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A Bibliometric Analysis of Early Childhood Education Studies on the Theme of Robotic Coding from a Developmental Perspective

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This research aims to analyze the studies scanned in the Web of Sciences (WOS) database on robotic coding for early childhood from a developmental perspective. The method of the research is bibliometric research from qualitative research designs. In this context, 70 academic publications scanned in the WOS database within the framework of the criteria determined by the researchers and dealing with robotic coding in early childhood constitute the research data sources. According to the obtained findings, 45 studies were carried out as quantitative, 11 as qualitative, 11 as mixed design, and three as design-based research. The results revealed that the activities carried out with robotic coding contribute to children's cognitive, language and socio-emotional development, as well as their computational thinking skills, collaborative working skills, analytical thinking skills, problem-solving skills and mathematics skills. On the other hand, adverse effects such as children's technology literacy and teachers' inadequacies in using robotic coding tools were also observed.

Keywords: Early childhood education, robotic coding, child development learning skills.

INTRODUCTION

As in every education period, modern technologies have started to be used effectively in early childhood education. Especially when the attractive, charming, motivating and intriguing features of technology are integrated into the educational process in a qualified way, it can offer the opportunity to effectively support all areas of development of the child. Many academic studies coincide with these results (Bird & Edwards, 2015; Blackwell et al, 2014; Burris, 2019; Can-Yaşar et al., 2012; Chrystalla, 2005; Donohue, & Schomburg, 2014; Fenty et al., 2014; Fox-Turnbull, 2019; Gibbons, 2010; Gimbert & Cristol, 2004; Ihmeideh, 2009; Jack & Higgins, 2019; Keengwe & Onchwari, 2009; Kermani & Aldemir, 2015; Lyons & Tredwell, 2015; Meadow, 2004; Ogegbo & Adebunmi, 2020; Ood et al., 2008; Palaiologou, 2016; Rasalingam et al., 2014; Romeo et al., 2003; Undheim, 2022; Wang & Hoot, 2006; Wang et al., 2010; Zabatiero et al., 2018). It can be considered that the children who comprehend the basic logic of software with coding activities designed by their age and developmental level will be successful in this field by developing these gains in the future. When children's learning paradigms are considered, technological tools are very effective as materials that will increase the child's desire and motivation in a rich stimulating environment, which is one of the main factors that improve learning (Nugroho et al., 2022). In this regard, the tools for robotic coding used in this context create learning environments that increase the child's motivation, increase inspiration, support collaborative work with the peer group and support socio-emotional development in this respect (Bers et al., 2014). It can also be anticipated that the results that children receive from robotic coding will reinforce their learning and contribute to more permanent education.

Today, there are sets by different manufacturers such as LEGO, Cubetto, Bee-Bot, Kibo, Dash and Dot, and Ozobot Bit that can be used in robotic coding teaching for children in early childhood. It can be stated that these sets used in teaching robotics and coding in early childhood have easy-to-use and understandable features, together with user-friendly design features and have a user-friendly design for children. In addition, it is possible to carry out computer-free teaching activities with the sets used in teaching robotics and coding in early childhood.

It can be put forward that these sets, designed to enable children to learn basic coding and robotics skills in a fun way, will positively affect children's motivation with their user-friendly designs, block-based programming tools and colorful visuals. While teaching children essential coding concepts, these sets can also contribute to developing motor skills, hand-eye coordination and problem-solving skills. Through teaching activities planned for robotic coding and group projects and games that encourage cooperation and creativity, children can develop their discovery and creativity skills in a fun way. With these standard features, these sets can provide an interactive, game-based and learning-supportive learning environment (Dorouka et al., 2022; Kewalramani et al., 2021; Yang et al., 2022).

On the other hand, it may not be straightforward to understand and apply coding concepts if the teaching activities planned in the teaching processes of robotic coding sets in early childhood are inappropriate for children's developmental levels (Bers et al., 2014). Since robotic coding activities involve the use of technology, the excessive use of technology may cause children to develop addiction and increase screen time. Therefore, adopting a balanced approach and allocating time for other games and activities is significant. The high cost of these robotic coding sets may create accessibility problems for educational institutions. Moreover, the fact

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that teachers have some deficiencies in using these tools can be regarded another negative situation in terms of use.

Thanks to the eclectic nature of the early childhood education program in our country (TEGM, 2013), it can be predicted that materials and activities for robotic coding will make contribution when designed on the basis of the age and developmental level and implemented to achieve the outcomes.

It can be stated that the use of robotic coding in teaching processes in early childhood may have positive or negative contributions to various developmental areas of children. In order to determine what these effects are, it is necessary to examine the findings of the studies on this subject in the literature. In this study, it was aimed to examine the studies scanned in the Web of Science (WOS) on the theme of robotic coding for early childhood from a developmental perspective.

METHOD

Research Model

This research is a qualitative study designed in a descriptive survey model. It aims to determine the current situation by examining the academic research on robotic coding in early childhood education in the WOS database regarding bibliometric indicators. The descriptive survey is expressed as a research model aiming to describe a past or ongoing situation as it exists. In this research approach; the situation, person, event or object that is the subject of the research is examined in its conditions without the aim of affecting them (Karasar, 2023).

Within the scope of the study, while searching the WOS database, "robotic in early childhood" and "robotic in preschool" keywords were used and bibliometric characteristics of the studies were determined. Bibliometrics is a method used for statistical and mathematical analysis and evaluation of scientific articles and books, and with this analysis method, academic studies can be investigated in line with specific parameters with statistical and mathematical analyses (Bozok et al., 2017; Fahimnia, 2015; Huang et al., 2006). In addition, the data such as the type of studies, year of publication, countries of publication, methods and research scope were also included in the analysis.

Data Sources

Bibliometric data were taken from the WOS database produced by Clarivate Analytics. WOS is the world's leading scientific citation search and analytical information platform. It offers a research tool that supports a wide range of scientific functions in various fields of knowledge and a data set for large-scale data-intensive studies (Li et al., 2018). The data sources of the research consist of articles and papers on robotic coding in early childhood education scanned in the Web of Sciences (WOS) database produced by Clarivate Analytics on 25.04.2023. In the database search, the analysis did not include academic genres such as books and book chapters related to the subject area. The analysis was carried out through articles and papers. Since the first academic study was published in the database in 2006, 2006 was considered as the starting date. In this context, a total of 349 academic studies were reached. From these studies, the publications with the exact duplicate from different keywords, the publications related to educational robots, the publications with literature reviews, the publications with publication reviews, the publications with book chapters, the publications with notes to the editor and 279 publications that could not be accessed in full-text content were removed from the study materials and 70 publications were analyzed. Information about the study materials is given in Table 1.

Table 1. Characteristics of the Data Sources

Data Sources	Variables	*f*
Genre	Article	51
	Paper	19
Year of Publication	2006	1
	2009	1
	2013	4
	2014	2
	2015	3
	2016	4
	2017	8
	2018	5
	2019	11
	2020	6
	2021	6
	2022	13
	2023	6
Country of Publication	Spain	15
	USA	14
	Türkiye	7
	South Korea	4
	People's Republic of China	4
	Greece	3
	Italy	2
	Costa Rica	2
	Portugal	2
	Uruguay	2
	Israel	2
	Malaysia	2
	Australia	1
	Iran	1
	Indonesia	1
	UK	1
	Sweden	1
	Switzerland	1
	Japan	1
	Lithuania	1
	Panama	1
	Peru	1
	Russian Federation	1
Research Method	Quantitative	45
	Qualitative	11
	Mixed	11
	Design Based Research	3
	Total	70

Data Analysis

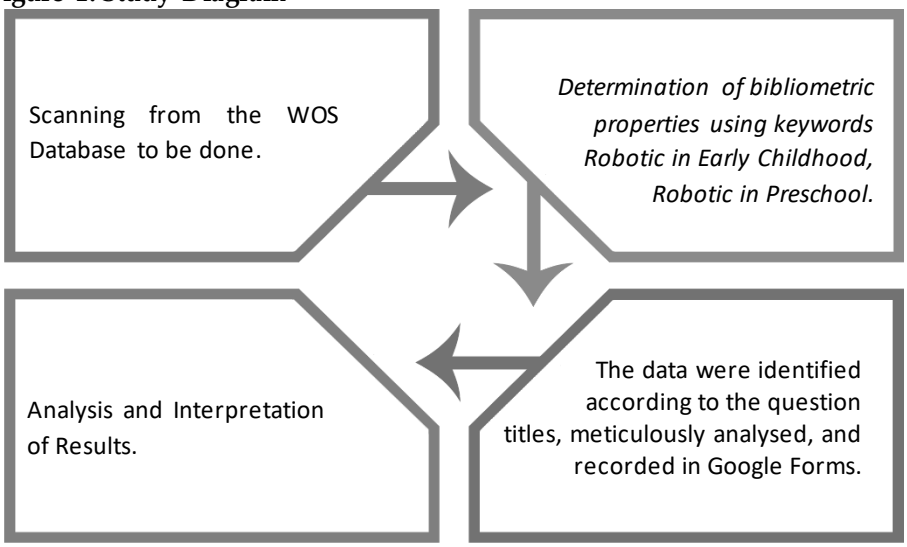
Bibliometrics was used as a data analysis method in the research. Bibliometrics is a numerical analysis method that enables the application of mathematical and statistical methods to books and other communication tools (Pritchard, 1969).

In the analysis of the data, the following questions were investigated; (a) How many academic studies are there in the WOS database with the keywords "robotics in early childhood" and "robotics in preschool"? (b) In

which years were the academic studies conducted? (c) In which countries were the academic studies conducted? (d) Which method was used in the academic studies? (e) What is the scope of the academic studies? (f) What are the positive findings of the academic studies on child development? (g) What are the negative findings of the academic studies?

In this context, the academic studies constituting the study material were meticulously examined within the framework of these titles, and the data were recorded on Google Forms. The diagram indicating the study process is given in Figure 1.

Figure 1. Study Diagram



FINDINGS

In this section, the findings of the study are presented. The findings regarding the data on the contribution of robotic coding activities to children's cognitive development are given in Table 2.

Table 2. Distribution of the Data on the Contribution of Robotic Coding Activities to Children's Cognitive Development

Codes	*f*
Supporting learning processes	62
Developing problem solving skills	19
Supporting concept development	13
Developing computational thinking skills	13
Developing math's skills	12
Developing analytical thinking skills	11
Developing creative thinking skills	9
Improving attention and motivation	7
Making learning fun	5
Developing mental skills	5
Enriching the learning environment	4
Making learning permanent	3
Contributing to the learning of children with special needs	3
Supporting prior learning	2
Learning by doing and experiencing	1
Total	**169**

When Table 2 was analyzed, it was detected that robotic coding activities supported learning processes (62), improved problem-solving skills (19), supported concept development and computational thinking skills (13), mathematics (12) and analytical thinking skills (11), and improved creative thinking skills (9). In addition, 30 of them were found to support other cognitive areas. The data on the contribution of robotic coding activities to children's language development are given in Table 3.

Table 3. Distribution of the Data on the Contribution of Robotic Coding Activities to Children's Language Development

Codes	*f*
Supporting listening and speaking skills	18
Supporting the receiving language	7
Supporting literacy skills	3
Total	**28**

The findings in Table 3 reveal that the studies on robotic coding support listening and speaking skills (18), receptive language (7) and literacy skills (3). The data on the contribution of robotic coding activities to children's socio-emotional development are given in Table 4.

Table 4. Distribution of the Data on the Contribution of Robotic Coding Activities to Children's Socio-Emotional Development

Codes	*f*
Development of social skills	12
Supporting cooperative learning	10
Self-confidence development	7
Developing a sense of responsibility	3
Development of self-regulation skills	2
Total	**34**

When the data on the contribution to children's socio-emotional development in Table 4 were analyzed, it was concluded that it supported the development of children's social skills (12), supported cooperative learning (10), contributed to the development of self-confidence (7), contributed to the development of a sense of responsibility (3) and improved self-regulation skills (2). The data on the contribution of robotic coding activities to children's psychomotor development are demonstrated in Table 5.

Table 5. Distribution of the Data on the Contribution of Robotic Coding Activities to Children's Psychomotor Developmentc

Codes	*f*
Development of object control skills	10
Other	7
Total	**17**

When the contribution of the robotic coding activities given in Table 5 to children's psychomotor development was examined, it was concluded that they supported the development of object control skills (10) and other (7) psychomotor development areas. The data on the contribution of robotic coding activities to children's technology literacy are presented in Table 6.

Table 6. Distribution of the Data on the Contribution of Robotic Coding Activities to Children's Technology Literacy

Codes	*f*
Supporting the ability to use technology	11
Supporting robotics technical skills	4
Supporting programming skills	3
Total	**18**

Table 6 provides the data on the contribution of robotic coding activities to children's technology literacy. According to these results, it was uncovered that robotic coding activities supported children's technology usage skills (11), robotic technical skills (4) and program skills (3). The data on the negative effects of robotic coding activities are given in Table 7.

Table 7. Distribution of the Data on the Negative Effects of Robotic Coding Activities

Codes	*f*
Negative impact on language development in young age groups	2
Material deficiencies	1
Suitability for education and training	1
Teacher deficiencies	1
Total	**5**

When the data in the Table 7 regarding the negative effects of robotic coding activities were analyzed, it was detected that there were negative effects on language development in young age groups (2), negativities due to material inadequacies (1), negativities due to the lack of appropriate selection for education (1) and negativities due to teacher inadequacies.

CONCLUSION, DISCUSSION and SUGGESTIONS

Today, the rapid development of information and communication technologies causes transformation in many areas. As a natural consequence of this transformation, it is possible to state that there is a change and transformation in the skills sought in human resources. One of the essential functions of formal education institutions is to prepare learners for higher education institutions and to ensure that they continue their education with the knowledge, skills and attitudes expected by higher education institutions. On the other hand, considering the skills required in today's qualified human resources, it is possible to advocate that the skills such as computational thinking, cooperation, problem-solving, analytical thinking and communication come to the fore. In this context, it can be noted that it is of great importance for learners to have learning activities and learning experiences that allow them to discover and develop these skills at an early age. The fact that 42 of the 70 studies analyzed within the scope of the research were conducted in the last five years is a finding which reveals that the interest in teaching activities involving robotic coding in early childhood has gradually increased.

On the other hand, it is among the findings that most of the analyzed studies were conducted by authors in Spain. It is explicit that the number of studies conducted in Turkey is moderate. Still, considering the importance of technology-based materials and robotic coding in the educational process today, it can be evaluated that the number of publications is low. It can be assessed that it is important to increase the research based on robotic coding, especially in early childhood, to reveal its positive effects on the education process and enable it to be integrated into education in a qualified way. In this context, many studies reveal the positive contributions of robotic coding to early childhood education and child development (Bati, 2022; Bers et al., 2019; Bers, 2019; Kalyenci et al., 2022; Kewalramani et al., 2021a; Kewalramani et al., 2021b; Lee, 2020; Macrides et al., 2022; Papadakis, 2020; Su & Jang, 2023; Sullivan & Bers, 2018; Turan & Aydoğdu, 2020; Yang et al., 2022; Zviel-Girshin et al., 2020).

The results obtained from the findings of the studies reveal that the teaching activities involving robotic coding in early childhood positively contribute to many developmental areas of children in the fields of cognitive, language, socio-affective, psychomotor and technology literacy. The environments with rich stimuli support all children's developmental areas, especially learning processes. It is the nature of education that learning does not occur independently from the environment, and learning environments by children's age and developmental levels positively affect their cognitive development. Robotic coding supports children's learning processes, enriches the learning environment, makes learning permanent, and provides positive contributions to increase attention. Motivation reveals the potential of robotic coding activities to give children a rich learning experience in teaching activities to be carried out in early childhood.

On the other side, it is also among the significant results obtained in the present research that it positively contributes to children's problem-solving, computational thinking, analytical thinking, and mathematical skills in cognitive development. In addition to increasing children's mental abilities and contributing to their academic success, these skills are the competencies that will contribute to children's ability to solve the problems they will encounter throughout their lives more effectively. Robotic coding activities also positively affect children's learning processes. Many academic studies reveal this result (Bati, 2022; Bers et al., 2014; Brainin et al., 2022; Canbeldek & Işıkoğlu, 2023; Çiftçi & Bildiren, 2020; Kazakoff et al., 2013; Martinez et al., 2015; Metin, 2022; Nam et al., 2019; Strawhacker and Bers., 2019).

The examined studies display that robotic coding teaching activities in early childhood support children's listening and speaking skills in other developmental areas, develop social skills and support collaborative learning, improve object control skills and provide positive contributions to technology use skills. All these findings indicate that the inclusion of robotic coding in teaching activities in early childhood has the potential to contribute to children's development significantly.

However, including robotic coding teaching activities in the teaching environment requires schools which have robotic coding teaching sets and teachers who have the knowledge and skills to use these sets. It should also be noted that the positive contributions expected from the planned robotic coding teaching activities are directly proportional to the appropriateness of the planned teaching activity to children's developmental levels. Providing the convenient infrastructure for robotic coding teaching activities in preschool education institutions in Türkiye, eliminating the knowledge and skill deficiencies of teachers on this subject, and enriching the teaching activities in the curriculum with robotic coding have the potential to make significant contributions to the development of children in this early period.

As a limitation of this study, it can be clearly expressed that the study was carried out only by examining the studies scanned in WOS. Examining the studies in other databases and comparing them with the findings obtained in this study will contribute to the literature. Last but not least, other academic studies that reveal the effects of technological tools on early childhood in terms of both software and hardware can also be considered as a research topic.

Declarations

Conflict of Interest

No potential conflicts of interest were disclosed by the author(s) with respect to the research, authorship, or publication of this article.

Ethics Approval

The formal ethics approval was granted by the Social and Human Sciences Research and Publication Ethics Committee of Inonu University. We conducted the study in accordance with the Helsinki Declaration in 1975.

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Research and Publication Ethics Statement

A Systematic Review is an analysis that incorporates assessments based on data from earlier studies. In this regard, the ethics committee's consent is not required.

Contribution Rates of Authors to the Article

1st author contributed 50%, 2nd author 50%.

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