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Nota introdutória

O Simpósio Internacional de Informática Educativa (SIIE) é um fórum internacional para a apresentação e discussão dos mais recentes avanços na investigação sobre tecnologias educativas e a sua aplicação prática em processos educativos. Também visa reunir investigadores, representantes institucionais e docentes para partilharem perspetivas, conhecimentos e experiências.

A 25.ª edição do Simpósio teve como foco sistemas, plataformas, pedagogias e educação baseada na prática em e-learning e b-learning, incluindo o uso de simuladores, sistemas de realidade aumentada, sistemas de realidade virtual e laboratórios virtuais, bem como pensamento computacional, programação e robótica educativa.

EDUCATIONAL ROBOTICS AND PROGRAMMING IN INCLUSIVE EDUCATIONAL SETTINGS: A SCOPING REVIEW

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***Abstract*—This article presents a map of studies on the educational potential of robotics and programming in inclusive settings. The scoping review methodology was used based on the procedures recommended by the Joanna Briggs Institute. This method was chosen because of the need to examine and map the main trends in the work done with robotics and programming in educational contexts for children with special needs. Our concern was to search for emerging scientific evidence on the educational potential of robotics and programming in inclusive contexts. Searches were conducted in the Scopus, Web of Science, and Eric databases between 2015 and 2022. The analysis identified five research papers that met the inclusion and exclusion criteria. The results show little abundance of studies in this area, which justifies the scoping methodology. The selected studies show a prevalent trend toward the inclusion of educational robotics and not so much programming. They reveal that the use of robotics and/or programming is a pedagogical strategy that promotes greater interaction, participation, and motivation in children, as well as greater socialization. The relevance of the theme and its complexity highlight the need for further research on this subject.**

Keywords— educational robotics, coding, inclusion

I. INTRODUCTION

Since the ratification of the Salamanca agreement in 1994 [1], schools have been concerned with implementing inclusive approaches that promote the success of all students through differentiated strategies and adaptations or curricular and environmental interventions, whenever necessary [2], [3]. The inclusion of children with diverse pathologies in regular education leads us to reflect on appropriate strategies to contribute to their inclusion in the groups or classes where they are inserted and in society in general. For modern education systems and their respective societies, equality and inclusion are unavoidable imperatives. In fact, in some countries, such as Finland, the term "students with inclusion needs" is not used since all students are included, seeking to develop their potential [4]. Portugal, in terms of legislation, also follows this logic [5].

The emergence of the competence school, driven by some countries and international organizations such as the European Union, UNESCO, and the OECD, has led to the creation of digital competence benchmarks for teachers. In these references, it has become increasingly evident that areas, dimensions, or domains that include the description of necessary competencies for teachers within the scope of educational inclusion have been created. More recent benchmarks, such as that of Quebec, even include a specific dimension of digital competencies for inclusion and special needs [6].

In an ever-changing digital society, education faces the challenge of educating for an uncertain world without leaving anyone behind. That is, all students must develop their cognitive potential, aiming for integration in an increasingly technological society, where the use of emerging digital tools becomes more and more relevant. In fact, educational robotics and programming are inseparable when trying to develop computational thinking skills at an early age. At these ages, robotics can have an advantage by making programming more tangible, while block programming becomes more abstract at the initiation stage of computational thinking [7].

In this school context, several studies argue that educational robotics, due to its characteristics, promotes the inclusion of all, including students with special needs [7]– [10]. Robotics is part of the technological tools available for the development of digital and cognitive skills necessary to live today, and children should start developing them from an early age [11], [12].

Numerous investigations have demonstrated the educational potential of educational robotics integrated with the classroom curriculum [13]–[15] and its potential as a tool for promoting successful curricular inclusion of children with specific needs. Robots are tangible objects that promote the participation and interaction of these children during curricular activities with peers who do not have inclusive needs [16].

Activities with robots involve learning to program, modifying toys, and adding robotic parts, sensors, lights of various colors, or small mechanized movements to them so that they can stimulate and interact with children. Robotics is considered a fruitful re-source in promoting inclusive education in the educational field, not only in social development situations but also as a promoter of cognitive or motor evolution of the children who explore it [9], [17], [18]. Moreover, when programming the robot's movement, students will think about the orientation of the instructions to be given, and consequently, they will need to define laterality and spatial orientation in the movement it must go through to reach its destination, generalizing these skills in everyday life situations. Spatial orientation is not an innate ability. Its structuring is a composition and a mental construction that takes place through movements in relation to objects in the environment, and robotics can be a powerful tool in this learning. By establishing sequences of actions, students are also developing abstraction, as the robot's actions are idealized prior to the action [8].

In turn, it should be recognized that programming is fundamental to supporting activities that can be developed with the help of robots. Moreover, block programming has emerged as a resource to promote cognitive skills in early childhood in a playful way. There are several tools that can be explored at this age, such as ScratchJr (https://www.scratchjr.org) and CODE.org (https://code.org/). These tools are available free of charge for teachers and parents. There are several studies and projects that demonstrate the benefits of programming at these ages in relation to the development of laterality, sequencing, abstraction, communication, and digital literacy. Among these works, we can highlight Bers and Resnick [19], Bers [20], [21], Miranda-Pinto and Osório [22], among others.

In view of these findings, we designed this research based on the scoping literature review methodology with the aim of analyzing an emerging but still little explored field of studies on the use of programming and educational robotics with children with inclusion needs at preschool age and in basic education (1st to 4th grade). Based on this methodology, we sought to examine and map how many and what research studies are on this theme, offering an overview of the literature and the evidence produced in these studies. To this end, we looked for research that could present the educational potentialities of robotics and programming in inclusion contexts. Studies addressing the potential of programming and robotics to provide meaningful learning for children and young people that will enable them to develop the necessary skills required by today's society [11], [12], [23], [24] have given rise to numerous investigations within inclusive education sup-ported by digital technologies. However, these studies do not seem to provide a solid body of information when addressing early childhood inclusion.

Recognition of the importance of digital technologies in promoting skills in children with inclusion needs goes back some time. For Sheehy and Green [25], Encarnação et al. [18], Ferm, Claesson, Ottesjö and Ericsson [16], Marcão [10], González-González [17], the important thing is to find ways to help these children experience motor experiences, the development of communication skills, manipulation, exploration, and the use of instruments to act on objects and people, promoting cognitive and perceptual development. Carmo [26] is another author who also highlights the need to use technologies that support the interaction, communication, and learning achievement of children with inclusion needs in conjunction with peers without inclusive needs. With the emergence of the computational thinking movement, programming and educational robotics have gained great momentum as support technologies for skill development in school settings. In the literature, we find many studies that have emerged in this area and that demonstrate their importance in the cognitive development of children. What is lacking, however, are more specific studies that demonstrate the pedagogical value of these emerging technologies in inclusive educational settings.

Based on this evidence, we believe that the school environment can promote ideal scenarios for an effective integration of educational robotics and programming through pedagogical strategies and approaches. School classrooms integrate children and young people with different inclusion needs into their classes, and they can equally enjoy the cognitive potential that these technologies can develop. The mapping of studies in inclusive settings for early childhood thus seems to us of extreme relevance.

II. Materials and Methods

We adopted for this study the scoping literature review methodology. According to Pham et al. [27], the purpose of a scoping review is to provide a map or overview of the literature on a topic without the need to perform an extensive data review. For Armstrong, Hall, Doyle and Waters [28], the scoping review can serve to explore the scope of literature in a particular field without describing the findings in detail and to identify the appropriate parameters of a review. Scoping reviews share with systematic reviews their rigor and the use of transparent methods to identify and analyze the relevant aspects of the literature in relation to a topic of interest [27], [28].

The scoping review adopted was based on the model generated by the Joanna Briggs Institute [29], as we considered it to be the most appropriate for the study in question, the aim of which was to examine the extent, scope, and nature of the use of robotics and programming in inclusive educational settings, without intending to describe research findings in detail but rather to map out areas of study where it is difficult to visualize the range of information that may be available and to identify research gaps in this area.

According to Arksey and O'Malley [30], identifying research gaps in a particular area allows one to draw conclusions about the overall state of the literature in that area. However, identifying gaps in the literature through a scoping review will not necessarily identify a lack of research quality since quality assessment is not part of this type of review.

A. Research Sources

The search terms were identified from scientific articles in Portuguese, English, and Spanish using Boolean operators in databases to review the literature. The selected sources were Scopus, Web of Science, and Eric, given their significance in the field of educational research. The search was restricted to the years 2015 to 2022. The descriptors used were (i)

inclusion AND *robotic* AND *education*; (ii) *code* AND *"inclusive education*.

B. Inclusion criteria

The inclusion criteria used in the research are specified in Table 1.

TABLE I. Inclusion criteria

Inclusion Criteria's	
Publishing years	Articles included in the period 2015–2022
Document type	Research and open and commercial access papers are included; the topic of the paper encompasses the objectives of the review.
Topic	The topic of the document refers to robotics and/or coding in inclusive educational settings.
Population	Articles in which the research covers a population between 5 and 10 years old.
Resource	The use of robotics and/or coding as educational resources is a cornerstone of the research.

C. Proceeding

The review is composed of different phases until reaching the result. Initially, 137 documents were identified that matched the established search criteria. Next, duplicate articles (87) were excluded due to their inclusion in the different databases consulted. We discarded 43 articles that, in an initial review, did not mention the use of robotics and/or coding with children with inclusive needs or because the topic was not related to the education of children between 5 and 10 years old, leaving a total of 44. We set out to read the resulting 44 articles and obtained the exclusion of 39 papers that presented studies on different inclusive contexts, such as socioeconomic exclusion, gender discrimination, teacher training courses for the use of robotics resources, and the use of coding for the development of computational thinking in schools, without addressing with specificity children with specific inclusion needs. After this analysis, only 5 articles remained that met the inclusion criteria and the objectives of this study.

Fig. 1 presents the diagram created according to the PRISMA model, in which one can see the process followed in the search, selection, and refinement of the articles found [31].

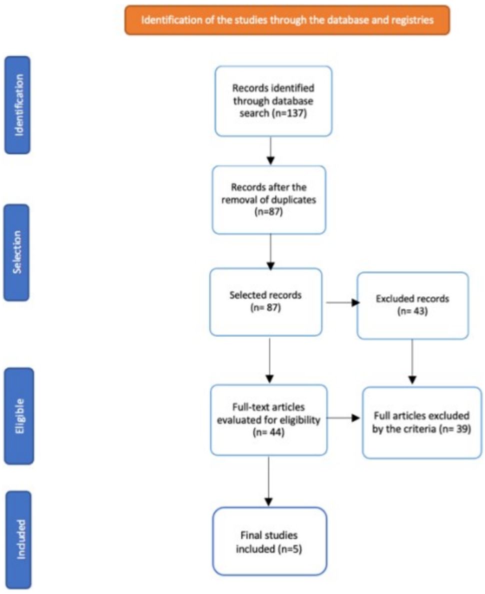

Fig. 1. Research process diagram created according to the PRISMA model[30].

III. Results

According to the results meeting the inclusion criteria, a table was drawn up for data analysis based on the following criteria: (i) year of publication; (ii) context of the studies; (iii) research methodology; (iv) resources used (robotics and/or programming/coding); (v) inclusion educational needs.

A. *Years of publication of the selected studies*

Table 2 shows the 5 selected sample articles, ordered chronologically. This research was conducted between March and June 2022, and may include articles published after this period that were not included in this study.

TABLE II. Identification of articles by year of publication.

Year of publication	*Reference*	*n*
2015	[2]	(n = 1)
2018	[3]	(n = 1)
2019	[4]	(n = 1)
2021	[1,5]	(n = 2)

B. *Contexts of the selected studies*

The studies were conducted in four different contexts. Fig. 2 presents the context, specifically the environments in which the selected studies took place.

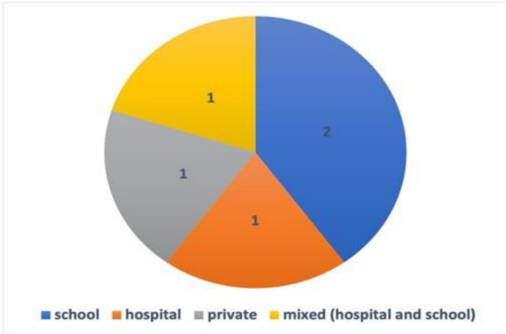

Fig. 2. Study environments.

C. *Research Methodology*

Regarding the methodological approach adopted in the studies, it was found that a mixed methodology prevails, with analysis of both qualitative and quantitative data (n=5), and action research or experimental research and observation were also adopted in 3 of these studies.

D. *Resources*

The use of educational robotics is addressed in most of the selected studies (n=4), and only one study presents the use of coding as a strategy for inclusive education. Table 3 shows the resources used in the selected studies.

TABLE III. Identification of the resources used

Study	*Resource*	*Brand*
[1]	coding	programming platforms
[2]	robot	Lego® Mindstorms® NXT® e EV3®, Lego® WeDo®
[3]	robot	Bee-bot®
[4]	coding and robot	Scratch e Makeblock®
[5]	robot	Lego Wedo 2.0®

E. *Population and Specific Inclusion Needs*

The analysis resulted in studies with different inclusion needs and educational approaches for teaching programming and robotics. Fig. 3 presents these special needs.

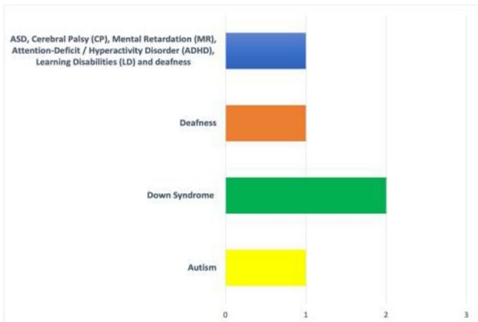

Fig. 3. Different inclusion needs presented in the studies.

IV. Discussion

According to the inclusion criteria, the selected articles had to present studies carried out in educational contexts with a population between 5 and 10 years old and with some specific inclusion needs. Based on criterion (i) publication year, it was found that the year 2021 had the highest number of publications (n = 2), while the previous year's 2015, 2018, and 2019 had only one publication each, which met our objective. Furthermore, it was observed that there were no research publications in 2016 and 2017, according to the criteria and objectives of this study.

Regarding the context, specifically the environments in which the studies were conducted, criterion (ii), it was found that two were carried out in primary schools or educational centers, one was conducted in a health setting, specifically a "hospital laboratory," one was conducted in a private setting, in a parish hall, and another was developed in two environments: educational centers and hospital classrooms.

The methodology, criterion (iii), used in all five studies was mixed methods, with the analysis of qualitative and quantitative data. It was also found that three studies adopted, in addition to mixed methods, action research, experimental research, and observation. These studies were funded by financial foundations.

The most common resource in the analyzed studies, criterion (iv), was educational robotics, with the aim of developing musical skills, computational thinking, motor skills, the Portuguese language, mathematics, cognition, and socialization.

According to criterion (v), the data revealed that studies seeking to meet the specific needs of children with Down syndrome, Autism spectrum disorder (ASD), Cerebral Palsy (CP), Mental Retardation (MR), Attention-Deficit/Hyperactivity Disorder (ADHD), Learning Disabilities (LD), and deafness were prevalent.

In Table 4, we present, in a summarized form, the factors expressed in the research: educational robotics and programming to meet specific needs in inclusive contexts. Note that the table does not seek to establish any relationship between the selected samples but rather illustrates the results in an orderly manner in the analyzed documents.

TABLE IV. CATEGORIZATION OF RESULTS

Population	***Special needs***	***Resource***	***Skills***
8 to 9 years old	Autism	Lego Wedo 2.0®	socialization
5 to 8 years old	Down syndrome	Robot Bee-bot®	cognitive functions and visuospatial memory
4 to 6 years old	Down syndrome	Coding (programming platforms)	computational thinking
5 to 10 years old	Deafness	Scratch e Makeblock®	musical
7 to 10 years old	ASD, CP, MR, ADHD, LD and deafness	Lego® Mindstorms®	Motor skills, Portuguese language, and mathematics

A factor of interest, present in most studies (n = 4), is the proposal of teacher training for the effective use of programming and robotics resources in inclusion contexts. This may be because these samples are studies of action research or experimental research in which the researchers were trainers of teacher training actions. In general, the selected samples present the results of educational actions with children with diverse inclusive needs, presenting activities carried out with robots or programming for the development of skills that promote greater inclusion and socialization of these children in diverse contexts.

The selected studies show a prevalent trend toward the inclusion of educational robotics rather than graphic programming on the screen. The investigations have a mixed nature and address different inclusion needs. The achieved results reveal that the use of robotics and/or programming is a pedagogical strategy that promotes greater interaction, participation, and motivation in children, as well as greater socialization with peers without specific inclusion needs.

V. Conclusions

This paper aims to examine and map the characteristics of studies on the educational potential of robotics and coding in inclusive settings in preschool and basic education. The scoping review methodology is based on the procedures recommended by the Joanna Briggs Institute [29] and aims to examine and map the main concepts and work carried out with robotics and coding in educational contexts with children with specific inclusion needs. The search for data was conducted on the Scopus, Web of Science, and ERIC databases for works published between 2015 and 2022. The review reveals that the topic of inclusion, despite occupying a prominent place in today's digital society, still lacks many studies within the scope of children with specific needs in school settings. This finding is reinforced by the small number of studies found in the accessed databases (n=5) that met the inclusion criteria and objectives of this research.

The theoretical approaches adopted in the studies mainly refer to the educational potential of programming and robotics to provide meaningful learning for children and young people to develop the necessary skills of today's society [11], [12], [24]. All these studies present a theoretical approach to pedagogical strategies that make students active subjects throughout the teaching and learning process, promoting meaningful learning that is constructed by the subject.

The most prevalent technological resource is educational robotics. This may be due to the interaction of children with the robot, which is a tangible and concrete resource compared to programming, which is not tangible and becomes more abstract. However, when we talk about educational activities with robots, coding is intrinsically involved since the robots' movements are the result of programming codes, that is, of coding, whether computer programs or integrated through buttons or commands in the robot itself.

The analyzed studies were conducted in various contexts, with only one study taking place in a private environment within a religious educational institution. Most studies were conducted in school and hospital environments, with an audience between 5 and 10 years old with specific inclusive needs. This suggests a growing interest in inclusive education, which aims to provide equal access to all children attending the early years of basic education (1st to 5th grades). Across all contexts, the studies emphasized the im portance of training education professionals to effectively integrate robotics and coding activities in educational and inclusive contexts.

There was a prevalence of studies that aimed to address the educational needs of children with Down syndrome, autism spectrum disorder (ASD), cerebral palsy (CP), mental retardation (MR), attention deficit/hyperactivity disorder (ADHD), learning disabilities (LD), and deafness. The studies focused on developing various skills, including musical, computational thinking, motor, language, mathematical, cognitive, and socialization skills.

The integration of educational robotics and coding in an inclusive way presents many challenges, particularly in matching the children's ages, curriculum, and developmental areas that are intended to be worked on. The results of this review indicate a scarcity of studies on the use of robotics and programming as educational resources for children with inclusion needs. The relevance of the topic and its complexity highlight the need for further research to fill this gap and enhance early intervention pedagogical practices supported by educational robotics and programming.

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