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Analysis of Studies in the Literature on Educational Robotics

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ABSTRACT
Based on the consistent development of technologization, robotics has become widely used in many fields of activity as a tool and an educational resource. This article presents some arguments about insufficiency, as well as the importance of further academic discourse, which can serve as a starting point for similar studies and the development of this dynamic direction. The purpose of this study is to reveal the direction of the most current studies on the educational robotics topic, published in some important databases. In order to detect the most common concepts of educational robotics research of the literature, a thematic analysis (descriptive content analysis) is done on the key concepts of educational robotics topic. The articles analyzed in this stud were only used sources from the Web of Science, Scopus and MDPI databases. The search in the database search engine was carried out by keywords: "Educational robotics", "Teaching educational robotics", "Integration of robotics", "Robotics in education" and "Education robotics". The data gathered from the reviewed articles are analyzed using descriptive statistical methods. In the findings obtained from the study, the keywords "integration of robotics" and "robotics in education" can be used most when searching for educational robotics. It has been concluded that the studies on educational robotics have increased gradually since 2018. At this point, the importance of studies on educational robotics is increasing day by day.

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Introduction

The relevance of solving factual and hypothetical issues related to teaching educational robotics involves further integration of scientific achievements and empirical data. The teaching staff systematically introduces new tools and updates the methods, but the introduction of educational robotics into the educational process will present certain difficulties for the practice of non-core

teachers. They need methodological assistance and retraining in a comfortable format. The relevance and problematic nature of studying the pedagogy of educational robotics remain, even though for half a century it has been in the mainstream of academic discourse, the interest is still strong since its interdisciplinary and adaptability to growing digitalization are increasing and it is actively integrated with other disciplines (Jung & Won, 2018). A quarter of a century ago, the potential possibilities of educational robotics collaboration were comprehended (Papert, 2020), and the systematic growth of modern education's attention to robotics (Miller & Nourbakhsh, 2016) continues in the technological direction.

The study group of Lopez-Belmonte based on the literature (Web of Science [WoS] database) that they have analyzed in Belmonte et al. (López-Belmonte et al., 2021) found the following tendencies:

- from 1975 to 2011, the subject of "education" has a high bibliometric indicator.
- from 2011 to 2013, the most important topics were "science" and "education"
- from 2013 to 2016, the most important topics were "programming" and "computational thinking".

Educational robotics implemented in STEM (Science, Technology, Engineering, and Mathematics), or the curricula of computer science, physics, biology, etc. As is customary, it makes a teacher responsible for disciplines such as mathematics, computer science, physics, etc. The development of strategies, recommendations in the light of interdisciplinary interpretation, the creation of an environment that supports both the concept of education and the concept of teaching, as well as the focus on maintaining this collaboration are still insufficient. There is no scientific consensus on many issues, and to achieve it, a choice of philosophy, policy, a vision of the immediate tasks and directions, and new approaches have to be identified (Koç & Büyük, 2021). The existing pluralism of empirical data on specific problem cases also does not seem to be exhaustive. It seems to us that purposeful research with a specific mission is suggested to achieve urgent, medium-term, and long-term tasks that can change based on social discourse. Educational robotics, as well as the actual use of robots, is very society oriented (Akgündüz et al, 2022). We are talking not only about the expected economic benefits of robotics, but also about the role of the future qualified teacher as a source of technological knowledge. One of the urgent tasks is teachers' university training, which is much more profitable in every sense than further retraining. The positive value of pre-training, the subsequent self-efficacy of teachers, and its measurement are noted by Schina et al. (2021). Associative research, acceptance, and self-efficacy of preschool teachers concerning educational robotics in the framework of the teacher training program before starting work and not retraining is considered (Tsai et al., 2021).

Based on the generation of scientific and empirical knowledge, a further discourse structure should be formed, its success and implementation in the practice of teachers depend on the cooperation of the higher and secondary school community, the participation of students and employers in discussions of curriculum reform, which will help further improve the learning process. This will be facilitated by adequate and suitable teaching methods developed based on specific guidelines (Giang et al., 2019), considering the goals of students and assessment methods (Giang, 2020). Individual improvements were tested with volunteer teachers, as the results were generalized for teachers who followed the CS (Computer Science) and robotics integration model (El-Hamamsy et al., 2021).

The importance and demand in modern society for the introduction of educational innovations in primary education and teacher training are noted by Forbes and Davis (2010), as well as Lucero et al. (2013), Kim et al. (2015) and Daniela & Lytras (2019) note positive ER factors when used for students with special needs.

A systematic review of English–language empirical articles from 2000 to 2016, on teachers' perception of STEM education directly, conducted by Margot and Kettler (2019) revealed similar problems related to the need to improve pedagogical teaching methods, solving problems with curricula and teaching based on an interdisciplinary approach. It is noted that STEM education requires a pedagogical transition to student-centered learning, one of the problems is the lack of

resources necessary for effective implementation in the educational process. The authors in the review refer to individual opinions. One of the possible reasons is insufficient cooperation between teachers in the subject area (Al Salami et al, 2017). In another study, teachers noted the standards of planning and content, which, in their opinion, may hinder interdisciplinary learning (Herro et al., 2017). They believe that collaboration and technology will be important for interdisciplinary teaching. The concept of interdisciplinary was found to be difficult for individual teachers due to the unification of four STEM disciplines (El-Deghaidy et al., 2017). Undoubtedly, interdisciplinary integration significantly complicates the role of one teacher performing the functions of several teachers in STEM, and this led to the conclusion that teachers will experience similar difficulties when combined with educational robotics and their subjects. Education Robotics (ER) technologies are used for teaching natural sciences, computer science, and STEM in different ways. This union is harmonious since ER is based on engineering, computer science, mathematics, and physics.

Maguth characterizes the involvement of high school students in ER and its relationship with STEM (Maguth, 2012). Multi-vector relationships with a wide range of issues, with different age categories and needs involved, are also considered. Hamner et al. (2016), Miller & Nourbakhsh (2016), Daniela & Lytras (2019), El-Hamamsy et al. (2021) and Greka Du franc et al. (2020) note the use of robots as an improving learning and motivation tool.

A separate promising vector of discourse is a step-by-step preparation for the study of educational robotics from preschool to university training. El-Hamamsy et al. (2021) believe that STEM is not the best option for the collaboration of educational robotics. They argue their hypothesis by observing studies of the use of ER as a means of teaching computational thinking skills, which in their opinion is more advantageous than STEM. They use ER as a medium for teaching CS concepts (Magnenat et al., 2014). Authors also draw attention to the interest of countries in such integration and implementation (Balanskat & Engelhardt, 2015). They believe that "Not only does a combined CS and robotics curriculum reform remain in line with the objectives of the CS Education curriculum, but it may even facilitate the introduction of more STEM-related activities into formal education in the long run." It should be noted that this study analyzes the results of a two-year continuing professional development (CPD) program for primary school teachers, while most studies are limited to describing the informal conditions of ER functioning.

One of the discussed problems is the struggle for integration ER into formal education (Benitti & Spolaôr, 2017; Eguchi, 2014; Negrini, 2020). Several researchers also concluded the importance of ER by reforming curricula to overcome its informal functioning. This reform would contribute to the elimination of limited access, and the lack of adequately trained teachers. The reasons preventing the inclusion of ER in the formal context, according to the authors, are high cost (Wallace & Freitas, 2016), the need to train teachers to use technological resources (Mester, 2016), students' digital competence (Núñez, 2016), and the need for pedagogical training of teachers (Sánchez et al., 2019).

From an educational point of view, robotics supports and improves the process of preschool and school education, which, eventually, should move into a formal context. More and more researchers emphasize the need to provide practitioners with recommendations for solving ethical and social problems related to the evolution of robots (Malinverni et al., 2021; Riek & Howard, 2014; Sallins, 2015; Zawieska, (2020).

Educational robotics encourages functional learning that generates resources that can be applied in a social environment (Gorjup & Liarokapis, 2020). Along with the expanding range of subjects integrating with educational robotics, students' independence skills are progressing due to pedagogical methods of project-based learning (Caballero-González & García-Valcarcel, 2020), and problem-solving skills are developing (López-Belmonte et al., 2021; Zhong & Li, 2020).

Based on the current literature, the topic of educational robotics has come a long way in terms of various aspects such as integration into the education of fields of STEM, computer sciences, mathematics, and physics. Also, it is clear that ER has some more social cognitive merits such as self-efficacy, acceptance, and motivation. Although these come in exceptionally handy, there still is much work to be done on the topic. The gap in the literature points to the need for a theoretical discourse on

the track the field should lead to in order to improve the generation of knowledge and build this knowledge on a sturdy philosophy. To feed this need, we aimed to reveal the direction of the most current studies on the educational robotics topic, published in some important databases. We point the road to build the discourse on the findings of this general direction, thus creating intellectual nourishment for future studies and researchers.

In this context, the problem sentences of the study are as follows:

- How is the distribution of studies on educational robotics published in Web of Science databases by category and year?
- How is the distribution of studies on educational robotics published in Scopus databases by subject area and year?
- How is the distribution of studies on educational robotics published in MDPI databases by category and year?

Methods

In order to detect the most common concepts of educational robotics research of the literature, a thematic analysis is done on the key concepts of educational robotics topic. A literature review involves the gathering and examining of writings, documents, maps, pictures, photographs etc. and the observing of visual and auditory elements according to a specific system, while a Thematic analysis is a method for identifying, analysing and reporting patterns (themes) within data (Braun & Clarke, 2006). Using a thematic review approach, studies were described and general trends were noted, the similarities and differences were noted as were the unmatched features of each study, which were clearly evident (Calik, Ayas & Ebenezer, 2005; Ormanci, Cepni, Deveci & Aydin, 2015). In order to improve the quality of analysis within the obvious limitations of a considerably wide and impure sea of papers in the literature, need for setting strict criteria is crucial. In the study, the thematic analyze (descriptive content analysis) method was preferred, since the situation in educational robotic studies was tried to be determined.

Data Collection

The articles analyzed in this stud were only used sources from the Web of Science, Scopus and MDPI databases. The reason for selecting these particular databases is their usage is very wide and the papers these databases index have a high impact of science. A review of the current literature on the three databases was conducted based on specific criteria. These criteria are shown in Table 1.

Table 1

Criteria Used in the Three Databases Included in the Literature Review

Index *Search criteria*	Web of Science	Scopus	MDPI
Year of release	for the last 5 years	for the last 5 years	for the last 5 years
JCI quartile	at least 3 quartiles	-	-
Access	Open access	Open access	Open access
Impact factor	not lower than 1.7	not lower than 1.7	-
Publisher	IEEE publisher	-	-
The acceptance rate	-	at least 25 %	-

As indicated in Table 1, searches were carried out in three databases, taking into account the search criteria. The search in the database search engine was carried out by keywords: “Educational robotics”, “Teaching educational robotics”, “Integration of robotics”, “Robotics in education" and

"Education robotics". We used automatic search to find articles related to this topic, and then conducted a manual review of them. The following criteria were taken into consideration in the articles reviewed in this process. The inclusion criteria were:

- research on the teaching of educational robotics at all stages of education from preschool to undergraduate, as well as in non-formal institutions;
- research on STEM, based on its interdisciplinarity, symmetrical interdisciplinarity OR;
- research on the role of teachers and their views on the integration of educational robotics;
- research on online educational robotics platforms and laboratories;
- research on the need for the transition of educational robotics to formal education;
- empirical research, including a systematic review of English-language empirical articles.

Not included in the review:

- special research on robotics, focused on narrow specialists;
- publications of an irrelevant nature.

Data Analysis

Data analysis is the central tool of our study. The thematic focus of data collection provided an opportunity to identify semantically significant topics. Further, content analysis, as one of the standard research methods, allowed us to identify the sources necessary for analysis from text data, including empirical research.

Qualitative methods of data collection were also prioritized. The articles obtained from the databases were analyzed using the matrix (Table 2). The data gathered from the reviewed articles are analyzed using descriptive statistical methods. The descriptive analysis includes percentages of the appropriate data.

Table 2

Analysis Dimensions Used in the Study

Databases	Key Words	Dimensions
Web of Science	Education robotics	Number of articles
SCOPUS	Educational robotics	Category/ subjest area
MDPI	Teaching educational robotics	Years
	Integration of robotics	
	Robotics in education	

Findings

In this section, the findings of the articles reviewed in three different databases (Web of Science, Scopus and MDPI) are given.

Findings on Articles Reviewed in the Web of Science Database

This section presents the search results up to the second quarter of 2022 by keywords (Table 3).

Table 3

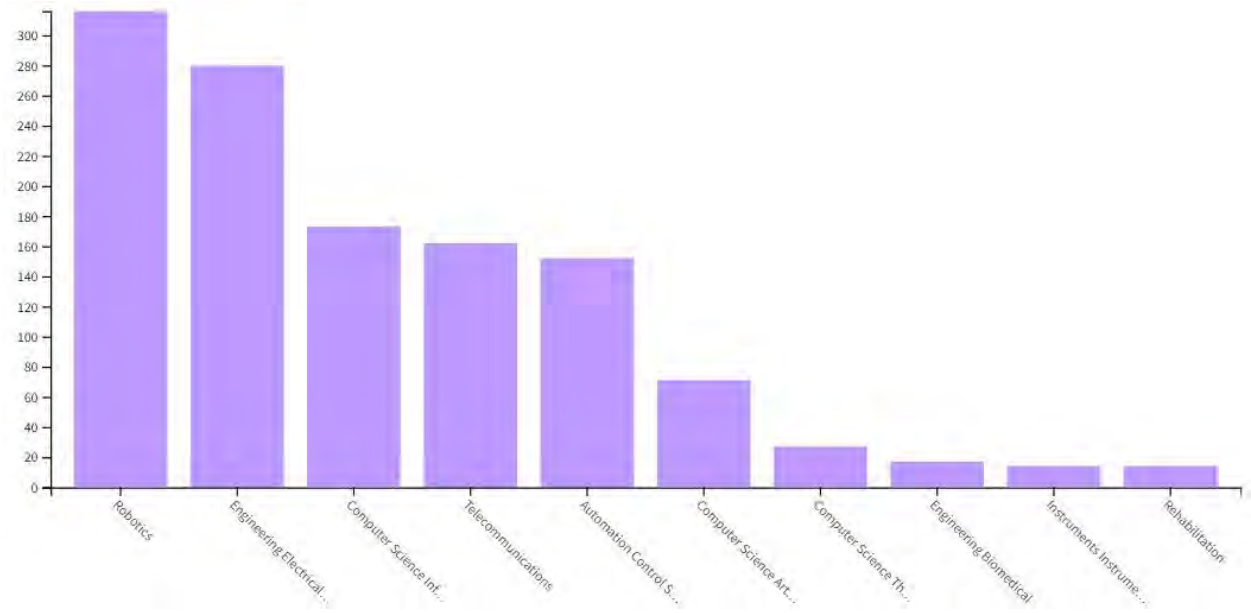
Findings on Keywords in the Web of Science Database

Key Words	f
Education robotics	559
Educational robotics	142
Teaching educational robotics	15
Integration of robotics	327
Robotics in education	588

As seen in Table 3, the web of science database, the keyword “education robotics” was entered 599 times, the keyword “robotics in education” 588, the keyword “integration of robotics” 327, the keyword “educational robotics” 142 and the keyword “teaching educational robotics” 15 times. Search by the keyword “Educational robotics”, 599 entries were found. The results of the analysis are shown in Figure 1.

Figure 1

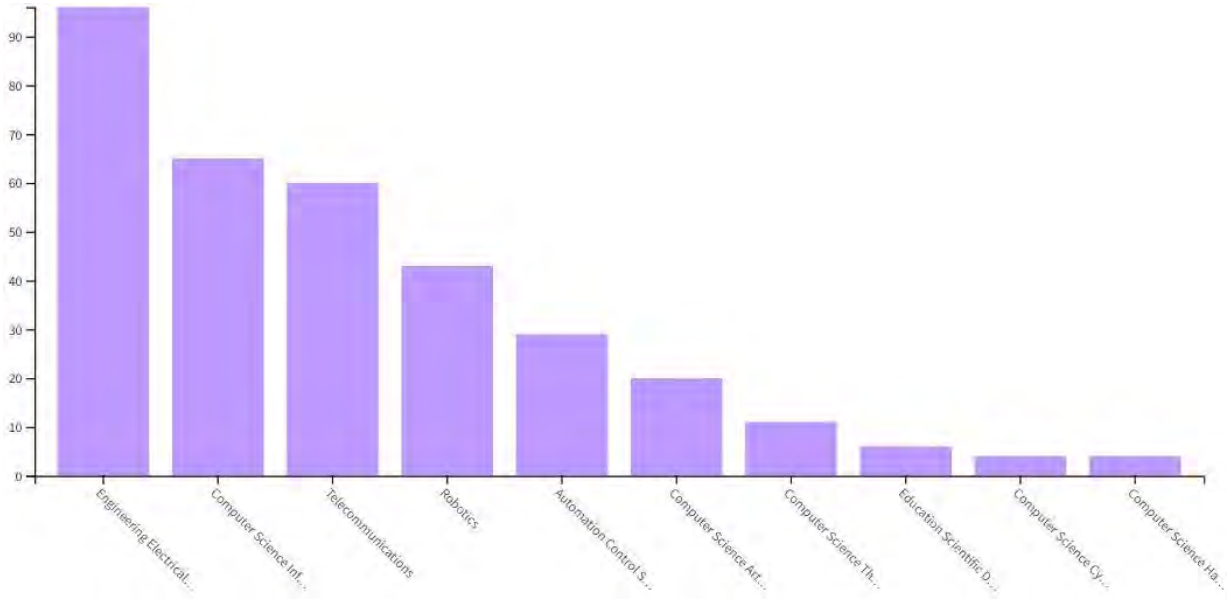
Analysis Results: “Education Robotics” in the Web of Science database



In Figure 1, the distribution of the articles related to the keyword "education robotics" in the categories in the Web of Science database is seen. The articles reached are mostly in the “robotics” and “engineering electrical electronic category”. Later, it is in the categories of “computer science information systems”, “telecommunications” and “automation control systems”. The search for the keyword “Educational robotics” found 142 entries. The results of the analysis are shown in Figure 2.

Figure 2

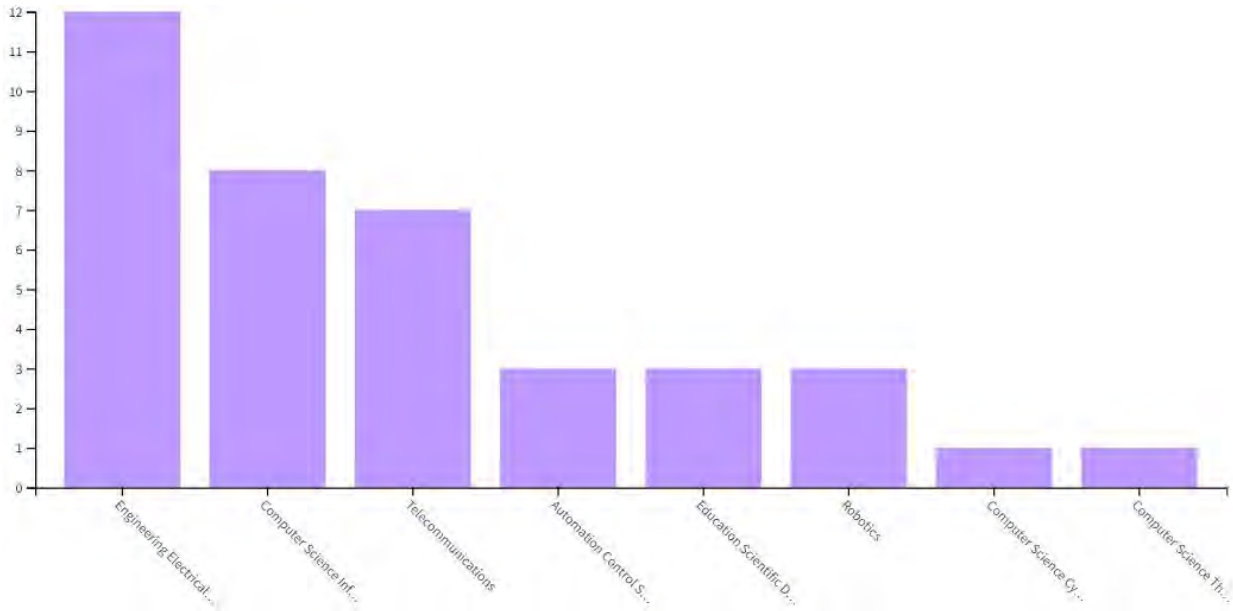
Analysis Results: "Educational Robotics" in the Web of Science database



In Figure 2, the distribution of the articles related to the keyword "educational robotics" in the categories in the Web of Science database is seen. The articles reached are mostly in the "engineering electrical electronic category". Later, it is in the categories of "computer science information systems", "telecommunications" and "robotics". As a result of the search for the keyword "Teaching educational robotics", 15 entries were found. The results of the analysis are shown in Figure 3.

Figure 3

Analysis Results: "Teaching Educational Robotics" in the Web of Science database

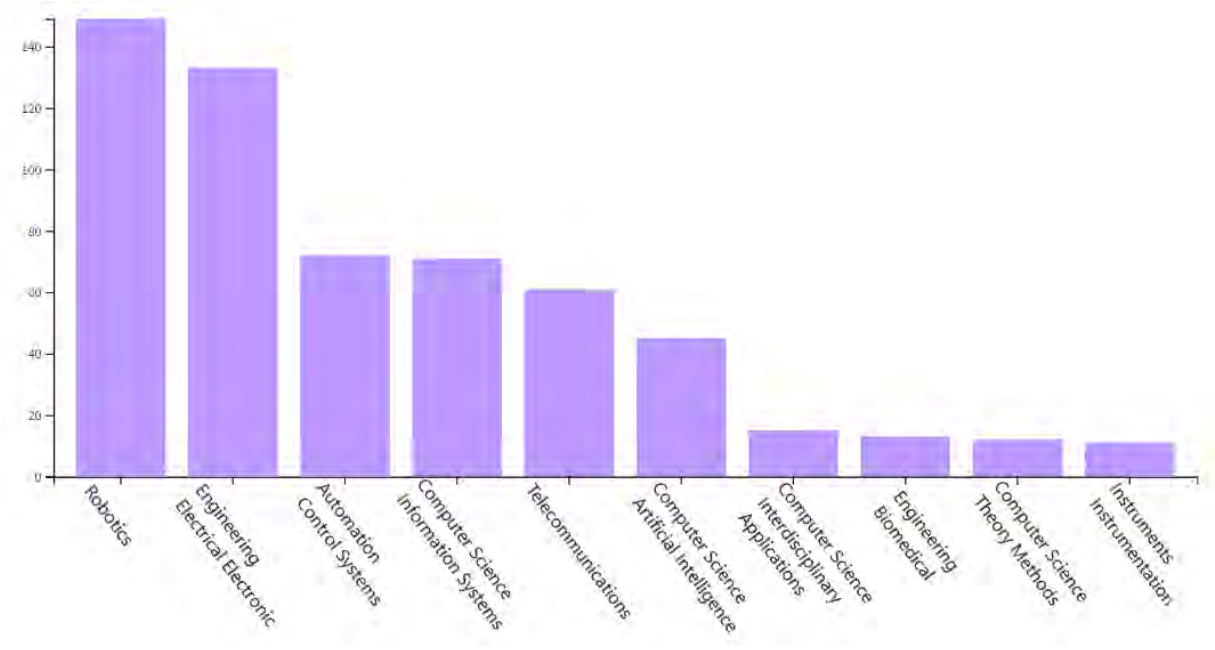


In Figure 3, the distribution of the articles related to the keyword " teaching educational robotics " in the categories in the Web of Science database is seen. The articles reached are mostly in the

"engineering electrical electronic category". Later, it is in the categories of "computer science information systems" and "telecommunications". The search for the keyword "Integration of robotics" 327 found entries. The results of the analysis are shown in Figure 4.

Figure 4

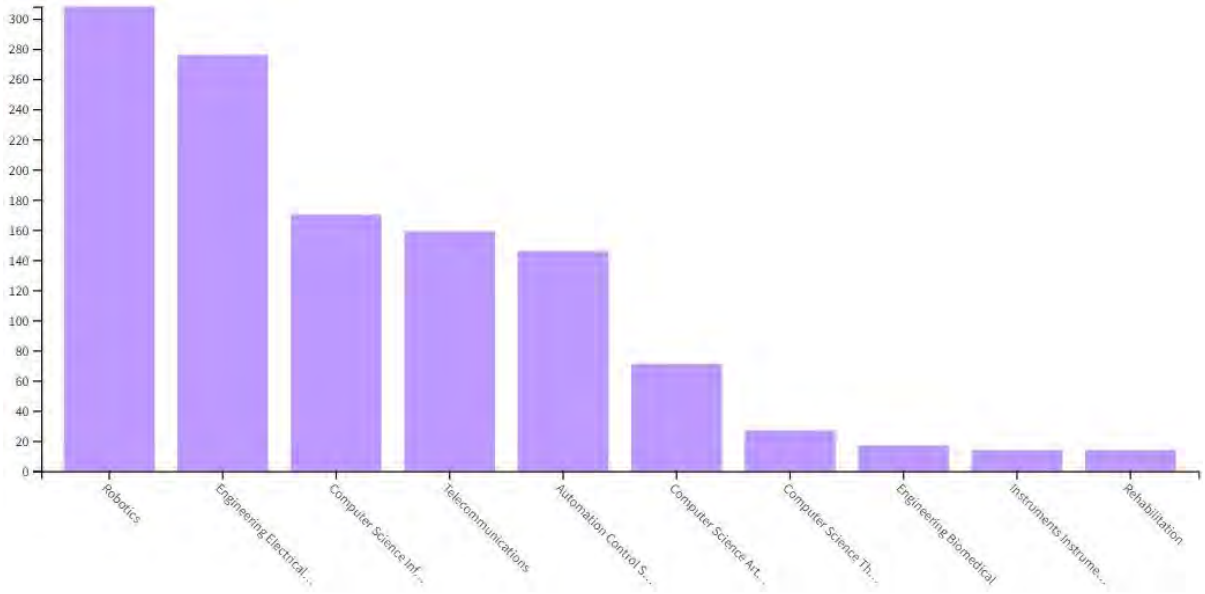
Analysis Results: "Integration of Robotics" in the Web of Science Database



In Figure 4, the distribution of the articles related to the keyword "integration of robotics" in the categories in the Web of Science database is seen. The articles reached are mostly in the "robotics" and "engineering electrical electronic category". Later, it is in the categories of "automation control systems", "computer science information systems" and "telecommunications". The search for the keyword "Robotics in education" 588 found entries. These results of the analysis are shown in Figure 5.

Figure 5

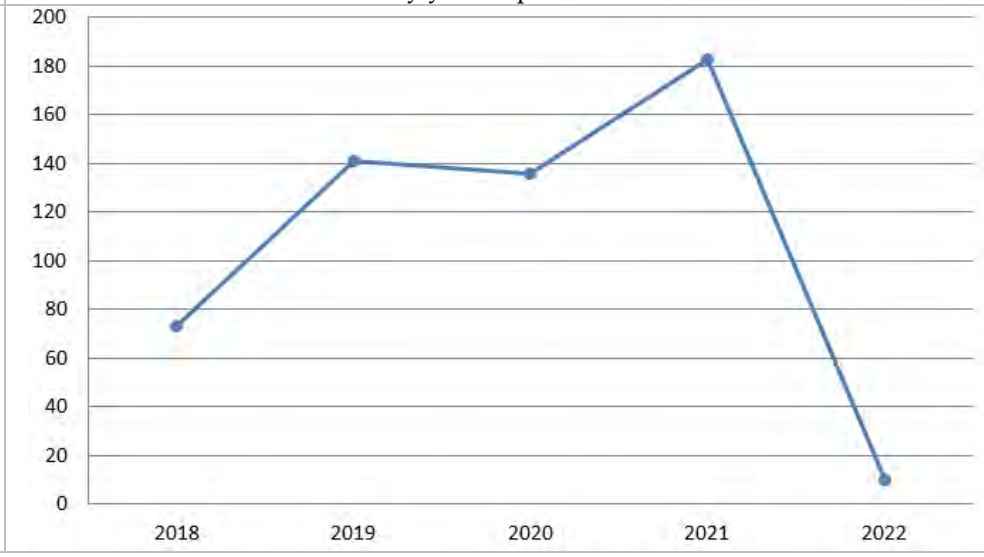
Analysis Results: "Robotics in Education" in the Web of Science database

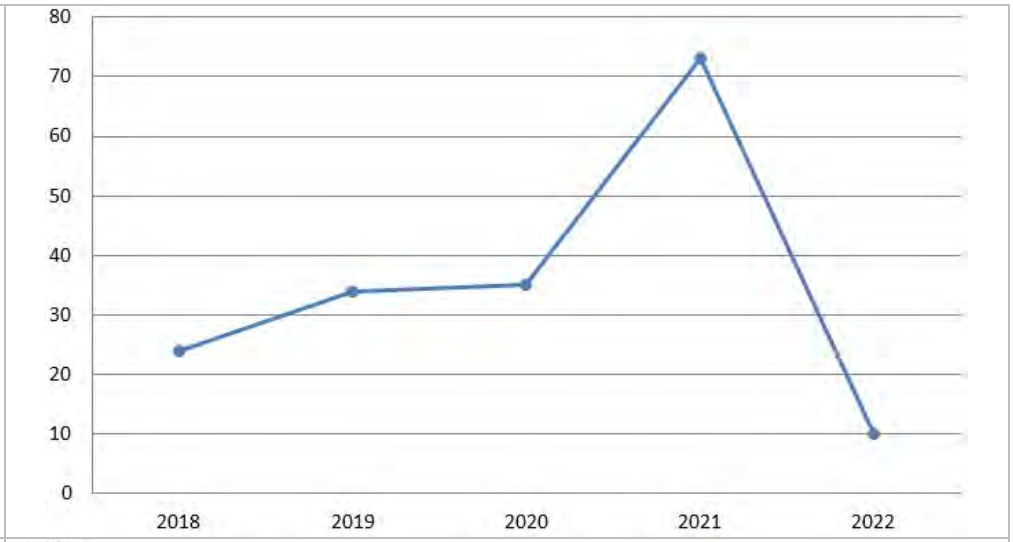
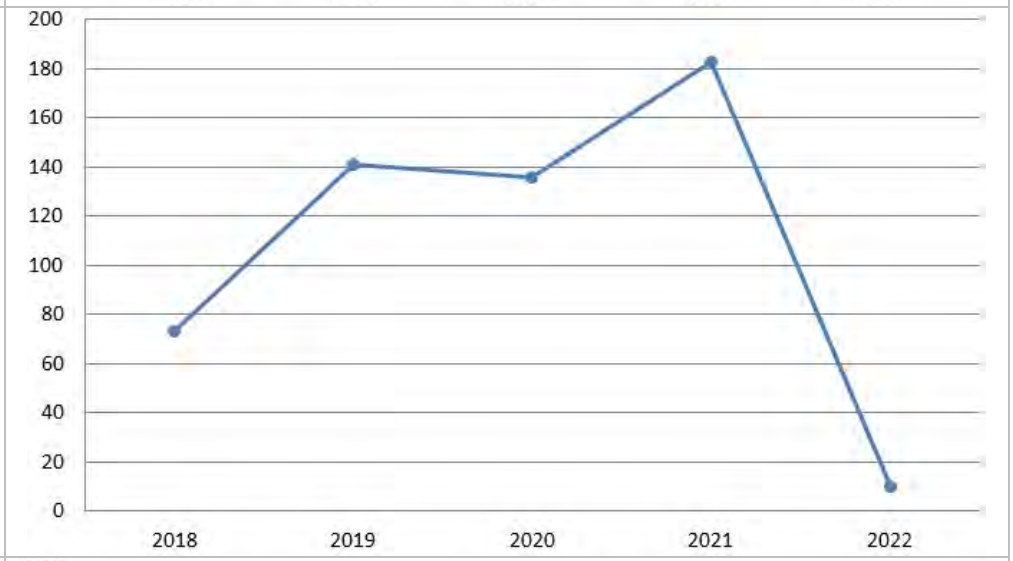
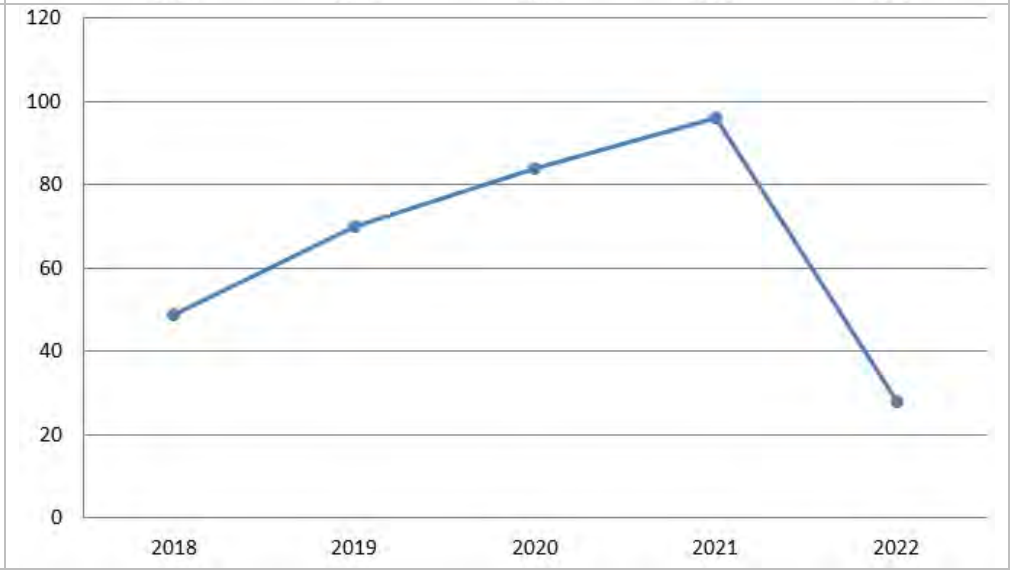


In Figure 5, the distribution of the articles related to the keyword "robotics in education" in the categories in the Web of Science database is seen. The articles reached are mostly in the "robotics" and "engineering electrical electronic category". Later, it is in the categories of "computer science information systems", "telecommunications" and "automation control systems". The distribution of articles by year of publication of articles in Web of Science is shown in Table 4.

Table 4

Distribution of Articles by Year of Publication of Web of Science

	Distribution by year of publication of articles
Education robotics - 599	

Educational robotics - 142	
Teaching educational robotics - 15	
Integration of robotics - 327	

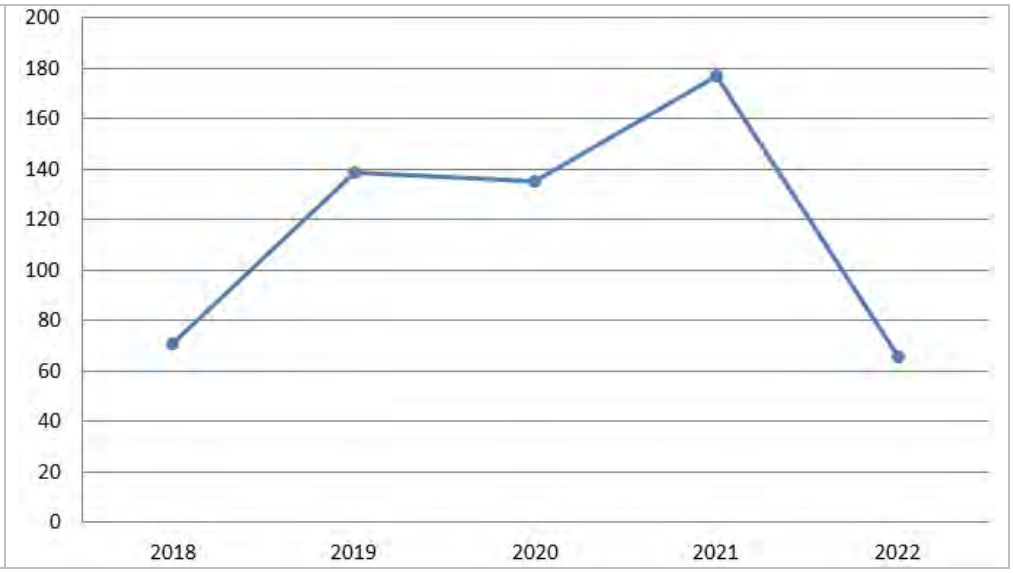
Robotics in education – 588	

Table 4 shows the distribution of robotics review a in the last five years. It is seen that there is an increase in all keywords from 2018 to 2019. From 2019 to 2020, there is a stability is visible here. This may be due to the fact that it coincides with the pandemic process. There is a large increase from 2020 to 2021. Since all researches in 2022 did not participate in the study, the information there is incomplete.

Findings on Articles Reviewed in the Scopus Database

This section presents the search results up to the second quarter of 2022 by keywords in the Scopus database (Table 5).

Table 5

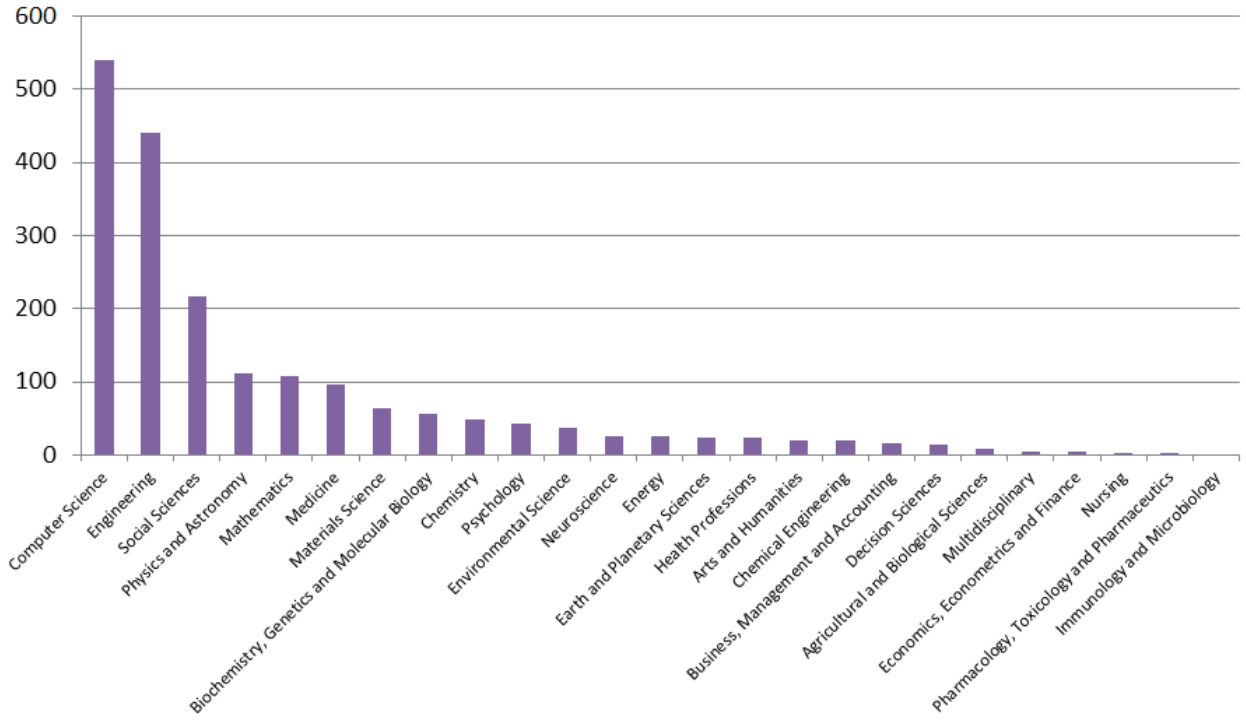
Findings on Keywords in the Scopus Database

Key Words	f
Educational robotics (with an additional parameter)	919
Teaching educational robotics	215
Integration of robotics	1447
Robotics in education	1121

As seen in Table 5, the Scopus database, the keyword "integration of robotics" was entered 1447 times, the keyword "robotics in education" 1121, the keyword "education robotics" 919 and the keyword "teaching educational robotics" 215 times. As a result of the search for the keyword "Educational robotics", 919 entries were found. The results of the analysis are shown in Figure 6.

Figure 6

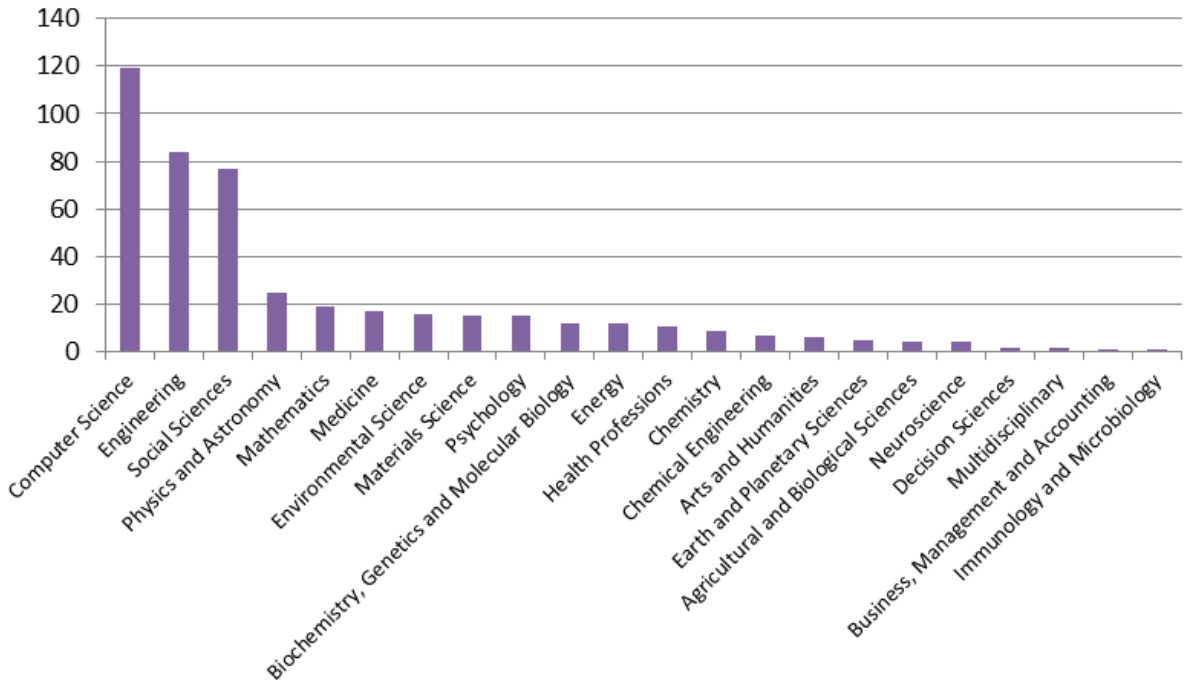
Analysis Results: "Educational robotics" in the Scopus Database



In Figure 6, the distribution of the articles related to the keyword "educational robotics" in the subject area in the Scopus database is seen. The articles reached are mostly in the "computer science". Later, it is in the subject area of "engineering" and "social sciences". As a result of a search for the keyword "Teaching educational robotics", 215 entries were found. The results of the analysis are shown in Figure 7.

Figure 7

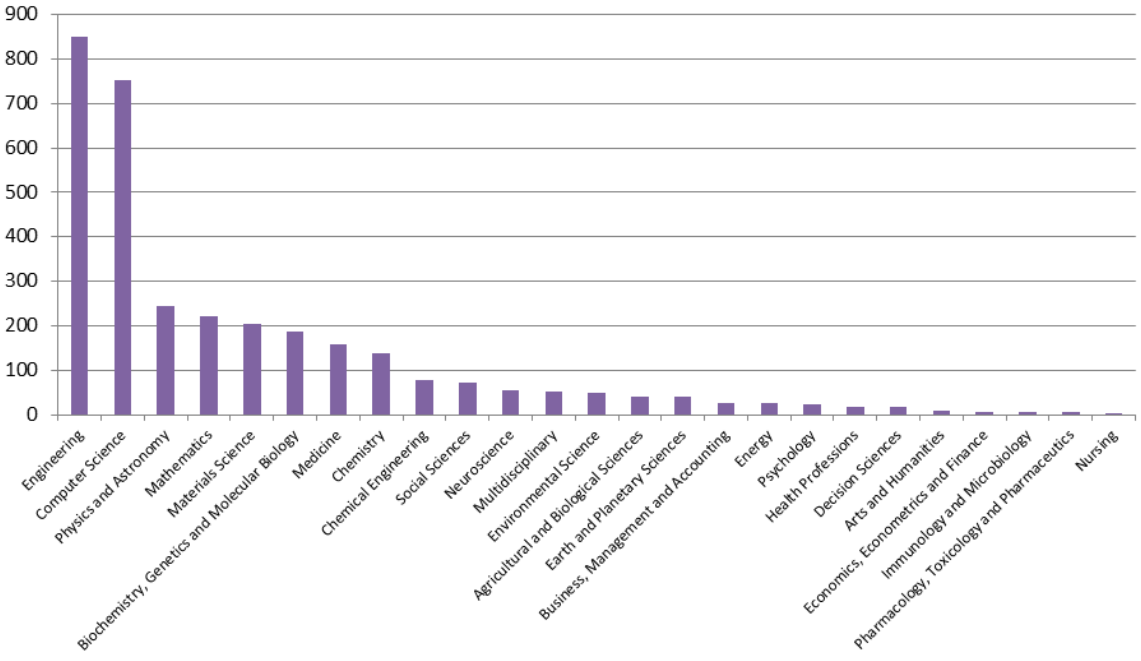
Analysis Results: "Teaching Educational Robotics" in the Scopus Database



In Figure 7, the distribution of the articles related to the keyword "Teaching educational robotics" in the subject area in the Scopus database is seen. The articles reached are mostly in the "computer science". Later, it is in the subject area of "engineering" and "social sciences". As a result of a search for the keyword "Integration of robotics", 1447 entries were found. The results of the analysis are shown in Figure 8.

Figure 8

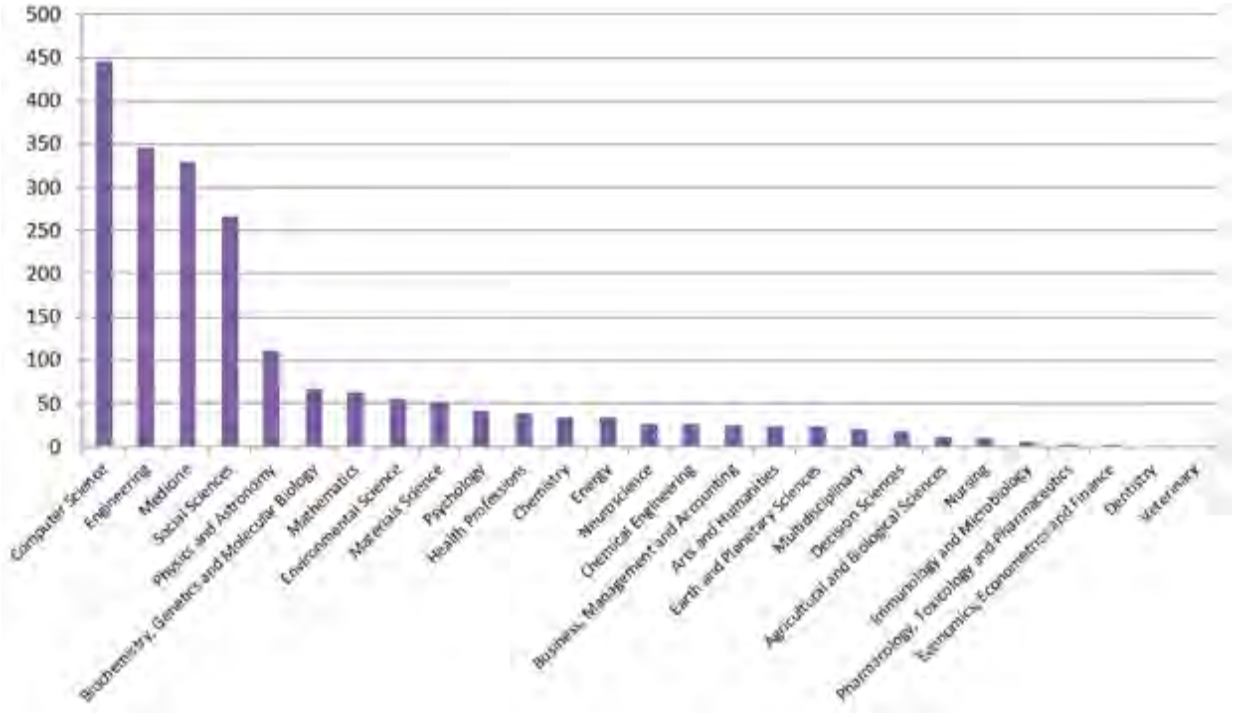
Analysis Results: "Robotics Integration" in the Scopus Database



In Figure 8, the distribution of the articles related to the keyword " Integration of robotics" in the subject area in the Scopus database is seen. The articles reached are mostly in the “engineering” and “computer science”. Later, it is in the subject area of “physics and astronomy”, “mathematics” and “materials science”. As a result of a search for the keyword “Robotics in education”, 1121 entries were found. The results of the analysis are shown in Figure 9.

Figure 9

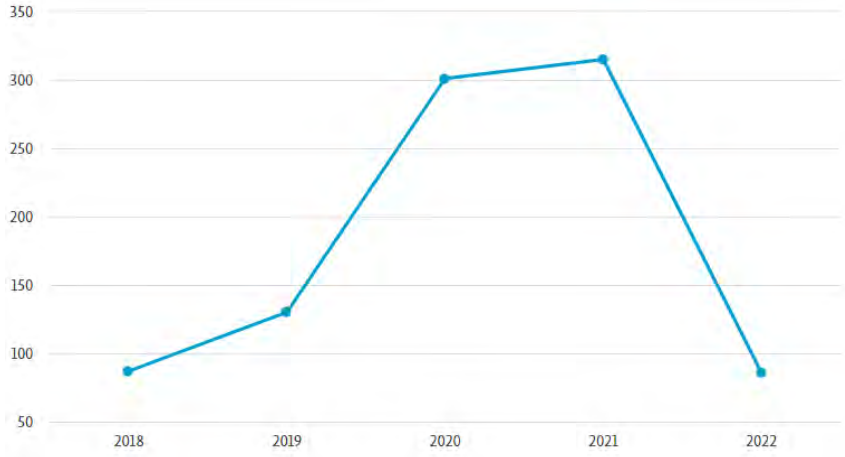
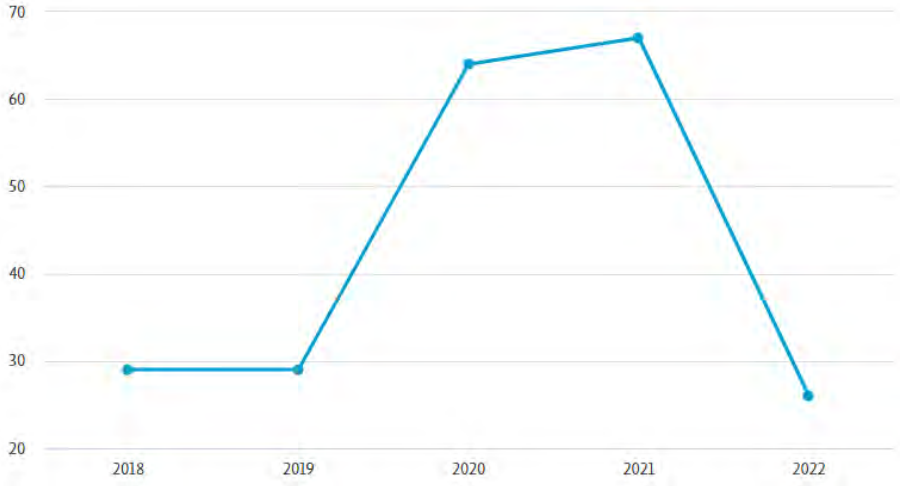
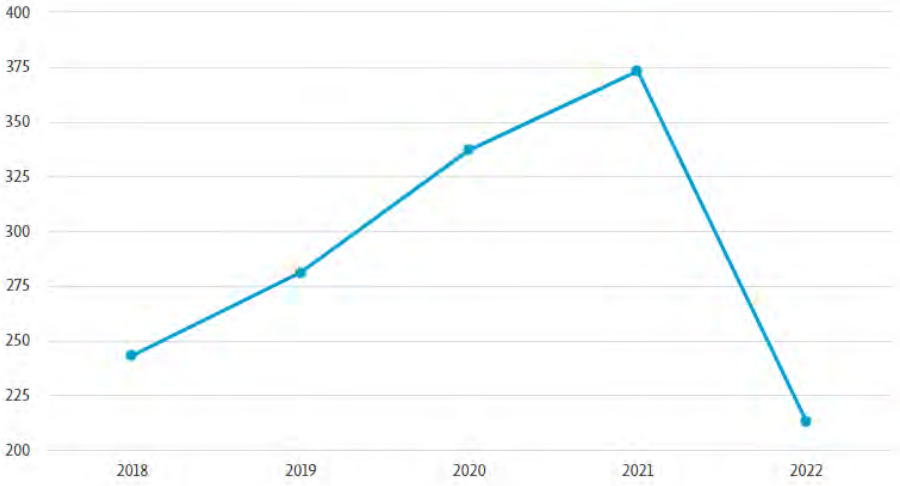
Analysis Results: “Robotics in Education” in the Scopus Database



In Figure 9, the distribution of the articles related to the keyword "Robotics in education " in the subject area in the Scopus database is seen. The articles reached are mostly in the “computer science”. Later, it is in the subject area of “engineering”, “medicine” and “social science”. The distribution of articles by year of publication of Scopus is shown in Table 6.

Table 6

Distribution of Articles by Year of Publication of Scopus

	Distribution by year of publication of articles
Educational Robotics - 919	
Teaching educational robotics- 215	
Integration of robotics- 1447	

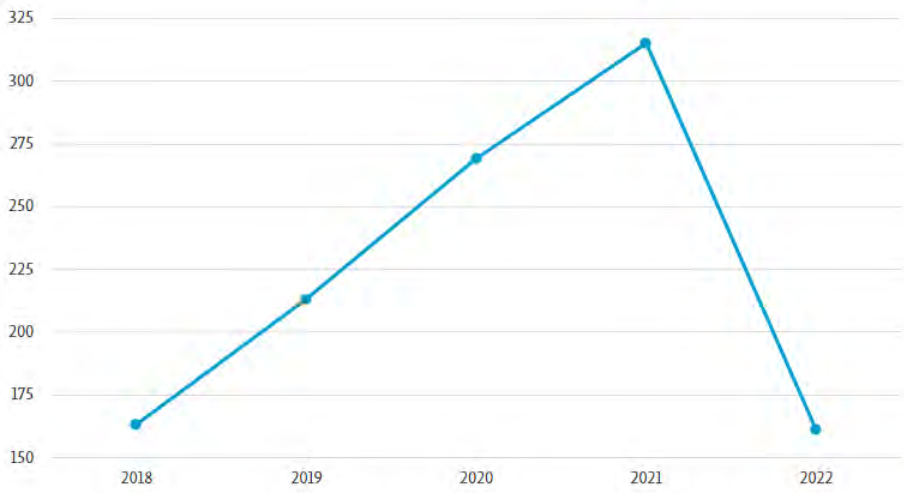
Robotics in Education - 1121	

Table 6 shows that each of our four keywords is becoming increasingly popular in academic research, as there is a clear increase from 2018 to 2021. The reduction in 2022 is due to the fact that the search was conducted before the second quarter of 2022, and it can be expected that more studies will be published before the end of the year. In addition, 2020 is the year when research in the field of educational robotics has almost tripled, and teaching of educational robotics has almost doubled. This may mean that the topic of robotics is gaining more and more interest not only as a scientific topic, but also as an area of education.

Findings on Articles Reviewed in the MDPI Database

When searching by keywords in the MDPI database until the second quarter of 2022, the following results were found (Table 7):

Table 7

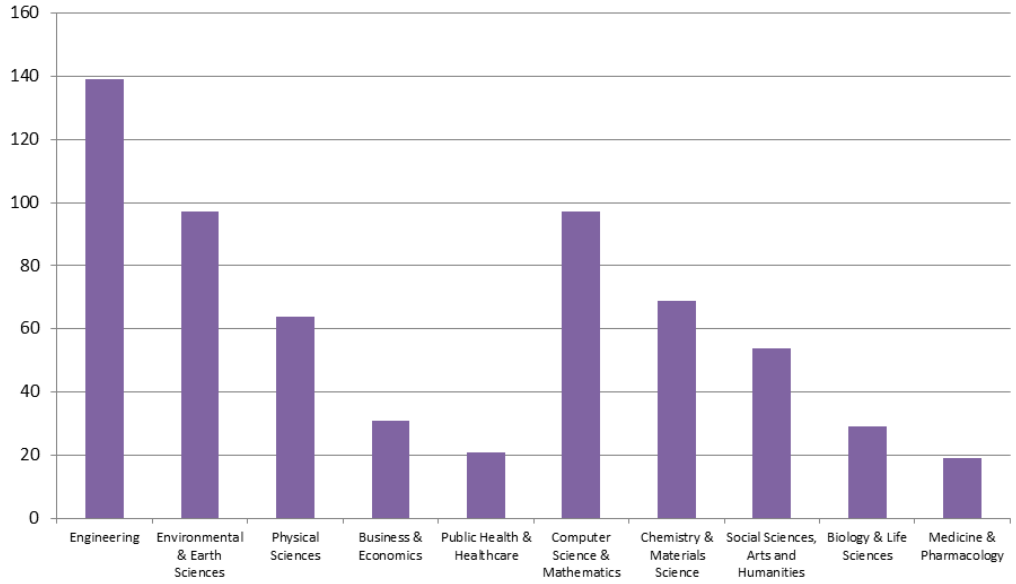
Findings on Keywords in the MDPI Database

Key Words	f
Educational robotics	201
Teaching educational robotics	58
Integration of robotics	947
Robotics in education	201

As seen in Table 7, the MDPI database, the keyword “integration of robotics” was entered 947 times, the keyword “education robotics”201, the keyword “robotics in education” 201 and the keyword “teaching educational robotics” 58 times. As a result of a search for the keyword “Educational Robotics”, 201 entries were found. The results of the analysis are shown in Figure 10.

Figure 10

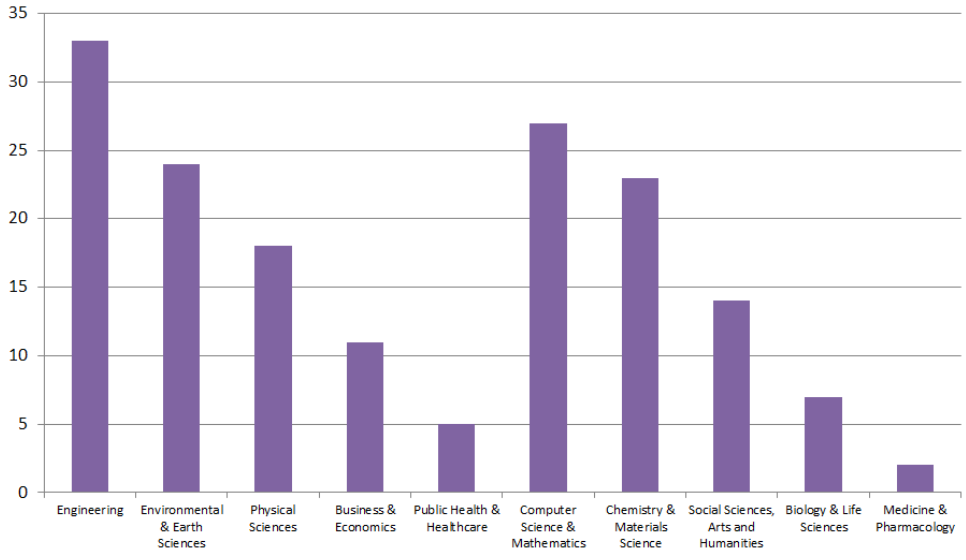
Analysis Results: "Educational Robotics" in the MDPI Database



In Figure 10, the distribution of the articles related to the keyword "educational robotics" in the categories in the MDPI database is seen. The articles reached are mostly in the "engineering". Later, it is in the categories of "environmental & earth sciences" and "computer science & mathematics". As a result of the search for the keyword "Teaching educational robotics", 58 entries were found. The results of the analysis are shown in Figure 11.

Figure 11

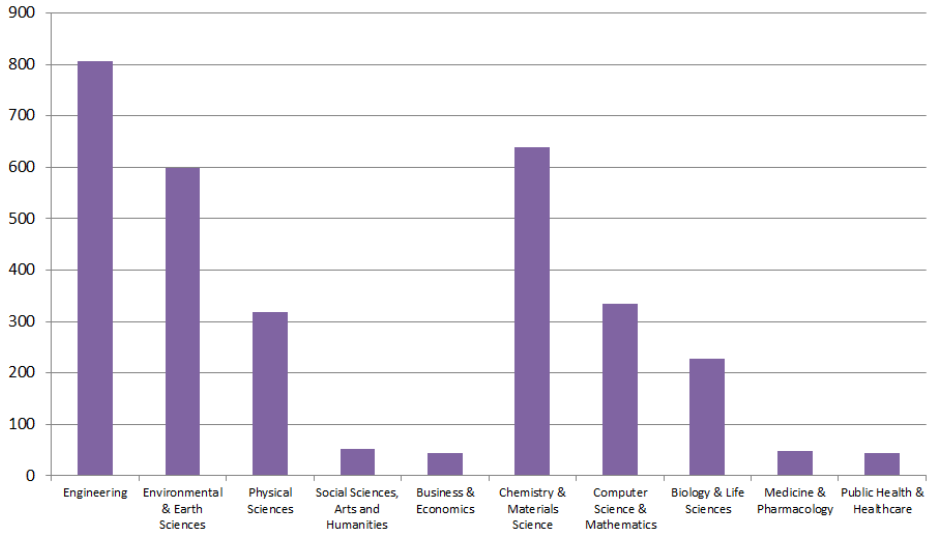
Analysis Results: "Teaching Educational Robotics" in the MDPI Database



In Figure 11, the distribution of the articles related to the keyword "Teaching educational robotics" in the categories in the MDPI database is seen. The articles reached are mostly in the "engineering". Later, it is in the categories of "computer science & mathematics", "environmental & earth sciences" and "chemistry & materials science". As a result of a search for the keyword "Robotics Integration", 947 entries were found. The results of the analysis are shown in Figure 12.

Figure 12

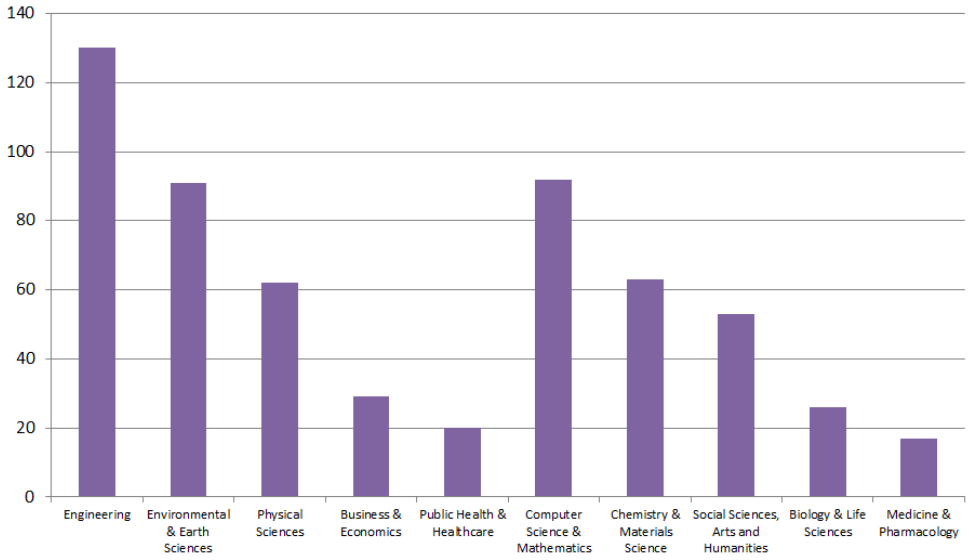
Analysis Results: "Robotics Integration" in the MDPI Database



In Figure 12, the distribution of the articles related to the keyword "Robotics Integration" in the categories in the MDPI database is seen. The articles reached are mostly in the "engineering". Later, it is in the categories of "chemistry & materials science" and "environmental & earth sciences". As a result of a search for the keyword "Robotics in education", 201 entries were found. The results of the analysis are shown in Figure 13.

Figure 13

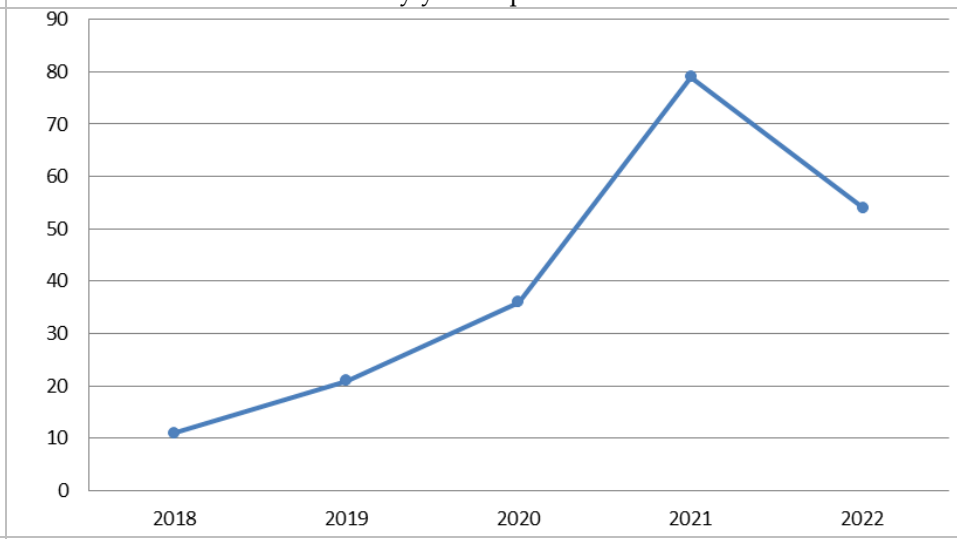
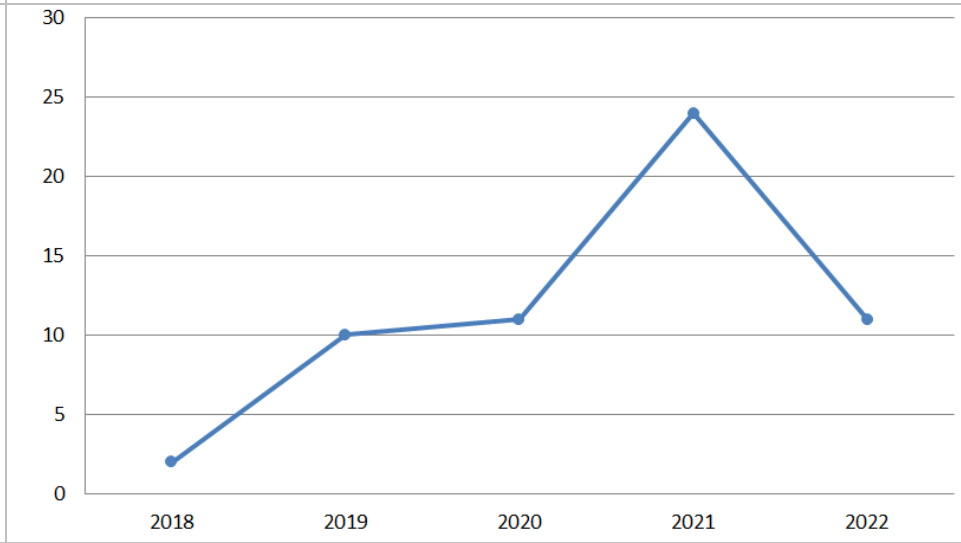
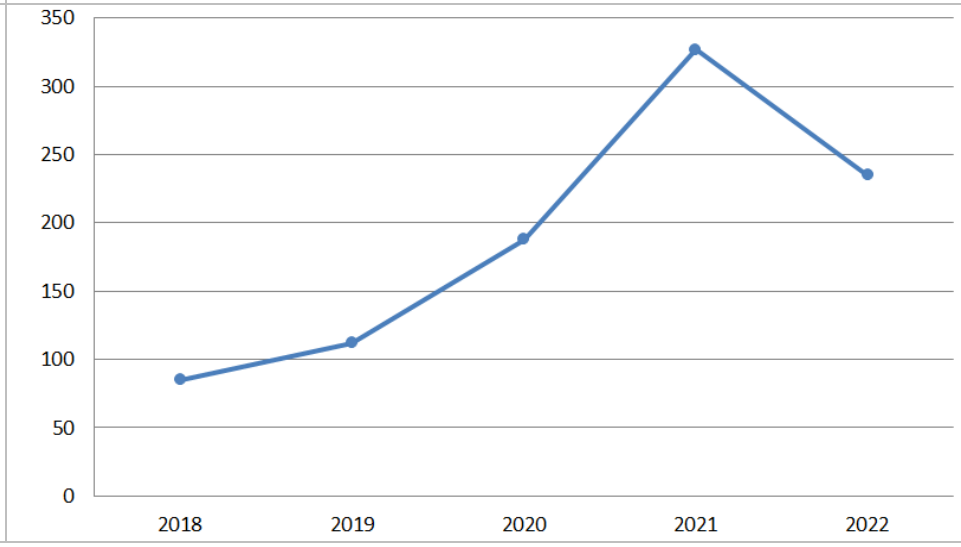
Analysis Results: "Robotics in Education" in the MDPI Database

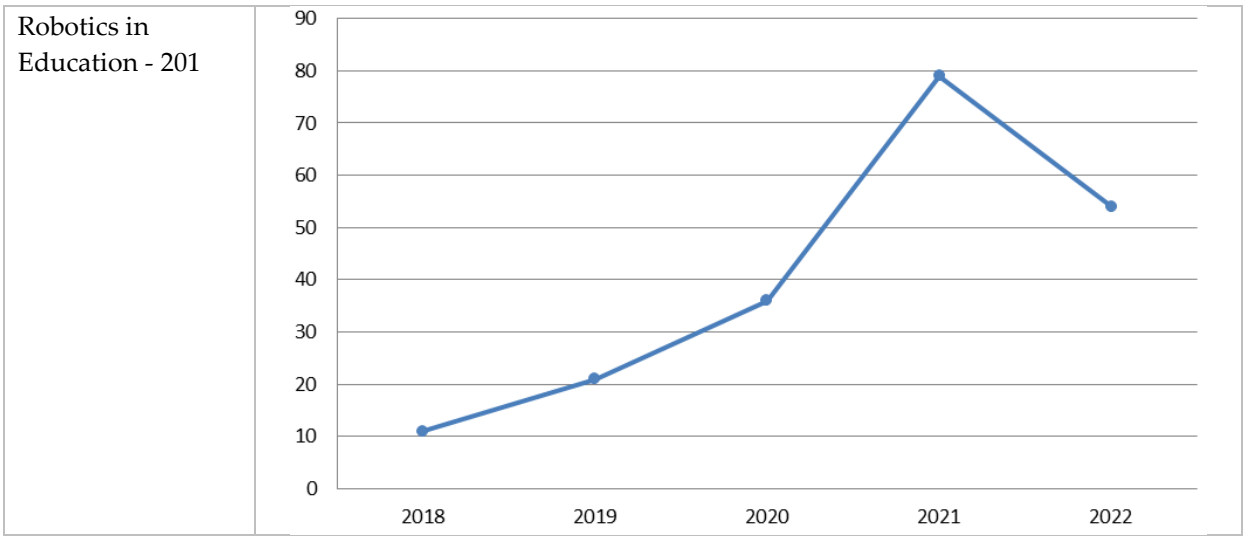


In Figure 13, the distribution of the articles related to the keyword "Robotics in education" in the categories in the MDPI database is seen. The articles reached are mostly in the "engineering". Later, it is in the categories of "computer science & mathematics" and "environmental & earth sciences". The distribution of articles by year of publication of articles in MDPI is shown in Table 8.

Table 8

Distribution of Articles by Year of MDPI Publications

	Distribution by year of publication of articles
Educational Robotics - 201	
Teaching educational robotics- 58	
Integration of robotics- 947	



According to the results of the analysis of the MDPI database, reflected in Table 8, from 2018 to 2021 there is a stable growth of publications. It is assumed that this trend will continue until the end of 2022. All the data in the tables indicate the relevance of this direction and its dynamic development.

Discussion and Conclusions

The lack of literature on similar research topics does not allow for a comparative analysis of sources. In this context, literature analysis studies to be done or done are important for determining the place of that subject in the field and especially for increasing its applications. This is especially important for the subject of educational robotics, which has an important place in the field. For example, Ospennikova et al. (2015) argue that knowledge of the basics of robotics should become the basic content of the curriculum of secondary schools. In this context, the importance of the analysis on educational robotics emerges in the study.

In the literature review conducted within the scope of the study, 1631 studies on the keywords "education robotics", "robotics in education", "integration of robotics", "educational robotics" and "teaching educational robotics" were found in the Web of Science database. In the Scopus database, 3702 articles were accessed in four key words. In the MDPI database, 1407 articles were reached in four key words. As a result of the reviews, it can be stated that the education robotics is an important and studied subject in the literature. Based on Anwar, Bascou, Menekse & Kardgar (2019)'s systematic review, they found a total of 147 studies published from the years 2000 to 2018. They classified these studies under five themes as: (1) general effectiveness of educational robotics; (2) learning and transfer skills; (3) creativity and motivation; (4) diversity and broadening participation; and (5) teachers' professional development. When we look at the databases we examined in our study, the most results were obtained in the Scopus database. This may be due to the number of journals and parallel articles in the databases or the trend towards the subject in the databases.

In our study, the most studies on the keywords "Educational robotics" and "Robotics in education" were found in the Web of science database. In the Scopus database, the most studies on the keywords "integration of robotics" and "robotics in education" were found. In the MDPI database, the most studies on the keyword "integration of robotics" were found. In this context, the keywords "integration of robotics" and "robotics in education" can be used most when searching for educational robotics.

In the searches made on educational robotics in the Web of Science database; the article was reached in the categories of "robotics", "engineering electrical electronic category", "computer science information systems", "telecommunications". The subject area, which is the most studied in the

Scopus database, is "computer science", "engineering" and "social sciences". In the categories in the MDPI database, the most studies were found in the fields of "engineering", "computer science & mathematics". At this point, the subject of educational robotics is a subject that has been studied in many areas. Another finding that we have already obtained supports this situation. When we look at the change in the studies on educational robotics in the last five years, it is understood that there was an increase from 2018 to 2019, a pause between 2019-2020 and then an increase again. In the Scopus database, our four keywords is becoming increasingly popular in academic research, as there is a clear increase from 2018 to 2021. In the MDPI database, keywords is becoming increasingly popular in academic research, as there is a clear increase from 2018 to 2021. It is normal to see a decrease from 2021 to 2022 as not all studies done in 2022 have been reached. As it can be understood, the educational robotics is being studied day by day in the literature and continues to be important.

As in other countries, educational robotics functions in the Republic of Kazakhstan within the framework of non-formal education and as an elective discipline. Initially, over 8000 computer science teachers were trained in the country to teach educational robotics through national centers and other training institutions. At Zhetysu University, where it is planned to conduct experimental work on the educational programs “Information Systems” and “Physics”, during the semester of the 2021-2022 academic year, interviews with teachers, questionnaires using the Likert scale were conducted, classes were attended, which at that time were held in a mixed, and then in an “off-line” format. Organization of the educational processes with the use of remote technologies, training sessions on the programming of robotic systems, educational robotics, and mechatronics were conducted “online”, “offline” and in a mixed format. “Op-line” classes during the pandemic were conducted in real-time: video conferences (Skype, Discord, MOODLE, ZOOM, Google Classroom, Microsoft Teams, Hangouts, Cisco WebEx Meetings, etc.). During the transition period, a mixed format was used.

“Offline” is carried out through internal communication services, chats and forums through its own Smart Zhetysu platform. Based on the analysis, it seems appropriate to build further experimental work based on pragmatic solutions aimed at modernizing the training of future non-core teachers of educational robotics. In Japan, there was a starting point for discussing a comprehensive robotics curriculum based on a modular approach. Based on the set of curricula of 19 departments in robotics, they identified the main courses that can be included in the preliminary concepts, and they will later become key modules for the study of robotics. Discussing the methodology of creating a comprehensive robotics curriculum, the authors note that the results obtained can be considered a kind of collective knowledge for creating a curriculum. In the future, the authors believe, that combining methodologies based on frameworks and modules will lead to constructive discussion and the creation of a comprehensive robotics curriculum.

The priority of modules in our view should be due to a collaborative curriculum, where the integration of educational robotics is due to an interdisciplinary approach, discursive hypotheses, research literature, and observations in the course of classes, allowing for flexible decisions. For full-fledged work, it is important to have a modern laboratory (Birk & Simunovic, 2021). A systematic review of the growing number of available robotic platforms is needed to keep up with current trends (Younis et al., 2021). Thus, the priority issues are the preparation of undergraduate students for the implementation of interdisciplinary opportunities in educational robotics, in comparison with retraining (Evripidou et al., 2020).

Suggestions

The architecture of the subsequent discourses in our vision should contribute to the improvement of curricula with flexible modules, which will be created in cooperation with the carriers of academic knowledge and empirical experience, as well as with the participation of students and employers. The improvement of educational and methodological complexes is rational with the direct cooperation of the departments of the subject area. Basic modern competencies, such as critical thinking, the ability to work in a team, and social skills, which are especially actively being formed in

the educational robotics course, should be directed to the "separation" of students as the most important component of independence. The novelty of the work concluded in the university training of future knowledge holders in educational robotics, is more expedient and promising than the subsequent retraining of personnel. This idea is based on the study of sources from the Web of Science and Scopus database, and MDPI over the past five years and the current situation in the country that solves personnel issues in this direction through retraining.

The results of the article will serve as a starting point for discussing and creating a curriculum and classification of the main modules in the educational programs "Information Systems" and "Physics", where an experiment is planned for the 2022-2023 academic years. As recommendations for future research directions, promising opportunities can be noted in the context of further pedagogization and humanization of educational robotics, focusing on methodological aspects, and not only on technical skills. We hope that our research will contribute to the concretization of academic discourse for solving priority and long-term tasks in this direction, solving urgent pedagogical problems related to the university training of graduates with basic skills in the use of educational robotics.

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