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EĞİTSEL ROBOTİK ALANINDAKİ GÜNCEL ÇALIŞMALARIN EĞİLİMLERİ: BİR İÇERİK ANALİZİ

TRENDS IN CURRENT STUDIES ON EDUCATIONAL ROBOTICS: A CONTENT ANALYSIS

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ÖZ: Bu çalışma, eğitsel robotik alanındaki son yıllardaki eğilimleri incelemeyi hedeflemiştir. Doküman incelemesi yöntemi kullanılarak eğitsel robotik alanında yayımlanan 100 makalenin içerik analizi yapılmıştır. Makaleler, yöntem, örneklem özellikleri, kullanılan robotik araçlar, ele alınan konular ve bulgular açısından analiz edilmiştir. Araştırma sonuçlarına göre, Lego Mindstorms, Arduino, Python ve Scratch en yaygın kullanılan robotik araçlar olarak öne çıkmaktadır. Çalışmalarda öğrencilerin en çok yer aldığı ve özellikle üniversite ve ortaokul düzeyinde yapılan çalışmaların baskın olduğu gözlenmiştir. Nicel çalışmalarda ölçek ve anket, nitel çalışmalarda ise görüşme ve gözlem formu en sık kullanılan ölçme araçlarıdır. Bilgi işlemsel düşünme, problem çözme, yaratıcılık, akademik başarı, iş birliği ve motivasyon en çok incelenen değişkenler arasında yer almaktadır. Eğitsel robotiğin olumlu etkileri ve diğer alanlara entegrasyonunun önemi vurgulanmış, ancak eğitmenlerin bilgi ve deneyim eksikliği, altyapı ve teknik sorunlar, uygulamadaki zorluklar dezavantaj olarak belirtilmiştir.

Anahtar sözcükler: Eğitsel robotik, İçerik analizi, Robotik araçlar

ABSTRACT: This study aims to analyze the general trends in educational robotics in recent years. The document analysis method was preferred in this research. Accordingly, the content of 100 articles published in the field of educational robotics in recent years was analyzed in terms of methodology, sample characteristics, robotic tools used, commonly covered topics, and findings. The study revealed that Lego Mindstorms, Arduino, Python, and Scratch are the most commonly used robotic tools in educational robotics. It was observed that students predominantly participated in the studies, with a focus on university and middle school levels. Moreover, the analysis indicated that quantitative studies mostly employed scales and questionnaires, whereas qualitative studies frequently used interviews and observation forms as measurement tools. The most frequently examined variables in these studies were computational thinking, problem-solving, creativity, academic achievement, collaboration, and motivation. While the findings generally emphasized the positive effects of educational robotics and its significance for integration into other domains, the challenges of educators' knowledge and experience in robotics, infrastructure and technical issues, and difficulties in practical implementation were also identified as disadvantages.

Keywords: Content analysis, Educational robotics, Robotic tools

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INTRODUCTION

Technological developments are directly or indirectly involved in every aspect of our lives and many areas benefit from these developments. One of the areas where the possibilities of technology are used is undoubtedly the field of education. The utilization of various technological devices and resources has transformed the application of educational activities, moving away from a singular approach of knowledge transfer by the teacher (Biletska et al., 2021). The use of technology in education can be enhanced through a variety of approaches or methods and robotics is one of the applications that has become widespread in recent years within the scope of integrating technology into education (Yang, Long, Sun, Aalst & Cheng, 2020). The use of robotic applications in learning environments has led to the use of the term "educational robotics". Educational robotics has become an important pedagogical resource for K-12 STEM education (Anwar, Bascou, Menekse & Kardgar 2019).

Educational robotics refers to the use of robots as a tool for teaching and learning in educational environments. It involves integrating robotic technology and concepts into the curriculum and educational activities to enhance students' learning experiences (Mikropoulos and Bellou, 2013). Educational robotics offers various alternatives, including coding, computer programming, Lego-based designs, and non-coding applications (Karypi, 2018). In other words, educational robots can take different forms, ranging from simple programmable toys for young children to more advanced robots that allow programming and customization (Hamilton et al., 2020). They can be utilized in various subjects such as mathematics, science, engineering, and technology, as well as in extracurricular activities such as robotics competitions (Ospennikova et al., 2015).

Educational robotics aims to provide a learning experience that supports the development of various skills. Some of these experiences and skills include: 1) Encouraging STEM education to enhance students' knowledge and skills in science, technology, engineering, and mathematics (Aris and Orcos, 2019). 2) Promoting problem-solving skills by presenting real-life problems that require critical and creative thinking (Adams et al., 2010).3) Encouraging creativity and innovation by motivating students to design and construct robots capable of performing various tasks (Çakır et al., 2021). 4) Fostering collaboration and teamwork by helping students develop communication, leadership, and social skills (Ioannou and Makridou, 2018). 5) Focusing on technical skills, educational robotics applications aim to enhance students' programming, circuit design, and mechanical engineering skills, aligning with their future career goals in STEM fields (You et al., 2021).6) Boosting students' confidence and motivation is another objective of educational robotics. Successfully designing and programming a robot allows students to develop self-confidence in their abilities and motivates them to learn new problem-solving strategies (Erol, 2020).

In addition to the objectives of educational robotics, the benefits it provides are frequently highlighted in research findings. Relevant studies demonstrate that educational robotics has a positive impact on students' learning outcomes and the development of skills in various areas, making it an effective tool for promoting STEM education and preparing students for careers in STEM fields (Khanlari, 2013). Educational robotics offers numerous contributions and advantages for individuals. It contributes to the development of cognitive skills such as problem-solving, computational thinking, innovation propensity, creativity, and critical thinking (Şişman and Küçük, 2019; Tzagkaraki et al., 2021). Students can utilize their creativity and imagination in designing and building robots capable of performing various tasks (Hou et al., 2022). Additionally, educational robotics provides students with the opportunity to enhance their psychomotor and technical skills necessary in STEM fields (Chang and Chen, 2022). Educational robotics often involves teamwork and collaboration, allowing individuals to improve their social skills (Kandlhofer and Steinbauer, 2016). Furthermore, as students gain experience and develop an understanding of technology-related applications, their interest in STEM fields tends to increase (Tekbıyık et al., 2022). Finally, students' self-efficacy also improves when they realize their capabilities in performing robotics applications (Fridberg et al., 2023).

Considering the benefits of educational robotics for individuals and its increasing prevalence in recent years, the outcomes of research in this field are considered significant. Understanding the effectiveness of educational robotics, its outcomes, and the emerging trends in this area are crucial in assessing the successful integration of technology in education. Therefore, examining the studies conducted in this field provides an overview of the reflection, role, usage, and effects of educational robotics in education. Content analysis is one of the commonly used techniques to conduct this literature review. Content analysis involves the systematic examination and interpretation of the content of academic studies or other written texts (Mayring, 2004). This method helps identify and categorize patterns, themes, and trends in the literature (Riffe et al., 2019).

Systematic review and content analysis studies have been conducted in the field of educational robotics. Table 1 presents a summary of the previous years' reviews of the studies on educational robotics.

Table 1

Reviews on educational robotics studies

Author(s), Year	Scope/Focus
Seckin-Kapucu, 2023	Robotics education in Science education
Güneş and Küçük, 2022	The integration of ER into the curriculum, ER tools, the need for STEM-based robotics courses
Atman-Uslu, 2022	The trends and gaps of ER experimental studies
Yumbul and Bayraktar, 2022	The effects of ER in primary education levels
Tselegkaridis and Sapounidis, 2022	STEM and robotics education in primary schools
Mohana et al., 2022	Artificial intelligence and robots usage in early childhood
Camargo et al., 2021	Realistic simulator applications in the context of ER
Zhang et al., 2021	The effect of ER on K-12 students' STEM attitudes and computational thinking
Pederson et al., 2021	Fostering girls' interest in STEM through ER
Yılmaz-İnce, 2020	The development of ER in Turkey
Zhong et al., 2020	The role of ER in Mathematics education
Çetin and Demircan, 2020	The empowerment of STEM education through robots
Anwar et al., 2019	General benefits and outcomes of ER
Souza et al., 2018	Lego use in education
Kubilinskiene et al., 2017	The role of ER in teaching and learning
Seckin-Kapucu, 2023	Robotics education in Science education
Güneş and Küçük, 2022	The integration of ER into the curriculum, ER tools, the need for STEM-based robotics courses

There are some reviews that focus exclusively on postgraduate theses (Güneş & Küçük, 2022), whereas others emphasize studies that were conducted in specific databases and areas (Dağlı et al., 2022). Therefore, it is believed that conducting more comprehensive reviews would be beneficial. Educational robotics, or in other words, the use of robotics in education, is a developing field where new trends emerge. Consequently, this study can shed light on how the recent developments and emerging trends in the field have changed and what the differences are compared to the past. Thus, it is expected that this study will provide researchers in the field with insights into the emerging trends in educational robotics. For these reasons, the aim of this study is to analyze the trends, findings, and objectives of studies conducted in the field of educational robotics in recent years. This way, a general overview of the current literature regarding studies conducted in recent years can be established. In line with these objectives, the sub-research questions posed for the relevant studies are as follows:

1. What is the distribution by publication year?
2. Which robotic tools have been used?
3. What are the characteristics of the samples?
4. What methods and designs have been employed?
5. How was the data analysis conducted?
6. What topics have been investigated in the studies?
7. What are the findings of the studies?

METHOD

In the study, content analysis, which is a qualitative research technique, was chosen. Based on certain criteria, studies regarding educational robotics were analyzed within the scope of the research.

Scanning and including criteria

The following criteria were used to include studies in the analysis of educational robotics:

Including criteria:

1. The studies must be published as articles.
2. The articles should be in English.
3. The relevant articles should have the terms "robot", "educational robotics", or "robotic tools" in their titles.
4. The relevant articles must be published between 2020 and 2023.
5. The full texts of the relevant articles should be openly accessible.
6. The articles should be indexed in Google Scholar (The reason for its selection is that it contains articles with more citations).

A total of 304 articles were accessed during the initial screening. However, in order to fully meet the relevant criteria, a second screening was conducted, and 100 articles were included in the content analysis process. The PRISMA literature process, depicted in Figure 1, was utilized during this process.

Exclusion criteria:

1. The articles that do not follow the article format have been excluded.
2. The articles that are not written in the English language have been excluded.
3. The articles that do not contain the words "robot", "educational robotics", or "robotic tools" have been excluded.
4. Articles dated before 2020 have been excluded. Considering the goal of identifying trends in recent years within the studies, the studies conducted before the year 2020 has been excluded.
5. The articles for which the full text is not openly accessible have been excluded.
6. The articles that are not accessible on Google Scholar have been excluded. The criterion was established due to Google Scholar's inclusion of articles from various databases.

Data collection and analysis

Google Scholar, ERIC, and Science Direct databases were searched using the keyword "educational robotics" to access relevant articles. After retrieving the papers, they were subjected to the process of PRISMA literature review. The PRISMA process includes stages of identification, scanning, convenience, and inclusion (Stovold et al., 2014). The accessed articles were selected according to the relevant criteria, and necessary eliminations were made during the second scanning process. In total, 100 articles were included in the content analysis process. Content analysis is an analytical technique used as a research method. This technique is utilized to enhance the understanding and description of a phenomenon. Depending on the research objectives, a specific dataset is examined, and the data is condensed and categorized (Stemler, 2015).

Content analysis involves examining, categorizing, and interpreting data. Researchers can use an impressionistic, intuitive, and interpretive approach during the data analysis process. This allows researchers to interpret the data based on their own experiences, instincts, and interpretations (Elo & Kyngäs, 2008). The answers to the research questions posed for the investigation of the relevant studies are typically expressed descriptively. This describes the statistical distribution of the data using frequencies or percentages. Based on this information, codes and categories are created during the analysis process to facilitate a more systematic analysis and interpretation of the data (Hsieh & Shannon, 2005).

Validity and reliability

The validity of the research is related to the appropriateness of the steps followed in the research to the research purpose and its credibility (Guba, 1981). Therefore, attention was paid to ensuring that the process followed in this research is suitable for the research purpose. Additionally, the data of the research were coded individually by the authors, and the percentage of agreement for the codes and categories was calculated using the formula provided by Miles and Huberman (2015). According to this formula, the reliability coefficient is calculated as: (Reliability = consensus / consensus + disagreement X 100) %96. Hence, it can be seen that the study is reliable.

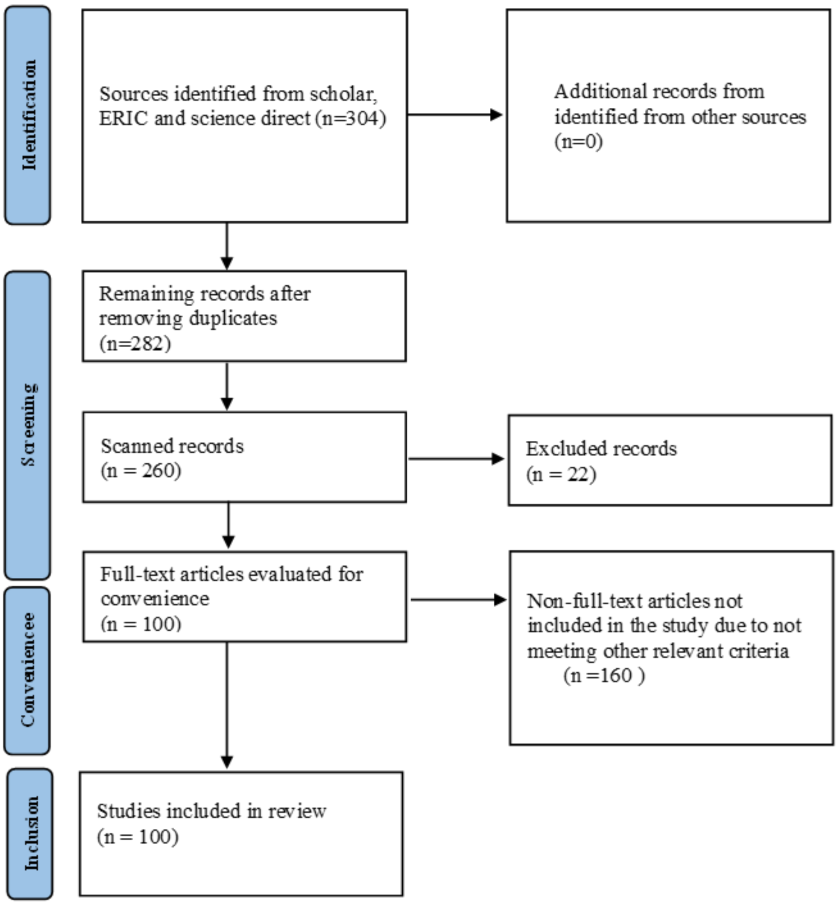

Figure 1. PRISMA flow diagram

FINDINGS

The codes and categories of the data from the examined articles have been presented through tables displaying frequency and percentage values.

Table 2

Distribution of studies by year

Year	f	%
2023	15	15
2022	35	35
2021	28	28
2020	22	22
Total	100	100

Table 2 presents the distribution of the examined articles by publication year. According to Table 1, the percentage of articles published in 2023 is 15%. The percentage of articles published in 2022 is 35%, while the percentage of articles published in 2021 is 28%. Articles published in 2020 account for 22% of the total.

Table 3

Distribution of studies by robotic tools

Category	Code	f	%
Robotic tools	Lego Mindstorms	32	32
	Arduino	27	27
	Python	17	17
	Scratch	13	13
	Lego We Do	4	4
	BeeBot	2	2
	Lego Robolab	2	2
	Tangible K	2	2
	Fisher technique	1	1
Total		100	100

Table 3 presents the distribution of the examined articles according to the robotic tools used. The most frequently used robotic tool among the examined articles is Lego Mindstorms, accounting for 32% of the total. Following that, Arduino is the second most used tool with a percentage of 27%. The third highest percentage belongs to Python, with 17%. Scratch has a usage rate of 13%. Additionally, Lego We Do has a 4% usage rate, while BeeBot, Lego Robolab, and Tangible K each have 2% usage rates. The Fisher technique was utilized in only one of the examined articles (1%).

Table 4

Distribution of studies by sample characteristics

Sample Type	f	%
Student	77	77
Teacher	18	18
Document	5	5
Total	100	100
Sample grade	f	%
Elementary school	6	6.31
Middle school	30	31.57
High school	24	25.26
University	35	36.84
Total	95	100

Table 4 presents the distribution of the relevant studies based on the characteristics of the samples. The most commonly used sample type is students, accounting for 77% of the relevant samples, while teachers make up 18% and documents constitute 5% of the samples. The majority of the studies, with a percentage of 36.84%, were conducted at the university level. This is followed by middle school studies, accounting for 31.57%. The percentage of studies conducted at the high school level is 25.26%, while elementary school studies make up 6.31%.

Table 5

Distribution of Studies by research method

Category	Code	f	%
Quantitative	Experimental	38	38
	Survey	17	17
Qualitative	Case study	20	20
	Document analysis	5	5
Mixed	Convergent design	7	7
	Concurrent design	5	5
	Explanatory design	3	3
	Not specified	5	5
Total		100	100

Table 5 displays the distribution of studies based on the research method. In 55% of the studies, a quantitative research type was preferred. Experimental research accounted for 38% of the studies, while 17% were conducted as surveys. Qualitative research type was employed in 25% of the studies. Among the studies analyzed, a case study was preferred by 20%, and document analysis was utilized in 5% of the studies. Mixed methods were employed in 20% of the studies. Furthermore, a convergent design was preferred by 7% of the studies, a concurrent design was employed in 5% of the studies, and an explanatory design was chosen by 3% of the studies.

Table 6

Distribution of studies by data collection tool

Category	Code	f	%
Quantitative	Scale	31	25.83
	Questionnaire	23	19.16
	Achievement test	9	7.5
	Multiple choice test	6	5
	Performance test	4	3.3
	Rubric	2	1.66
Qualitative	Interview form	30	25
	Observation form	10	8.33
	Open-ended assessment form	5	4.17
Total		120	100

Table 6 presents the distribution of the relevant studies according to the measurement tools used. In the quantitative category, the scale is the most frequently used measurement tool, accounting for 25.83% of the studies. Following that, in the qualitative category, the interview form is the second most used tool, comprising 25% of the studies. In the quantitative category, the questionnaire ranks third (19.16%). This is followed by the observation form (8.33%). The usage rate of achievement tests is 7.5%.

Table 7

Distribution of studies by the investigated topic

Category	Code	f	%
Cognitive	Computational thinking	21	14.48
	Problem solving	10	6.90
	Creativity	9	6.21
	Academic achievement	9	6.21
	Metacognition	3	2.07
	STEM skills	3	2.07
	Transferring	2	1.38
	Pedagogical skills	2	1.38
	Reflective thinking	1	0.69
	Spatial skills	1	0.69
	Critical thinking	1	0.69
	Learning ability	1	0.69
	Life skills	1	0.69
	Technological thinking	1	0.69
	Technological literacy	1	0.69
	Conceptual knowledge level	1	0.69
Affective	Collaboration	13	8.97
	Motivation	10	6.90
	Social relationships	4	2.76
	Perspective	4	2.76
	Interest in STEM	3	2.07
	Self-confidence	1	0.69
	Interest in robotics	1	0.69
	Robotics perception	1	0.69

	Interest in engineering	1	0.69
	Enhancing the inclusion	1	0.69
	Self-efficacy	1	0.69
	Perseverance	1	0.69
	Leadership	1	0.69
	Adoption	1	0.69
Integration	STEM integration	2	1.38
	Mathematics integration	1	0.69
	Artificial intelligence integration	1	0.69
	Project based learning integration	1	0.69
	Curriculum integration	1	0.69
Disseminating impact	Robotics course for teachers	3	2.07
	Design and dissemination	3	2.07
	Application in students with special needs	2	1.38
	Perspective of gender	2	1.38
	Application at schools	2	1.38
Other	View	4	2.76
	Experience	5	3.45
	Content analysis	5	3.45
	Needs analysis	1	0.69
	Scale development	1	0.69
	Examination of the robotics kits	1	0.69
Total		145	100

Table 7 consists of the categories of cognitive, affective, integration, disseminating impact, and other. In table 6, it can be observed that the most frequently addressed topic or variable in the studies is computational thinking (14.148%). This is followed by collaboration in the affective category (8.97%). With a percentage of 6.90 each, problem-solving in the cognitive category and motivation in the affective category rank third. The rate of creativity and academic achievement in the cognitive category was 6.21%, and the rate of content analysis and experience in the category of other is 3.45%. While the rate of view in the category of other is 2.76%, the rate of robotics courses for teachers and design and dissemination in the category of disseminating impact is 2.07%. In the integration category, the rate of STEM integration is 1.38%.

Table 8

Distribution of studies by the findings

Category	Code	f	%
Positive/Significant result	Computational thinking	20	13.16
	Problem solving	8	5.26
	Creativity	8	5.26
	Academic achievement	5	3.29
	Metacognition	3	1.97
	STEM skills	3	1.97
	Transferring	2	1.32
	Pedagogical skills	2	1.32
	Reflective thinking	1	0.66
	Spatial skills	1	0.66
	Critical thinking	1	0.66

	Learning ability	1	0.66
	Life skills	1	0.66
	Technological thinking	1	0.66
	Technological literacy	1	0.66
	Conceptual knowledge level	1	0.66
	Collaboration	11	7.24
	Motivation	8	5.26
	Social relationships	3	1.97
	Perspective	4	2.63
	Interest in STEM	3	1.97
	Self-confidence	1	0.66
	Interest in robotics	1	0.66
	Robotics perception	1	0.66
	Interest in engineering	1	0.66
	Enhancing the inclusion	1	0.66
	Self-efficacy	1	0.66
	Perseverance	1	0.66
	Leadership	1	0.66
	Adoption	1	0.66
Insignificant result	Academic achievement	4	2.63
	Problem solving	2	1.32
	Creativity	1	0.66
	Computational thinking	1	0.66
	Social relationships	1	0.66
	Motivation	2	1.32
	Collaboration	2	1.32
Negative sides	Technical issues	16	10.53
	The lackness in experience	7	4.61
	Difficulty in application	3	1.97
	Financial issues	3	1.97
	Difficulty working in groups	1	0.66
Integration	The importance of integration	6	3.95
	The efficiency of the integration	4	2.63
Total		152	100

Table 8 consists of the categories positive/significant result, insignificant result, negative sides, and integration. The code with the highest overall percentage, 13.6%, belongs to the category of positive/significant result, and it is computational thinking. This code indicates a significant increase in computational thinking. Additionally, in the same category, problem solving and creativity codes (f=8) show a higher significant increase compared to insignificant results. The percentage of insignificant result for problem solving is 1.32%, while creativity is 0.66%. Furthermore, the significant increase rates for collaboration and motivation are 7.24% and 5.26%, respectively. In category of the insignificant result, the code with the highest percentage is academic achievement (2.63%). Among the codes in the category of the negative sides, technical issues (10.53%) and the lack of experiences (4.61%) have relatively higher percentages. The codes in the category of integration are the importance of integration (3.95%) and the efficiency of integration (2.63%). These codes pertain to the integration of robotics education with other domains or the curriculum.

CONCLUSION and DISCUSSION

The aim of the study was to analyze the trends in the studies on educational robotics conducted in the years 2020-2023. Accordingly, 100 articles published in English in the field of educational robotics were analyzed using content analysis technique. The articles wereanalyzed in terms of publication year, sample characteristics, method-design, data collection tools, examined themes, and findings. According to the distribution of articles by publication year, the most articles were published in 2022, followed by 2021. Hangün et al. (2022) stated that due to the pandemic, there were fewer studies on robotics education conducted in 2020 compared to 2021 and subsequent years.

The most commonly used robotic tools in the studies on educational robotics are Lego Mindstorms, Arduino, Scratch, and Lego WeDo. Similar findings have been obtained in relevant studies as well. Atman Uslu et al. (2022) found a higher tendency towards the Scratch platform in educational robotics, Zhong and Xia (2020) found that Lego robot kits were the most commonly used in educational robotics, and a systematic review study conducted by Güneş and Küçük (2022) found that Arduino was the most frequently used tool. As can be observed from the sample characteristics, students are the most common participants, followed by teachers. In terms of educational levels, studies conducted at universities and middle schools stand out in terms of quantity. This result differs from some systematic reviews conducted in the field. Xia ve Zhong (2018) and Hangün et al. (2022) found that studies conducted with middle school students were more prevalent than those conducted at universities in the field of educational robotics. The necessity of acquiring cognitive skills such as algorithmic thinking and problem-solving during early developmental stages has been emphasized by specialists (Keen, 2011). In addition, middle school students undergo rapid cognitive development (Wigfield, Lutz & Wagner, 2005). For these reasons, it is believed that there is a significant number of robotics studies conducted with middle school students. However, it should be noted that robotics education is also implemented and observed in departments such as engineering (Vaganova et al., 2019) and computer science (Miller and Nourbakhsh, 2016) in universities.

According to the analysis, it was observed that quantitative, qualitative, and mixed methods were used. However, the use of quantitative methods and the preference for experimental and survey designs were more common. Similar trends can be observed in other reviews related to the field of education (Meral ve Akgül, 2022). The case study design has been widely utilized in qualitative research, which aligns with its common application in educational research. An analysis of data collection tools reveals a notable preference for scales and questionnaires, indicating their frequent utilization. An analysis of data collection tools reveals a notable preference for scales and questionnaires, indicating their frequent utilization. The abundance of scales and questionnaires addressing the variables of interest, such as problem-solving, creativity, critical thinking, computational thinking, attitudes, and motivation, coupled with their suitability for measurement purposes, has contributed to their widespread adoption as data collection tools. Other reasons for the frequent preference for quantitative research include higher generalizability and the ability to collect more data in a shorter period (Polit and Beck, 2010). Additionally, in qualitative studies, it was observed that interview forms were most commonly used. Similarly, Güneş and Küçük (2020) concluded in their relevant review that scales were predominantly used in quantitative studies in the field of educational robotics, while observation and interview forms were mostly used in qualitative studies. Since the interview method is frequently preferred for identifying perspectives and experiences, the use of interview forms is also widespread (Hannabuss, 1996).

The themes examined in studies have been classified into the categories of cognitive, affective, disseminating effect, and other. In the cognitive category, it is noteworthy that the most frequently studied variable in recent years in the field of educational robotics is computational thinking skills. Additionally, problem-solving, creativity, academic achievement, and metacognition are among the frequently researched themes. Academic achievement, problem-solving, and creativity are not only extensively studied in educational robotics but also in general educational studies (Meral & Akgül, 2022). The reasons for the frequent examination of these cognitive skills in the field of educational robotics can be attributed to the focus of educational robotics on developing these skills (Aris & Orcos, 2019) and its core objectives of supporting individuals' problem-solving, algorithmic, and numerical thinking (Tzagkaraki et al., 2021). According to Jung and Won (2018) study, the implementation of robotic education for young students has shown promising results in enhancing cognitive skills, particularly problem-solving and critical thinking. In the affective category, the most frequently examined variables or themes are collaboration, motivation, social relationships, and perspective. Likewise, Canbeldek and Isikoglu (2023) definitively concluded that a robotic coding program implemented during the preschool period had a positive impact on the cognitive skills of preschool children, based on their study. In addition, Liu et al. (2023) have observed that there has been considerable investigation into the influence of robotic education on cognitive skills; however, the findings have displayed a lack of consistency. They ascribe this inconsistency to the limitations of the instruments employed for assessing cognitive skills. Nevertheless, this study propose that the underlying cause for this inconsistency may be the existence of numerous factors that impact cognitive skills (Jou, Mariñas & Saflor, 2022) and the challenge of controlling for these extraneous variables in previous research endeavors.

Since collaborative work is common in robotic applications and robotic applications also aim to develop collaboration and leadership skills (Ioannou & Makridou, 2018), it is reasonable for these themes to be extensively studied. Additionally, studies have been conducted on views and experiences related to robotics education. This aims to determine the effectiveness of robotics education and to uncover perspectives on robotics education (Fridberg et al., 2023; Tang et al., 2023). Robotics education and the relationship between STEM education and robotics are also discussed, as is the impact of robotics on STEM interest and STEM skills. There are many studies that integrate STEM and robotics, and moreover, STEM and robotics education are considered complementary to each other due to their similar goals (Chang & Chen, 2020; Kaygısız et al., 2020; Latip et al., 2020; Wan et al., 2023).

The findings regarding general trends support the findings of other systematic analyses. According to Atman and Uslu (2022), higher-order thinking skills are frequently studied while Talan (2020) highlighted motivation and academic achievement, and Privetti et al. (2020) addressed communication and interaction skills. Lastly, the overall state of the findings in the studies has been analyzed. According to this analysis, positive results are more numerous in the research. It has been observed that there is a generally significant positive effect on computational thinking, problem-solving, creativity, collaboration, and motivation. The results of some studies examining academic achievement demonstrate a significant positive improvement, whereas the results of others do not show a significant impact. According to two studies conducted by Çam and Kıyıcı (2022) and Kert et al. (2020), it has been concluded that the use of educational robotics applications can improve academic achievement. However, Zhong and Xia (2020) have found that educational robotics does not have a significant impact on academic performance. It should be noted that there are numerous factors that can influence academic achievement (Jama et al., 2008) and the challenges of rapid developments in this area (Farrington et al., 2012) can also make it difficult to draw consistent conclusions. These factors may contribute to the divergent results found in the literature regarding the impact of educational robotics on academic performance. However, overall, it can be seen that educational robotics has a positive impact both cognitively and affectively. Temizkan (2014) also demonstrated in a relevant content analysis that educational robotics has a positive effect on learning outcomes. In addition, the importance and effectiveness of integrating robotics into other disciplines or the curriculum have been emphasized in studies. However, the existence of disadvantages or limitations mentioned in the studies should also be taken into consideration. These negative aspects generally include technical issues, infrastructure and lack of experience, the difficulty of implementation, and financial challenges. Several studies have noted problems with internet connections and inadequacies related to robotic kits. Additionally, the lack of experience among instructors implementing robotics education has been mentioned. Many studies have indicated that students face difficulties in placing robotic kits and logos. Furthermore, the financial burden of robotic kits is also among the mentioned limitations. It was stated in Talan's (2020) study that the assembly of circuits during robotic applications is challenging, and Tzagkaraki et al. (2021) mentioned that deficiencies in instructors' knowledge and experience, as well as technical issues, emerged as a disadvantage. Recent studies have revealed that some platforms are still in their early stages of development (Goda et al., 2014). Moreover, despite the advancements in robotics, there is a lack of empirical evidence supporting the effectiveness of cognitive tutoring systems at the university level (Chaka, 2023). The emergence of a multitude of challenges and disadvantages in the field of robotics can be attributed to its complex and multidimensional nature, which encompasses various aspects such as computing, technology, and infrastructure. Furthermore, the integration of robotics into education has arisen as a consequence of the evolving needs of the modern era, which were not previously considered (Ospennikova et al., 2015). As a result, this has led to deficiencies in adapting to and gaining experience within this particular field.

In this study, a content analysis of studies in the field of educational robotics was conducted. The analysis indicated that, in general, the studies primarily focused on themes related to the cognitive domain. Therefore, it is recommended that in future studies, the number of studies focusing on other domains should also be increased. The studies highlighted certain drawbacks in the implementation of educational robotics, with notable disadvantages including inadequate knowledge and experience among instructors, as well as financial challenges. Hence, it is necessary to promote in-service training programs for teachers in the field of robotics and encourage the use of affordable robotic materials. In the future, researchers conducting content analysis in this field can perform systematic analyses focusing on the implementation of educational robotics in specific subjects (e.g., Mathematics, Foreign Languages, etc.). Additionally, they can conduct systematic analysis in the field of educational robotics that target specific skills (e.g., higher-order thinking skills, 21st-century skills) or specific target groups (e.g., individuals with special needs, preschool students).

Limitations

It is imperative to note that this study is significantly limited by its exclusive focus on articles written in English and its sole emphasis on the examination of articles, disregarding other types of academic works such as theses and conference papers from the research scope. Furthermore, it's worth noting that the study is limited to a sample of only 100 articles, as some other articles were inaccessible due to various reasons.

GENİŞLETİLMİŞ ÖZET

Teknolojik gelişmeler yaşamımızın her alanında doğrudan ya da dolaylı olarak yer almakta ve birçok alanda bu gelişmelerden yararlanılmaktadır. Teknolojinin eğitime entegrasyonu kapsamında son yıllarda yaygınlaşan uygulamalardan birisi de robotik uygulamalardır (Yang vd.,2020). Robotik uygulamaların öğrenme ortamlarında kullanımı eğitsel robotik teriminin kullanılmasına yol açmıştır. Eğitsel robotik, K-12 STEM eğitimi için önemli bir pedagojik araç kaynağı haline gelmiştir (Anwar vd., 2019). Eğitsel robotik, robotların eğitim ortamlarında öğretme ve öğrenme için bir araç olarak kullanılmasını ifade etmektedir. Öğrencilerin öğrenme deneyimini geliştirmede robot teknolojisi ve kavramlarının müfredata ve eğitim faaliyetlerine entegrasyonunu içermektedir (Mikropoulos and Bellou, 2013). Eğitsel robotik; kodlama, bilgisayar programlama, Lego tabanlı tasarımlar ve non-coding uygulamaları içeren farklı birçok alternatif sunmaktadır (Karypi, 2018).

Eğitsel robotiğin bireyler açısından faydaları ve son yıllarda daha da yaygınlaşmaya başladığı göz önünde bulundurulduğunda bu alanda yapılan çalışmaların çıktılarının önem arz ettiği düşünülmektedir. Eğitsel robotiğin bireyler üzerinde ne denli etkili olduğu, ne tür sonuçlara yol açtığı ve bu alandaki yeni eğilimlerin neler olduğunun belirlenmesi eğitsel robotiğin teknolojinin eğitime entegrasyonun da ne kadar başarılı olduğu konusunda bize bir kavrayış sunacaktır. Dolayısıyla bu alanda gerçekleştirilen çalışmaları genel olarak incelemek ER'nin eğitimdeki yansıması, yeri, kullanımı ve etkileri hakkında fikir verecektir. Bu alan incelemesini yapmada en sık kullanılan tekniklerden biri içerik analizidir. İçerik analizi, akademik çalışmalar veya diğer yazılı metinlerin içeriğinin sistematik olarak incelenmesini ve yorumlanmasını içermektedir (Mayring, 2004) ve bu yöntem ile ilgili literatürün kalıpları, temaları ve eğilimleri tanımlanır, kategorize edilir (Riffe vd., 2019). Dolayısıyla bu çalışma ile bu alanda ortaya çıkan yeni eğilimler hakkında ilgili araştırmacıların fikir edinebileceği beklenmektedir. Bu sebeplerden dolayı bu çalışmada son yıllarda gerçekleştirilen eğitsel robotik alanındaki çalışmaların eğilimleri, bulguları ve amaçlarının incelenmesi amaçlanmıştır. Bu sayede son yıllara ait yürütülen çalışmalar ile ilgili güncel literatür hakkında genel bir durum tespiti ortaya koymak hedeflenmektedir.

Bu kapsamda çalışmada belirli kriterler doğrultusunda 100 makale içerik analizi tekniği ile incelenmiştir. Makalelerin seçim aşamasında "PRISMA akış diyagramı" adlı süreç izlenmiştir. Makalelerin demografik özellikleri, incelenen temalar ve değişkenler, yöntem bilgisi, kullanılan robotik araçlar, elde edilen bulgu ve sonuçlar ele alınmıştır. Bu veriler kod-kategori ve frekans-yüzde değerleri ile tablolar halinde sunulmuştur. Makalelerin yayım yılına göre dağılımına bakıldığında 2020-2023 aralığında makalelerin en çok 2022 yılında yayımlandığı bu sırayı da 2021 yılının takip ettiği görülmektedir. Eğitsel robotik ile ilgili yürütülen çalışmalarda en yaygın kullanılan robotik araçlar ise; Lego Mindstorms, Arduino, Scratch ve Lego We Do'dur. Örneklem özelliklerine bakıldığında ise en çok öğrencilerin daha sonra da öğretmenlerin yer aldığı görülmektedir. Kademe olarak ise en çok üniversitelerde daha sonra ise ortaokullarda yürütülen çalışmalar sayıca dikkat çekmektedir. Araştırmalarda nicel, nitel ve karma yöntemlerin kullanıldığı görülmüştür. Ancak nicel yöntemlerin kullanıldığı ve bu yönteme ait deneysel ve tarama desenlerinin tercihi daha yaygındır.

Araştırmalarda incelenen temalar "bilişsel", "duyuşsal", "yaygınlaştırıcı etk"i ve "diğer" kategorilerine göre sınıflandırılmıştır. "Bilişsel" kategorisinde son yıllarda eğitsel robotik alanında en çok incelenen değişkenin bilgi işlemsel düşünme becerileri olduğu dikkat çekmektedir. Bunun yanı sıra problem çözme, yaratıcılık, akademik başarı ve metabiliş de sıkça araştırılan temalar arasında yer almaktadır. "Duyuşsal" kategorisinde ise en çok incelenen değişken ya da temaların işbirliği, motivasyon, sosyal ilişkiler ve perspektiftir. Araştırmalardaki genel bulgulara bakıldığında bilgi işlemsel düşünme, problem çözme, yaratıcılık, işbirliği ve motivasyona ilişkin genel olarak anlamlı düzeyde pozitif etki olduğu gözlenmiştir. Akademik başarının incelendiği çalışmalardan bazılarında anlamlı düzeyde pozitif artış gözlenirken bazılarında anlamlı düzeyde bir artış gözlenmemiştir. Ancak genel olarak bakıldığında eğitsel robotiğin bilişsel ve duyuşsal anlamda olumlu etkiye sahip olduğu söz konusudur. Çalışmalara ait negatif bulgular da mevcuttur. Bu negatif yönler genel olarak teknik aksaklıklar, altyapı ve deneyim eksikliği, uygulamanın zor olması, finansal zorluklardır. Bazı çalışmalarda internet bağlantı problemleri ve robotik kitlere yönelik yetersizlik olduğu ifade edilmiştir. Ayrıca robotik eğitimini uygulayacak eğitmenlerin deneyim yetersizliğinden de söz edilmiştir. Birçok çalışmada ise öğrenciler robotik kitleri, logoları yerleştirirken zorluklar yaşadığını ifade etmiştir.

Gelecekte yapılacak çalışmalar için diğer alanlara yönelik çalışmaların sayısının da artırılması gerektiği önerilmektedir. Çalışmalarda eğitsel robotiğin uygulanmasına yönelik birtakım dezavantajların olduğu tespit edilmiştir. Bu dezavantajların en önemlileri arasında eğitmenlerin bilgi ve deneyim eksikliği ve finansal sorunlar yer almaktadır. Bu nedenle öğretmenlere yönelik robotik alanında hizmet içi eğitimlerin yaygınlaştırılması gerekmektedir ve uygun fiyatlı robotik malzemelerin kullanımının yaygınlaştırılması önerilmektedir. Gelecekte bu alanda içerik analizi çalışması yapacak olan araştırmacılar eğitsel robotiğin belirli departmanlarda (örneğin; Matematik, Yabancı dil vb.) uygulanmasına yönelik sistematik analiz gerçekleştirebilirler. Bunun yanı sıra belirli becerilere (üst düzey düşünme, 21.yüzyıl vb.) ya da hedef kitlelere (özel gereksinimli bireyler, anaokulu öğrencileri vb.) odaklanan eğitsel robotik alanına yönelik sistematik analiz çalışmaları gerçekleştirebilirler.

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