	-	2022	Sustainability	Thailand

Table 7. The pedagogical framework of the articles included in the present scoping review

No	Disciplines	Grade levels	Didactic tools
1.	Coding	Kindergarten	1. Cubetto 2. Several thematic mats, including an ‘‘outer space’’ theme and a ‘‘city’’ theme, as well as the basic mat that comes equipped with the robot, which has grid squares depicting a cactus, a boat, a castle, and a tree, as well as solid color and patterned squares that become the context for Cubetto's adventures.
2.	Coding	Elementary school, High school	KidBright

Discussion

Studying the results of the present scoping review, we realize that the field of the parallel cultivation of CT skills and environmental awareness via robotics in early childhood education is underinvestigated. Moreover, both articles that provide evidence of relevant studies were published in 2022, signifying the novelty of the field.

Silvis et al. (2022) presented a study that was implemented in the context of an early childhood coding curriculum designed to support CT in kindergarten, and, at the same time, establish forms of responsibility for technology. Towards this end, they exploited a robot called Cubetto, aiming at developing a notion of a technological ethic of care, located in children's early coding experiences. The qualitative research methodology was adopted, and, thus, no assessment tools were employed in order to measure the cultivation of CT skills and the advancement of children's technological ethic of care.

Elaborating further on the study of Silvis et al. (2022), we should mention that although the technological ethic of care is not directly related to environmental awareness, since these concepts are distinct in their focus, they overlap and intersect in certain contexts. An ethic of care exists wherever humans' actions denote caring for their objects and environments, fostering their maintenance (Puig de la Bellacasa, 2017). Embracing care and maintenance for computer technologies in early learning settings is of the essence in today's complicated socio-ecological contexts, since it assists in bridging frameworks for child–computer interactions with perspectives on nature-culture relations (Bers, 2020; Silvis et al., 2022). Silvis et al. (2022) examined how children cared for materials like coding robots since keeping technologies in working order pertains to cultivating a "maintenance mindset" (Vinsel & Russell, 2020), and forms a social structure between children and the material world in which they live (Denis & Pontille, 2015).

Tan-a-ram et al. (2022) presented the use and design of KidBright and demonstrated its effectiveness in the context of software and hardware through empirical investigations. In the abstract, they mentioned that "coding is regarded as a gateway to computational thinking". Nevertheless, no evidence was provided about the cultivation of CT skills via educational activities that exploited KidBright. Furthermore, no evidence was provided regarding the achievement of environmental awareness via the activity they proposed i.e., the construction of the dust-monitoring device. Finally, no information was available regarding the sample size of the participants or their age. Tan-a-ram et al. (2022) reported the suitability of KidBright for elementary and high school students, although they were not specific regarding the age of the target group of the activities recorded in the article. Nevertheless, from 2018 to 2020, the KidBright team distributed 200,000 KidBright boards to more than 3200 elementary and high schools in Thailand and supported relevant educational activities, within the context of the Coding at School project (Tan-a-ram et al., 2022). Since the first and second grade of elementary education is included in early childhood education, and Tan-a-ram et al. (2022) did not provide evidence that they excluded these grades from their target group, we assume that KidBright was used in early childhood settings in order to promote coding education.

An important issue that has to be discussed regarding the study of Tan-a-ram et al. (2022) is that the authors did not explicitly mention the role of KidBright activities in cultivating environmental awareness. However, they claimed that the firmware and the hardware extension paradigm of KidBright promote the concept of sustainability, while the KidBright software framework supports open-source and sustainability goals. At this point, it has to be clarified that the word sustainability refers to the utilization of resources in a way that will not cause their depletion (Cogut et al., 2019). Individuals that adopt the culture of sustainability are aware of major environmental (and social/economic) challenges, are behaving in sustainable ways, and are committed to a sustainable lifestyle for both the present and future (Marans et al., 2015, p. 170). Thus, sustainability and environmental awareness are distinct, but overlapping concepts in specific contexts.

Limitations and foresight

A restriction of this study is the limited access to the articles resulting from the research in the selected databases. Another limitation is that the databases searched were only Science Direct, Eric, Wiley Online Library, SpringerLink, Sage Journals, Taylor & Francis Online, and JSTOR. Finally, only articles and conference papers were reviewed. Thus, books, theses, etc., were excluded from the reviewing process.

As far as our next research steps, we have already designed a research study that remains to be implemented, exploiting educational robotics in order to enhance environmental awareness and CT skills in early childhood settings.

Conclusions

In early childhood education, learning occurs when children, using information captured by their senses, share ideas, test their limits and receive feedback. In these actions, imagination and creativity play an important role in the production of new knowledge (García-Valcárcel-Muñoz-Repiso & Caballero-González, 2019). In this context, robotics is an excellent way to motivate learning (Witt & Kimple, 2008) and promote fundamental 21-st century skills, such as CT (Caballero-Gonzalez et al., 2019; Papadakis, 2020) and environmental awareness (Teixeira et al., 2018).

Orienting education toward environmental awareness and sustainability cultivates individual and collective environmental and health consciousness (Cruz et al., 2021). Towards this end, Next Generation Science Standards (NGSS) have already set out several environmental issues, such as the role of water in earth's surface processes, human impacts on earth systems, and global climate change, as disciplinary core ideas of science. NGSS also include the influence of engineering, technology and science on society, and the natural world in the list of proposed crosscutting concepts (Next Generation Science Standards, 2023). Since high-quality early childhood education and care lays the foundations for later success in life in terms of education, well-being, employability, and social integration (European Commission), it is important to cultivate young students' 21-century skills as soon as possible.

The present scoping review regarding the parallel cultivation of CT skills and environmental awareness via robotics in early childhood education was conducted in order to assess the extent of the available evidence and to highlight potential research gaps. Indeed, it revealed that this particular topic remains underinvestigated, although the importance of the acquisition of these skills is well-documented, as well as the educational effectiveness of robotics.

Conflict of interest

The authors declare no conflict of interest.

Authors' contribution

Both authors contributed equally to this scoping review.

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