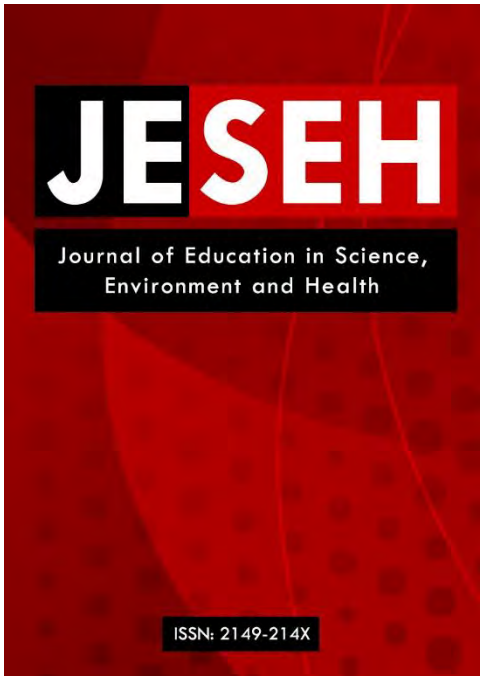

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Using Technology in Science Education: A Bibliometric Analysis

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Abstract

The aim of this study is to reveal the bibliometric profile of articles published in the field of science education and technology. In the study, in which descriptive research model was used, bibliometric analysis method was preferred in order to reveal and examine the research trends of scientific publications on science education and technology. In the study, Web of Science Core Collection was preferred as the database and VOSviewer program was preferred as the bibliometric network analysis program. In the Web of Science Core Collection database, 2485 articles were accessed after searching with the keywords "science educat*" and "technology*". As a result of the research, it was determined that the first article in the relevant subject area was published in 1980 and the most articles were published in 2022. The country with the highest number of publications in the related field is the USA. The researcher who published the most in the related field is Franz Xaver Bogner. The most publications were published in the Journal of Science Education. Most frequently used keyword in the related articles is science education. The study is important in terms of revealing the research trend of science education and technology articles.

Introduction

The adventure of technology started its journey as the construction and use of simple tools in daily life. Today, technology is an indispensable part of the age we live in and is involved in every aspect of life. The invention of computers and the spread of the internet have made technology an indispensable factor of daily life. Today, new information is produced every second, new inventions and new discoveries are made. These rapid changes and developments in science and technology bring about change in the field of education as in all fields (Turvey & Pachler, 2020). From the beginning of the history of education until today, education has continued its existence with two purposes. One of these purposes is the transfer of scientific knowledge, that is, what is known, while the other has been to support change and development in this context, to support creativity, to turn towards the unknown and to encourage innovation (Haddad & Draxter, 2002). In this context, it is not possible to consider technology and education as two separate elements. In today's world where scientific knowledge and technological developments are increasing rapidly, the ways of meeting the need for information may also differ. Educational systems and learning activities should be updated and made more effective in order to raise individuals with the qualifications to keep up with the age. This has been possible with the integration of technology into education systems (Dickinson & Bass, 2020; Means, 2010).

New competencies and skills required for the sustainability of knowledge-based societies necessitate continuous change in educational practices. Learners growing up in the digital age need to be skilled and equipped to process information faster than previous generations. For this reason, in recent years, information technologies, especially computer materials and other resources, have been used extensively in national educational institutions as part of the activities of many of the subjects. Digital games, web-based learning, video-conferencing, simulation programs, digital textbooks, virtual reality applications are some of these applications (Fernandes, et al., 2019; Plumb & Zamfir, 2008; Salazar, 2010). Many benefits such as designing appropriate learning environments focused on individual differences, developing these environments, making education and training services unlimited, delivering them to large masses (online, hybrid education, etc.), creating up-to-date, interactive and dynamic content, organizing in-class and out-of-class activities, ensuring active participation, ease in accessing and accessing information, realizing meaningful learning, designing alternative learning and measurement methods have been possible with the integration of technological information and systems into educational processes and programs. In the digital age we live in, technology is one of the leading factors affecting education systems, their effectiveness and efficiency. The most striking example of this situation is the global pandemic. Shortly after the start of the Covid-19 outbreak, schools and workplaces were closed to combat the pandemic. In some countries, curfews were imposed for control purposes. If technological systems that enable online education had not been developed and integrated in this process, millions of students around

the world would not have been able to attend education, online classes during the pandemic. Due to all these benefits, technology is used at every level and field of education (Melo et al., 2020; Raja & Nagasubramani, 2018; Teräs et al., 2020).

Although technology is used in all areas of education, science education is a field in which the relationship between education and technology is examined and questioned. When science education curricula from past to present are examined, the emphasis on technology in almost all curricula stands out. Over time, the relationship between science and technology has been emphasized with different concepts such as science, technology and society (STS) and STEM. When the nature of science and curricula are examined, it is clearly seen that they aim to provide individuals with many knowledge, skills, attitudes and behaviors on the nature, use, and development of technology. One of the clearest indicators of this aim is that one of the skills that science aims to provide individuals with is technological literacy. Science education and technology are two elements that support and develop each other (Barak, 2006; Looi et al., 2014; Young, et al., 2002). In this context, the aim of this study is to examine the bibliometric profile by determining the research trends of studies on science education and technology. Profile analysis of science and technology studies with bibliometric maps is of great importance considering that it can guide researchers who will work in this field. Researchers who want to conduct a study in the field of science education and technology will be able to access many bibliometric data such as the research areas in this field, the years with the most publications, the journals with the most publications, the authors, the most cited documents, the most frequently used keywords by examining the current study. Presenting these data to the literature will be a guide for future studies in the field of technology and science education.

Method

Research Model

The aim of this study is to examine the research trends of scientific publications on science education and technology and to reveal the bibliometric profile of the published articles. The study is a quantitative study. In the study in which the descriptive research model was preferred, it was deemed appropriate to use the bibliometric analysis method in order to reveal and examine the research trends of scientific publications on science education and technology. The bibliometric analysis method is one of the quantitative analysis methods because it presents the bibliographic characteristics of the literature in the subject area from past to present in the database in the form of numerical data (Hawkins, 2001). With the bibliometric analysis method, which is a popular method especially in recent times, it is possible to process large volume of scientific data obtained from scientific databases such as Scopus and Web of Science through bibliometric software such as Gephi, Leximancer, R, VOSviewer, and to determine the research trend and research profile for the selected topic (Donthu, et al., 2021; Donthu et al., 2021; Verma & Gustafsson, 2020).

Research Data

In the research, Web of Science Core Collection was preferred as the database from which bibliometric data would be obtained and VOSviewer program was preferred as the bibliometric network analysis program. The Web of Science Core Collection database was searched with the keywords “science educat*” and “technology*” in the topic title. In order to ensure that the documents that will constitute the data set consist of documents that are maximally related to the topic of science education and technology, which is the focus of the research, searches were made with these two key concepts. The title, abstract, keyword plus and author keywords tabs are searched with the searches made in the topic heading. For this reason, it was preferred to search under the topic heading in the research.

Through the search, 3983 scientific publications were reached. Among these publications, articles were what we focused on. Articles were the focus type of the study because they are the most common and representative type of scientific publications, have bibliometric indicators, contain original research findings, are comparable, and can be analyzed with bibliometric methods (Prahani et al., 2024). While creating the data file of the research, data for the year 2024 were not included in the data set. The interpretation of the data of 2024, which belongs to a year that has not yet been completed, was not included in the study on the grounds that it could affect the bibliometric profile and bias it. In this context, this study reveals the research trend of scientific articles on science education and technology until 2024. After the elimination process 2485 articles were selected in the relevant database constituted the data file of the study.

Data Collection Process

The data of the study were collected by the researchers in the spring semester of 2023-2024. Web of Science (WoS) database (Web of Science Core Collection provided by Clarivate Analytics) was used as the database in the study. Web of Science (WoS) was chosen as a database because it provides data from many different disciplines, has a wide coverage area, and contains reliable and high-impact scientific publications (Goodman & Deis, 2007; Zyoud et al., 2017). During the data collection process, the Web of Science Core Correlation database was searched with the keyword groups "science educat*" and "technology*" and the total number was recorded. The data file of the study consists of scientific articles published in the relevant subject area until 2024 in the Web of Science Core Collection database. After the creation of the data file, the data were analyzed. The data selection process is presented in Figure 1.

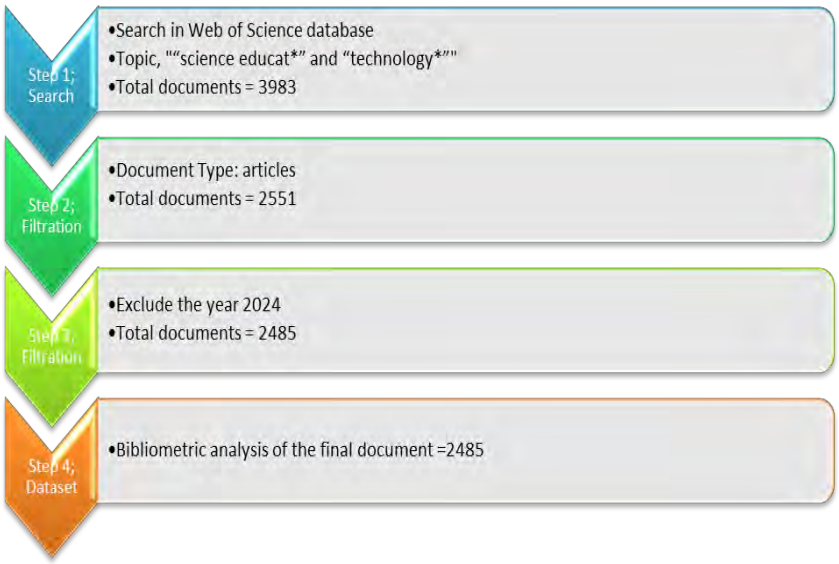


Figure 1. Data Selection Process

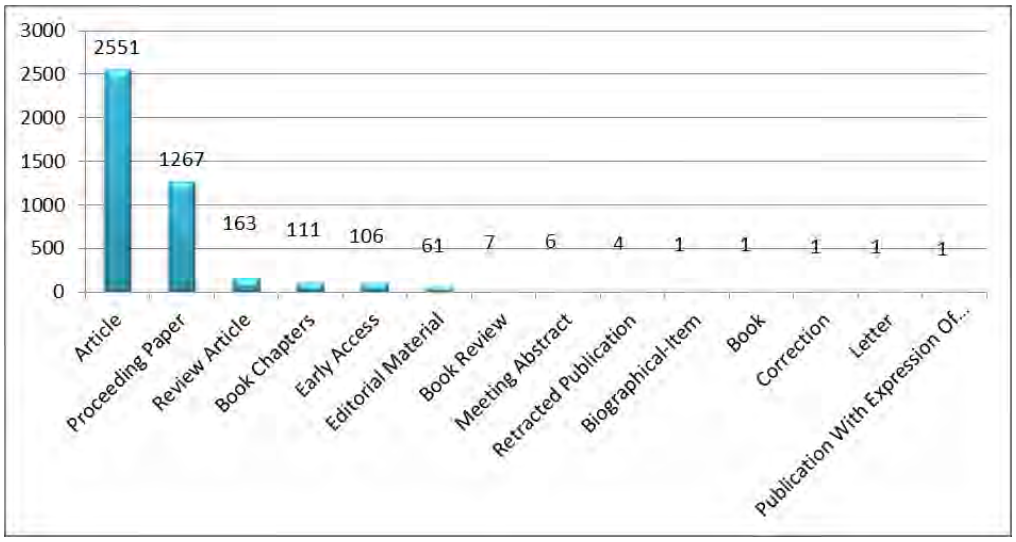
Data Analysis

As a result of the filtering for the research, the data file was created and analyzed. Descriptive analysis was performed to identify the main information, source titles, countries producing the most publications, and links in the research on science education and technology. The VOSviewer program uses the VOS (Visualization of Similarities) algorithm to visualize the data (Van Eck & Waltman, 2009). The biggest advantage of this program for the researcher is that it presents high quality visual material to the reader (Sinkovics, 2016). In addition, the program makes large-scale scientific network graphics easy to understand (Van Eck & Waltman, 2017). For all these reasons, the VOSviewer program was preferred for the analysis of bibliometric data in this study. As a result of the analysis performed with the VOSviewer program, co-occurrence network maps of the data were obtained. The circles in these visuals are related to the number of publications produced in the relevant unit (country, institution, journal, author, etc.). As the number of publications increases, the circle size increases. The links between the circles show the relationship between the units. The frequency of use of keywords is an indicator of the popularity of themes in a research area. In this context, in this study, keyword co-occurrence mapping was used to determine the frequency of keywords used in articles and to reflect the centrality of these concepts with a visual. In this map, the stronger the correlation between two keywords, the higher the frequency of their co-occurrence in the same publication (Pie et al., 2021; Van Eck & Waltman, 2014).

Results

In this part of the study, the distribution of articles published on science education and technology according to years, countries, institutions, authors and journals were examined. Graphs were used to visualize these distributions. While creating the graphs, the top 20 highest values were included in the graph to ensure data readability. Afterwards, unit collaborations were analyzed through network analysis. Within the scope of the research, the number of citations and the distribution of the relationship strength of these units were examined.

Finally, 20 frequently used keywords and the relationship between these words were analyzed. Before this information, the distribution of total documents by type is given to create a general framework about the documents on science education and technology published in the Web of Science database until 2024 (Graph 1).

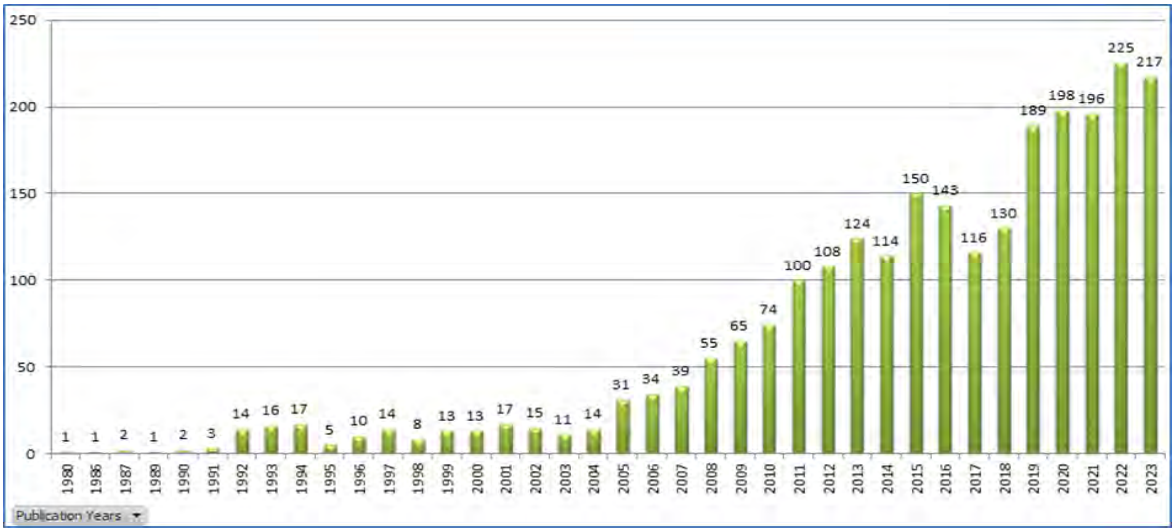


Graphic 1. Types of documents and numbers

In the Web of Science database, 3983 scientific documents on science education and technology have been published from past to present. As can be seen in the graph, the type of document with the highest publication rate is articles. Of these documents, 2551 are articles. 66 of the 2551 articles were published in 2024. In the Web of Science database, 2485 articles were published until 2024.

Findings Related to the Distribution of Science Education and Technology Articles by Years

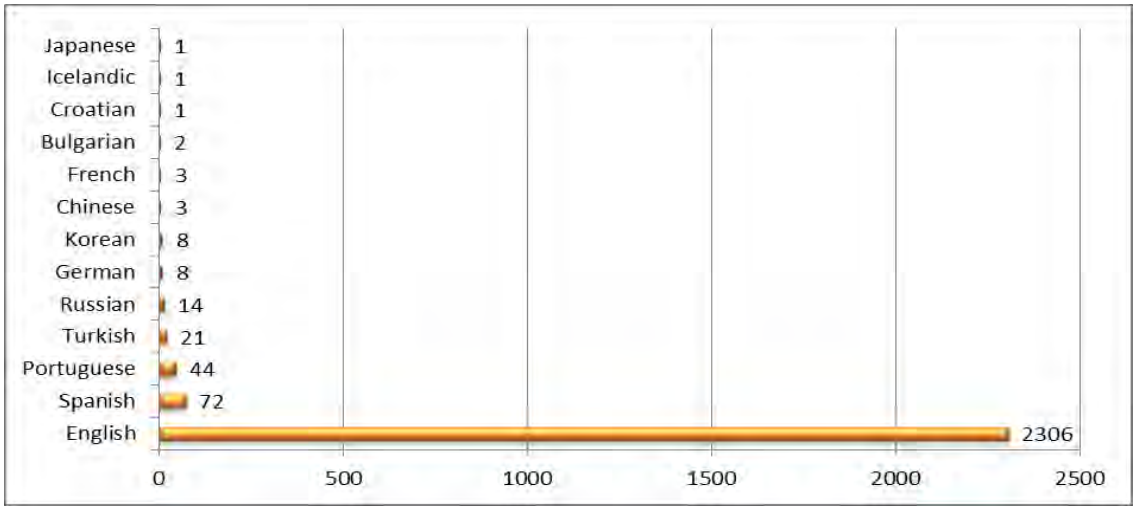
The first article on science education and technology in the Web of Science database was published in 1980. The first article published in the related database is "Technology in Science Education: The Next 10 Years." The article was published in a journal called "Computer". The publication year of the article after the first article is 1986. This article, "Science and Technology Related Global Problems - An International Survey of Science Educators", published 6 years after the first article, was published in the "Journal of Research in Science Teaching". From 1980 to 2023, there is a general increase in the trend of the number of articles is observed. The year with the highest number of articles published is 2022. In 2022, 225 articles on science education and technology were published in the Web of Science database. The least number of articles were published in 1980, 1986 and 1989. In all three years, 1 article was published (Graph 2). In this context, this study reflects the indicators and trends of the 44-year research trend between 1980 and 2023.



Graphic 2. Publication year and number of articles

Findings Related to the Language of Publication of Science Education and Technology Articles

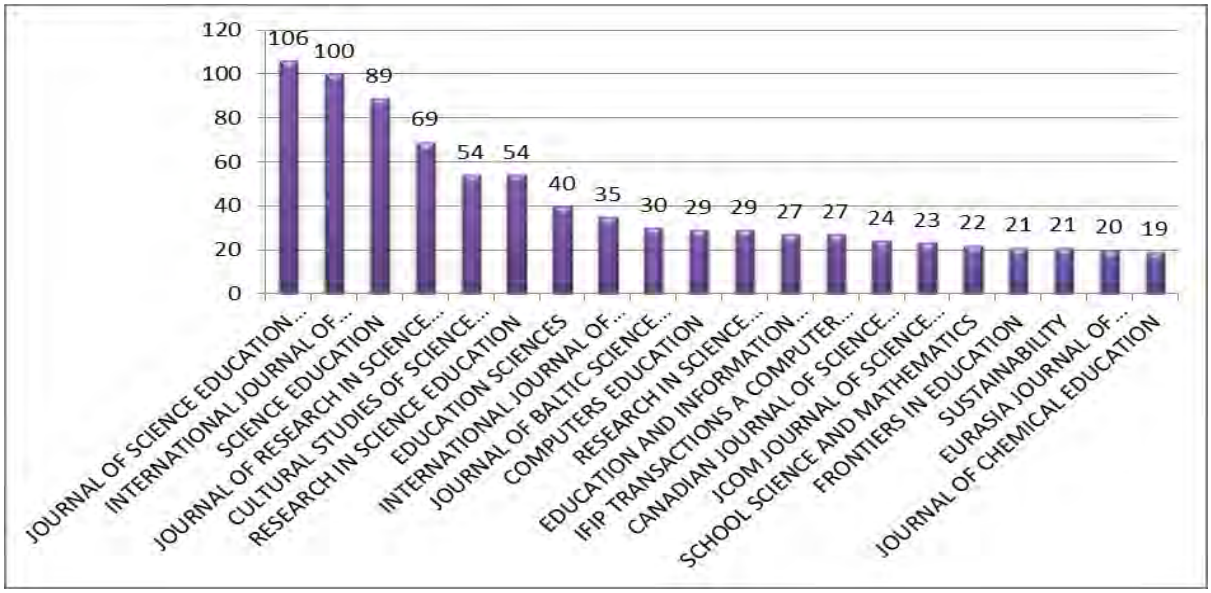
At this stage, the publication language of 2485 articles in the Web of Science database on science education and technology was analyzed. Among these articles, 2306 of them were published in English. 72 articles were written in Spanish, 44 in Portuguese, 21 in Turkish and 14 in Russian. In database, 13 different languages in which articles in the relevant subject area were published were identified. The publication languages and the number of publications in these languages are presented in Graph 3.



Graphic 3. Publication language and number of articles

Findings Related to the Distribution of Journals in which Science Education and Technology Articles Published

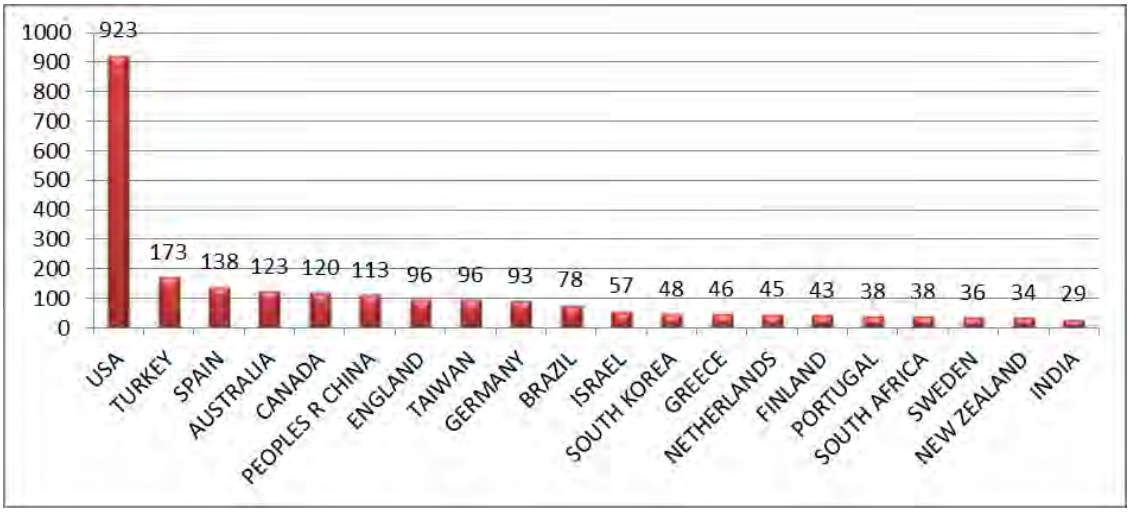
In the Web of Science database, the journal "Journal of Science Education and Technology" hosts the highest number of publications on science education and technology. It was determined that the journal published 106 articles on science education and technology. The second journal with the highest number of articles in the related subject area is "International Journal of Science Education" with 100 articles in the related subject area. "Science Education" ranked third with 89 articles, "Journal of Research in Science Teaching" ranked fourth with 69 articles, "Cultural Studies of Science Education" and "Research in Science Education" ranked fifth with 54 articles. There are 890 journals publishing articles on the subject in the relevant database. For the ease of data visualization, first 20 journals are presented (Graph 4).



Graphic 4. Publication titles and numbers

Findings on the Distribution of Science Education and Technology Articles by Country

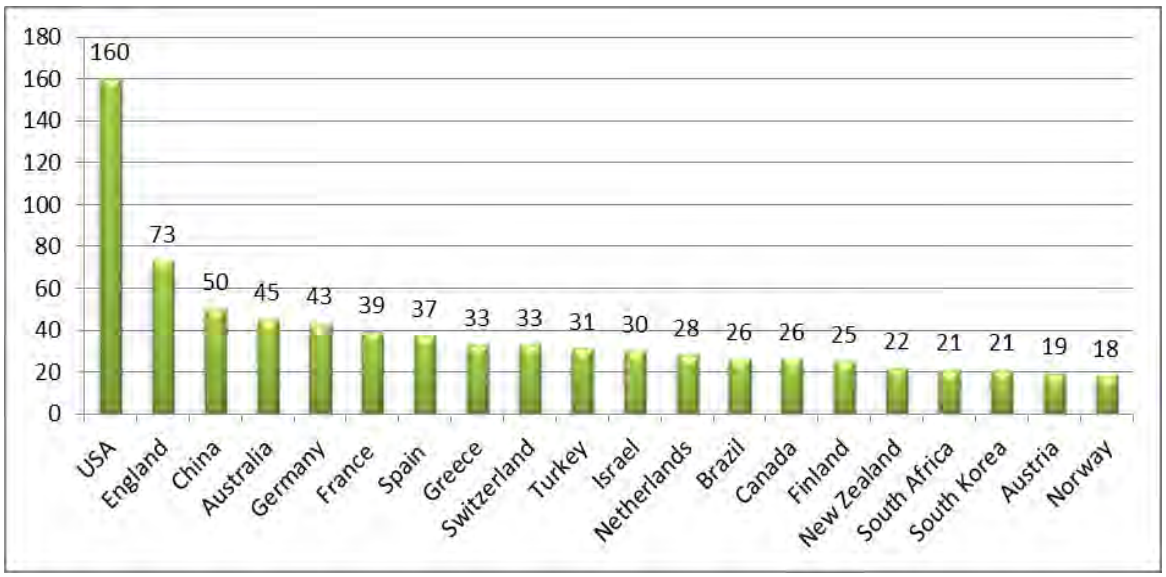
In the Web of Science database, the country with the highest number of publications in the subject area of science education and technology is the United States of America. The USA has 923 articles. Turkey ranks second with 173 articles. Spain ranks third with 138 articles, Australia ranks fourth with 123 articles and Canada ranks fifth with 120 articles. Although there are 116 countries/regions in the relevant database with articles on science education and technology, the first 20 countries are included for the ease of data readability (Graph 5).



Graphic 5. Countries and number of articles

Findings Related to Country Collaboration Publication Distribution of Science Education and Technology Articles

The countries with the highest number of publications on science education and technology in the Web of Science database are presented in Graph 5. The information on the relationship strength of the top 20 countries with the highest level of collaboration in articles on science education and technology published in the Web of Science database is presented in Graph 6.



Graphic 6. Countries and total relationship strength

When Graph 6 is analyzed, it is observed that the country with the highest number of collaborative publications in the field of science and technology is the United States of America. The United States is followed by England (73), China (50), Australia (45) and Germany (43). The network map of country-based collaboration of science and technology articles is presented in Figure 2.

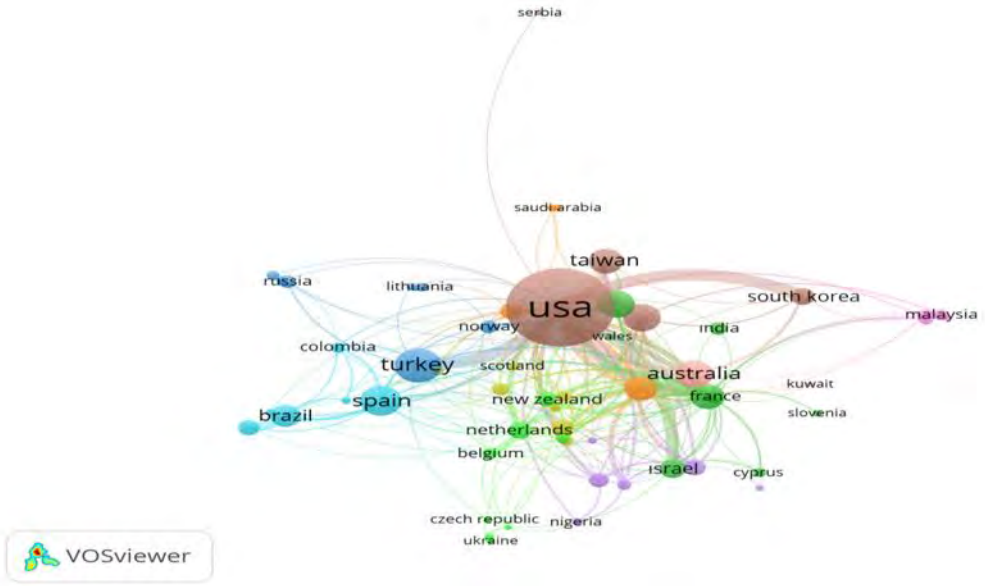
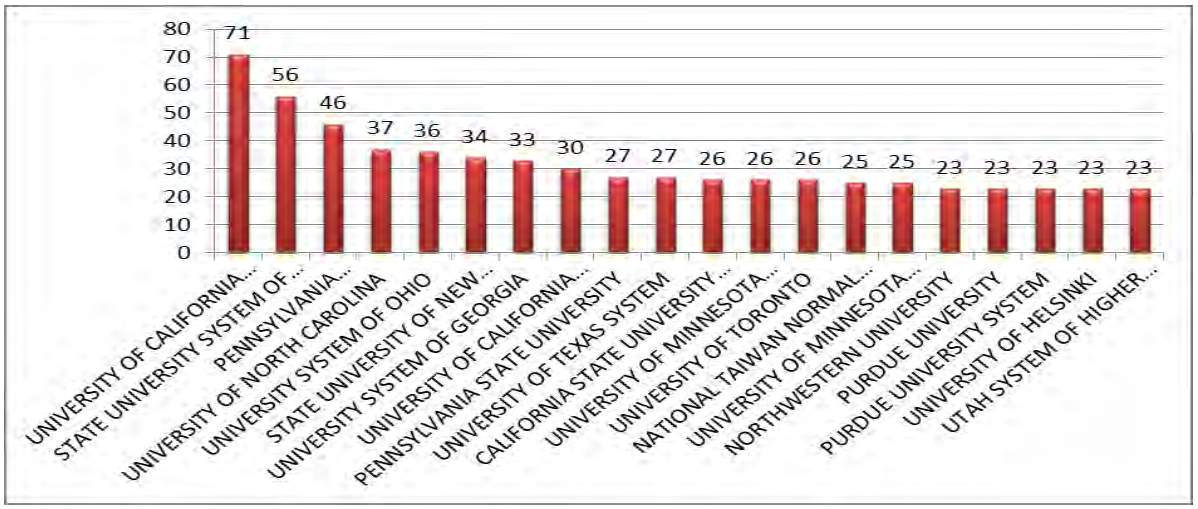


Figure 2. Country collaboration network map

When the network formation map presented in Figure 2 is examined, it is seen that the country with the highest number of collaborative and joint publications in the related subject area is the USA.

Findings Related to the Distribution of Science Education and Technology Publications by Publishing Institutions

When the institutions where analyzed, 2211 different institutions were observed as a result of the analysis. The institution with the highest number of studies in the related subject area is the "University of California System". University Of Calıfornia System was the institution where 71 articles on science and technology were studied. In the second place was the State University System of Florida (56), third was the Commonwealth System of Pennsylvania (46), fourth was the University of North Carolina (37) and fifth was the University System of Ohio (36). The top 20 institutions with the highest number of publications are presented in Graph 7.

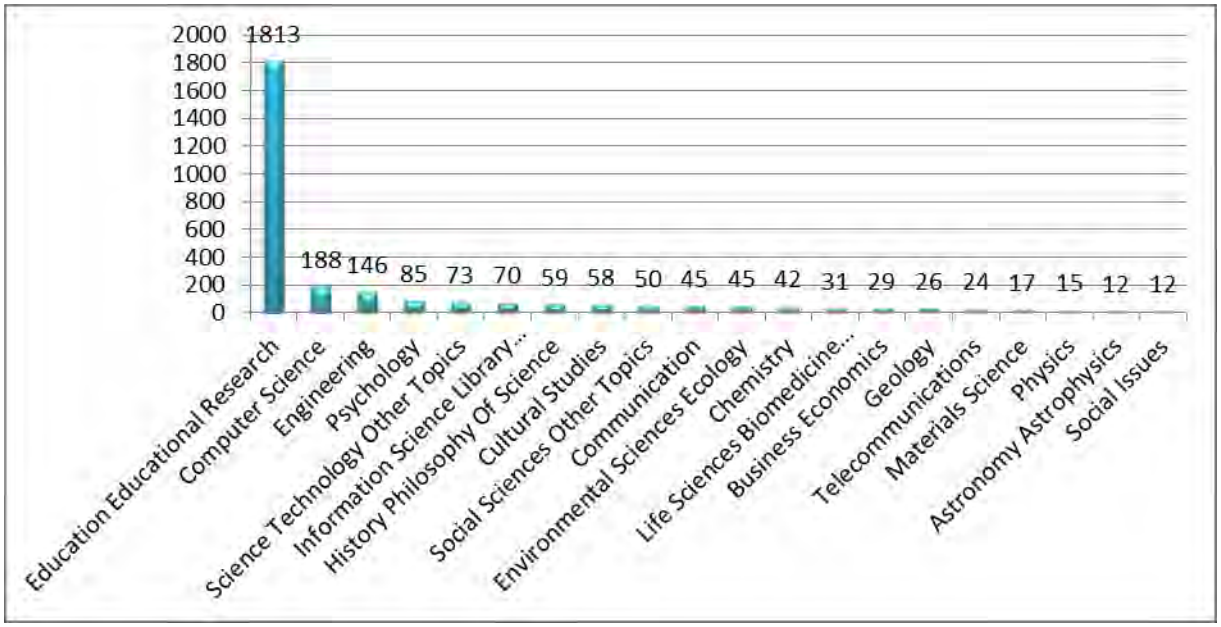


Graphic 7. Affiliations and number of articles

Findings Related to the Research Areas of Articles on Science Education and Technology

When the research areas of the articles on science education and technology published in the Web of Science database were analyzed, it was determined that the highest number of publications on this subject was in the

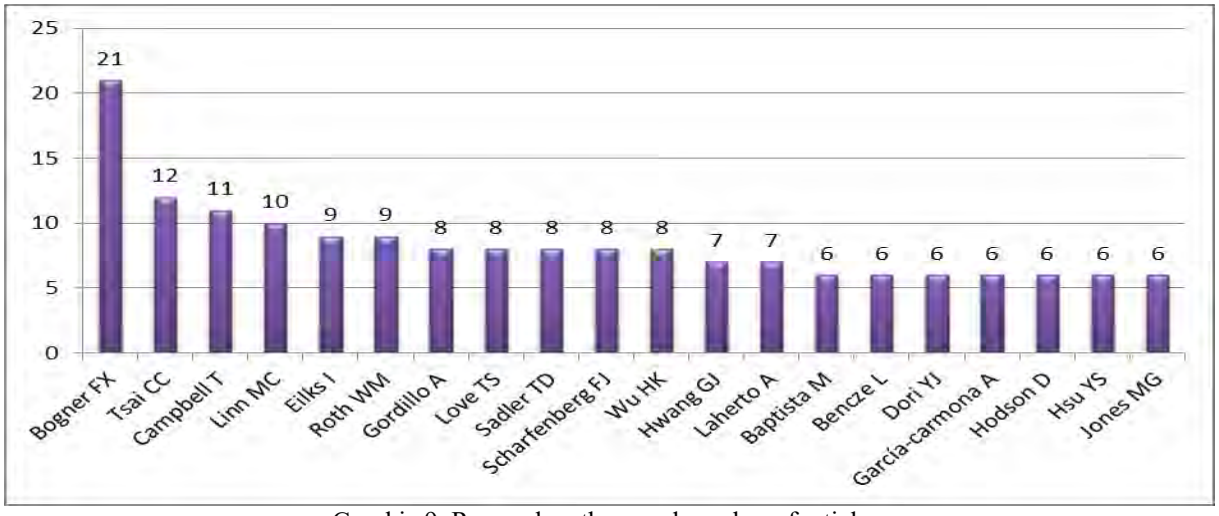
field of Educational Research. Of the 2485 articles analyzed, 1813 were in the field of Educational Research. Educational research is followed by Computer Science (188), Engineering (146), Psychology (85) and Science Technologies (73). Although 106 research areas with related topics are presented in the Web of Science database, the top 20 areas with the highest number of articles are presented in Graph 8.



Graphic 8. Research areas and number of articles

Findings Related to the Distribution of Science Education and Technology Articles by Author

When the Web of Science database was searched, there were 6401 authors who worked as researcher authors in articles on science education and technology. Among these authors, the researcher with the most articles in the related subject area is Bogner, Franz Xaver. The institution where the researcher author works is University of Bayreuth. The researcher has 21 articles in the area of research. The second author with the highest number of articles is Tsai, Chin-Chung (12), the third author is Campbell, Todd (11), the fourth author is Linn, Marcia C. (10) and the fifth author is Eilks, Ingo (9). The top 20 authors with the highest number of publications are listed in Graph 9.



Graphic 9. Research authors and number of articles

Within the scope of the analysis, the relationship strength of the collaboration of the authors working on science education and technology articles was also examined. The network formation map of the relationship strength of the authors is presented in Figure 3.

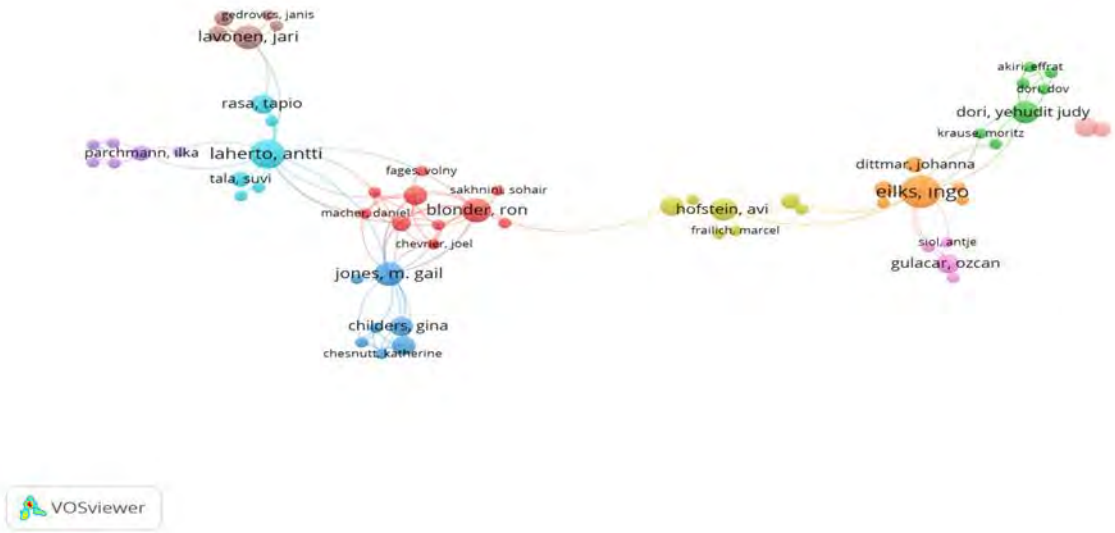
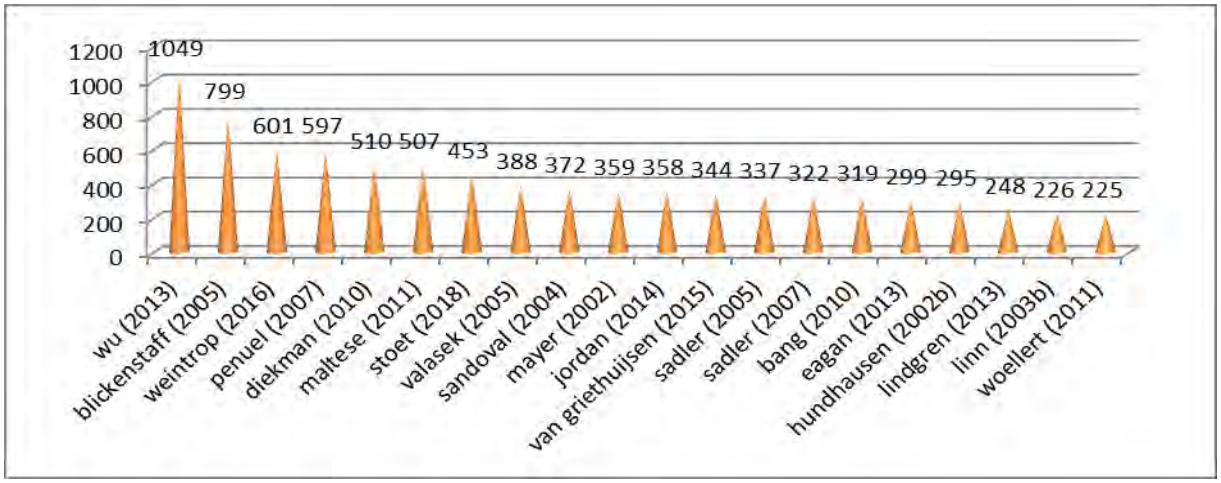


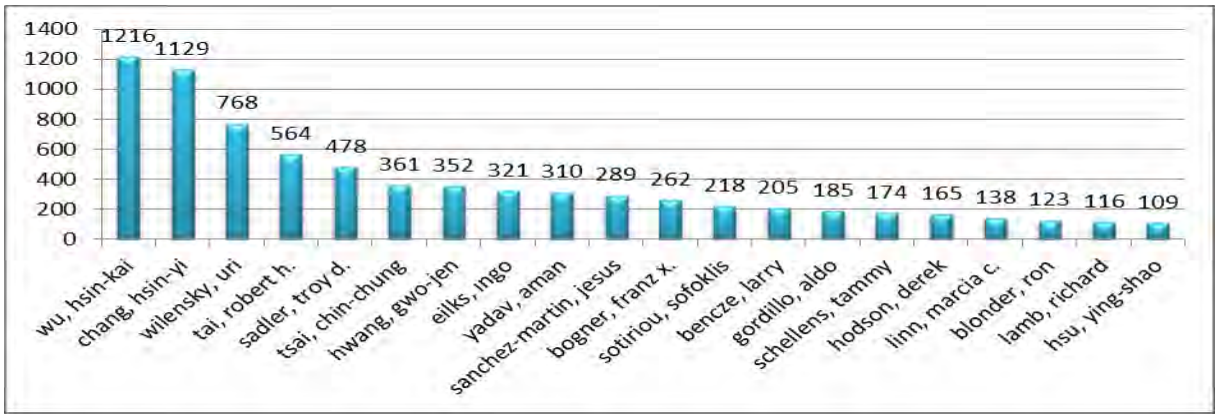
Figure 3. Author collaboration network map

Findings Related to Citation Statistics of Articles on Science Education and Technology

The document with the highest number of citations among the articles on science education and technology published in the Web of Science database is the study titled "Current status, opportunities and challenges of augmented reality in education" published in the journal "Computers and Education" in 2013. The document has 1049 citations. The 20 documents with the highest number of citations are presented in Graph 10.



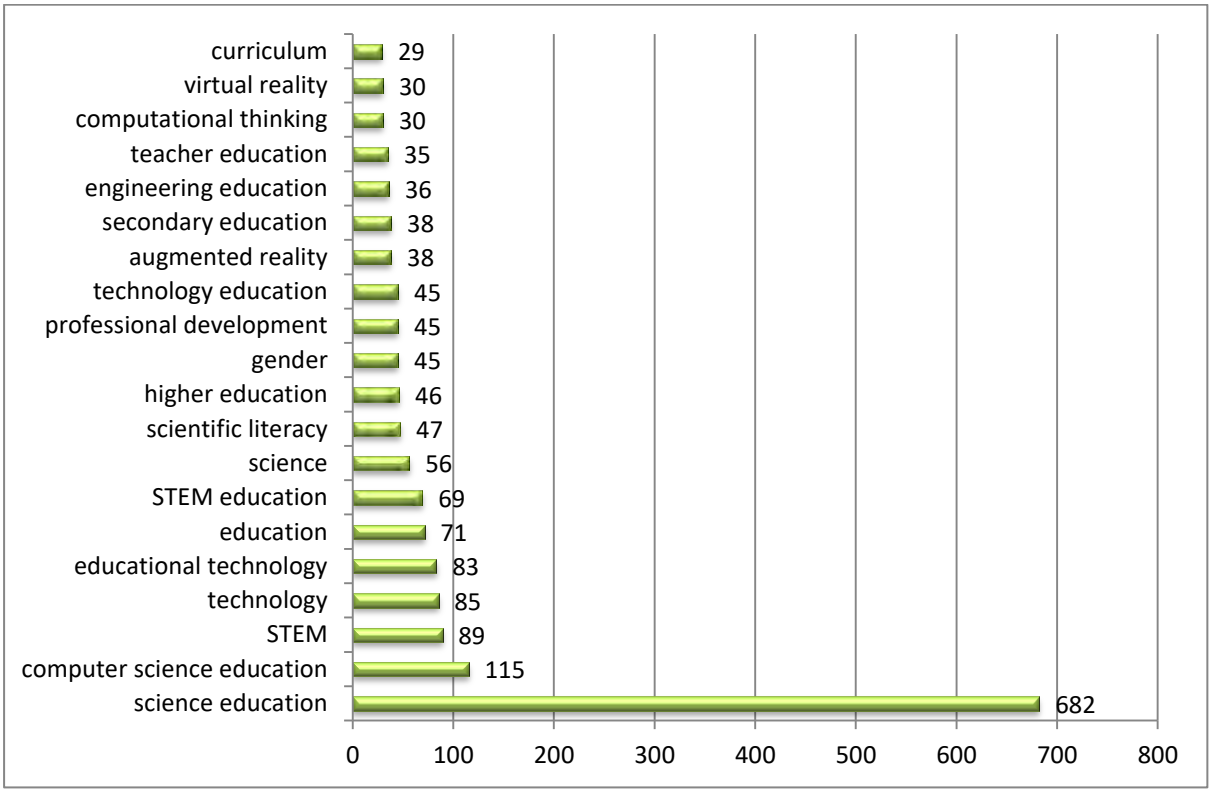
Graphic 10. Documents and citations



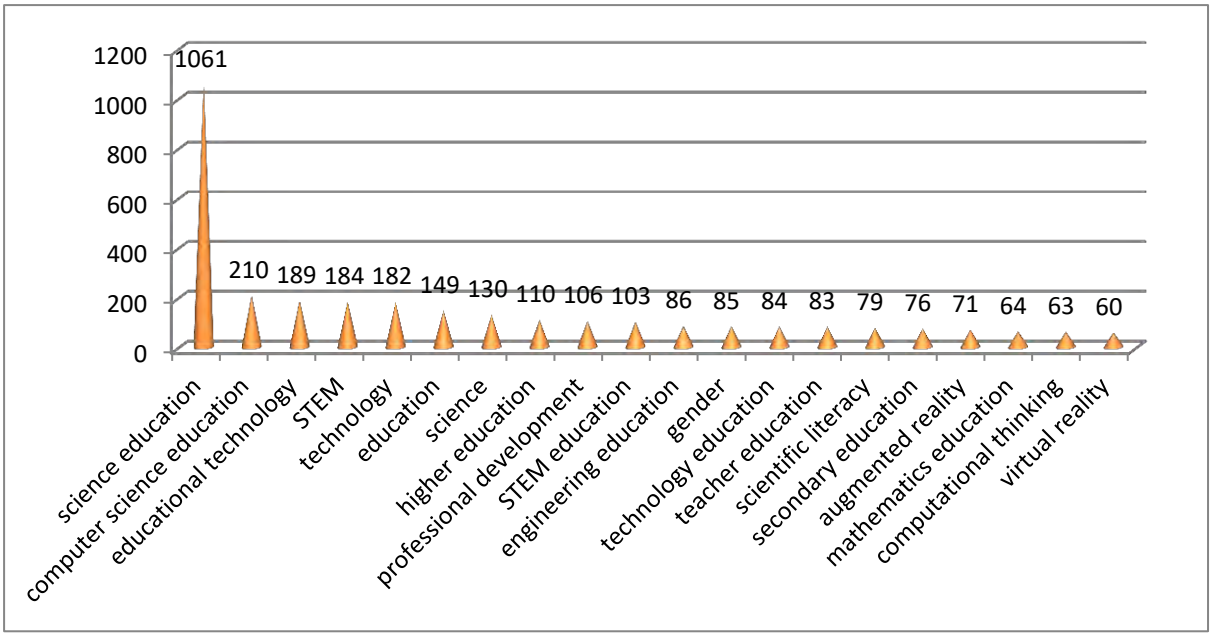
Graphic 11. Authors and citations

Findings Related to Keywords Used in Articles on Science Education and Technology

When the keywords used in the articles on science education and technology published in the Web of science database were analyzed, 5567 keywords were identified. 207 of these keywords were used at least 5 times or more. The most frequently used keyword is "science education". Science education has a frequency of use of 682 in related articles. The second most frequently used keyword is "computer science education" (115), the third keyword is "stem" (89), the fourth keyword is "technology" (85) and the fifth keyword is "educational technology" (83). The top 20 most frequently used keywords and their frequency of use are presented in Graph 12.



Graphic 12. Keywords and frequency of usage



Graphic 13. Keywords and total link strength

The total relationship strength of the 5 most frequently used keywords is as follows: science education (1061), computer science education (210), educational technology (189), stem (184) and technology (182). The keyword with the highest association strength is "science education", which is the most frequently used keyword. The top 20 keywords with the highest total relationship strength are presented in Graph 13.

The centrality and frequency of keywords are shown by co-occurrence mapping. As seen in the figure, the keywords with the largest ring are the most frequently used keywords. The larger the area of the figure with the keyword, the higher the frequency of use (Figure 4).

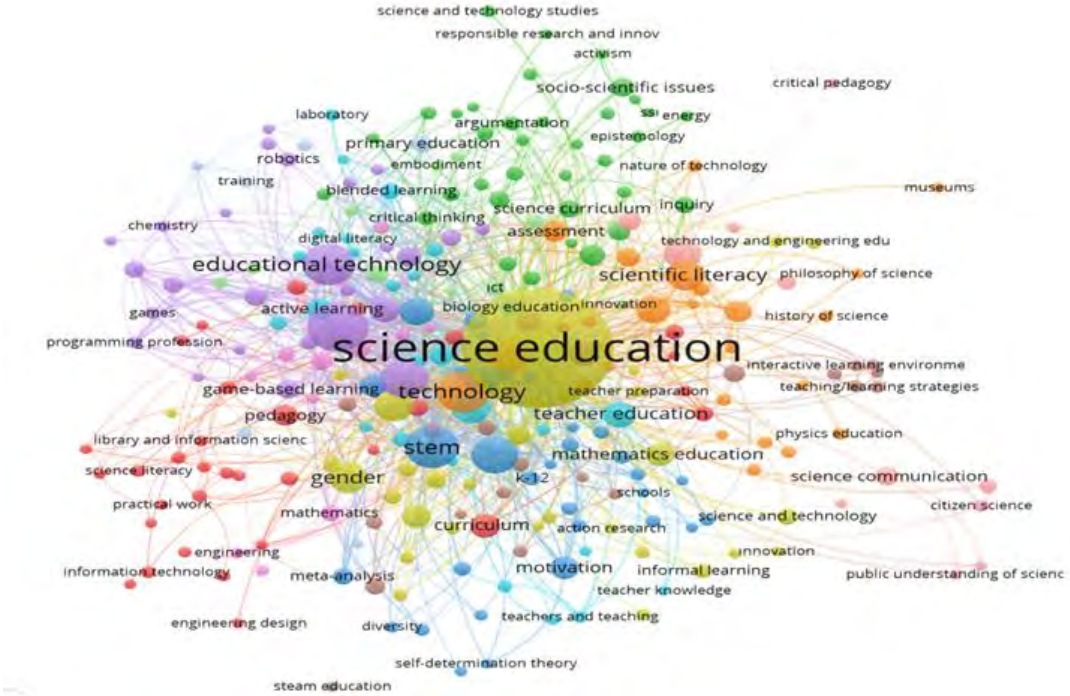


Figure 4. Keyword co-occurrence map

The co-occurrence map showing the keywords used together with the term science education, which is the most frequently used keyword, is presented in Figure 5.

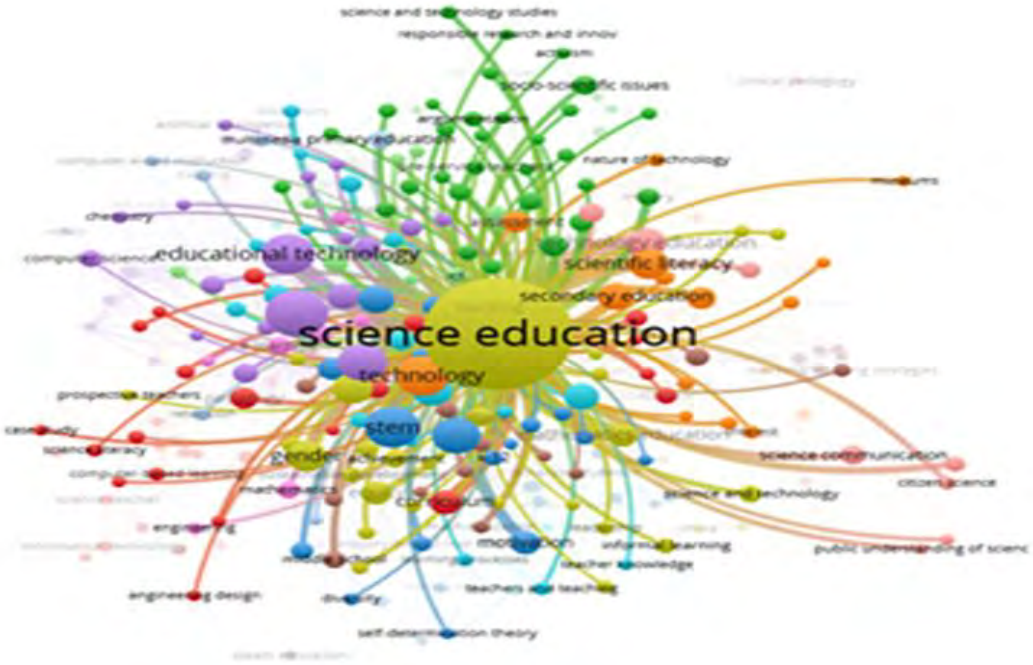


Figure 5. "Science education" co-occurrence map

Conclusion and Discussion

This study was conducted to determine the bibliometric profile of the articles on science education and technology in the literature. The research is a quantitative research. In the study where descriptive research model was adopted, bibliometric analysis method was used. In the study, bibliometric data were visualized and presented with graphs and co-occurrence maps. Web of Science database was used as the database to be scanned in the research and VOSviewer program was used as the analysis program. As a result of the first search in the database with keywords, 3983 documents on science education and technology were found in the Web of Science database. The documents were filtered by type and year. Due to the fact that scientific publications in the field of science education and technology may show the research profile incompletely, may negatively affect the interpretation of the research trend, and may lead to incorrect inferences, the current year 2024 data were not included in the study. After this filtering process, the analysis continued with the remaining 2485 articles.

When the data of the research are analyzed, it is seen that the first article on science education and technology in the relevant database was published in 1980. From 1980 to 2023, it can be said that there is a general increase in the number of publications. The year with the highest number of publications in the related subject area is 2022; the years with the least number of publications are 1980, 1986, and 1989. According to the results of the analysis, 92.7% of the 2485 articles were published in English. This is not surprising considering that English is the most widely spoken language in the world and academic world. The journal that hosts the highest number of publications in the related subject area is "Journal of Science Education and Technology". As the name of the journal suggests, it is a science education and technology themed journal. The journal hosted 4.26% of the total publications from 1992, the first year of publication, until 2023. Another finding of the study is the result regarding the countries where the publications were made. According to the results of the analysis, 37.1% of the articles in the relevant subject area were published in the United States of America. When the cooperation relationship of these countries was analyzed, it was determined that the USA was the country that cooperated the most in the related subject area publications. When the institutions where science education and technology subject area publications were made were examined, it was determined that the institution with the highest number of publications in the relevant subject area was the University of California System. As a result of the institutional analysis, 2211 institutions were observed and among these institutions, Unıversıty Of Californıa System ranked first with 71 articles on the subject. As seen in the results of the study, the country that publishes the most and cooperates the most on the relevant subject is the USA. The institution with the highest number of publications on the relevant subject is also located within the borders of the USA. These results can be interpreted as a result of the fact that science education and technology is a subject that is taken very seriously in USA educational institutions. In the United States, many societies such as the International Society for Technology in Education and the National Research Council have emphasized the importance of integrating technology into science education through their reports. It is known that science education and technology integration took place in university programs in the United States in the 1970' s with the Science-Technology-Society (STS) trilogy (Yager & Roy, 1990). It is also known that the concept of STEM, which is based on the integration of science and technology, originated in the United States (Cunningham & Higgins, 2015). Another finding of the study is the results related to the fields of study of the related articles. The results of the analysis show that most of the articles on science education and technology were conducted in the field of educational studies. 72.9% (1813 articles) of the related articles were conducted within the scope of educational research. Educational research is followed by computer science and engineering. When the authors of science education and technology articles are analyzed, 6401 researchers are listed in the database. The name with the most publications among the researchers is Bogner, Franz Xaver. The researcher author has 21 articles on the related subject and his institution is University of Bayreuth.

Another result of the research is the findings related to the citation statistics of articles in the field of science education and technology. When the citation statistics were examined, it was determined that the most cited article in this field was the publication titled "Current status, opportunities and challenges of augmented reality in education" written by Wu et al. (2013). The publication has 1049 citations. The researcher with the highest number of citations is Hsin Kai Wu, who one of the authors of the article with the highest number of citations. The researcher has 1216 citations. When the researcher author's research areas are examined, science education, technology learning and early STEM education attract attention. The most cited journal in the related field is "Science Education". The total number of citations of the journal's articles in the related subject area is 4017. The institution with the highest number of citations is Northwestern University. The total number of citations from the articles published in the related subject is 2248. The country with the highest number of citations is the United States of America, the country with the highest number of publications and collaborations. The United States of America received a total of 24281 citations from the articles published on the related subject. The keywords used in articles on science education and mathematics were analyzed. According to the results of the

analysis, the most frequently used keywords in science education and technology subject areas were science education (1061), computer science education (210), educational technology (189). In the fourth place is the concept of STEM (184), which is one of the most current and popular terms for the integration of technology into science education. The fact that the most frequently used word in the academic studies published on the related subject is science education can be interpreted as a result of the emphasis on the integration of technology and science education. It is only possible for individuals to acquire a behavior through education. In this context, one of the skills that individuals should acquire in the age of technology we are in is technology literacy skill. Science and technology cannot be considered separately, they are the locomotive of each other. For this reason, it is a situation that all facts related to technology should be included in science education. Technology learning and all skills related to technology are closely related to science education.

In this study, 44 years of research trends of articles on science education and technology were analyzed and bibliometric profile was revealed. The results of the study serve as a guide for researchers who want to conduct research or study in the field of science education and technology. By examining the study, a researcher interested in the field will be able to access the fields of study, journals, institutions, and countries that identify the relevant subject area as a theme. In addition, researchers will be able to have information about the authors who work and collaborate in this field the most, the most referenced articles, and will be able to access internationally influential sources. They will be able to access the most frequently used keywords in this field. In this context, researchers will be able to determine in which disciplines they will continue their research and which concepts they can include in their study. A researcher who has all this information will be able to conduct a literature review and plan his/her research in these contexts by accessing the research trends of articles on science education and technology. Another benefit of presenting bibliometric data is that it provides information about the institutions, documents and researchers that researchers who need information or support in the relevant field can turn to for help. Presenting this information to the literature is of great importance for researchers who want to examine the research trend of the subject area.

Recommendations

Researchers who want to have more detailed information on the relevant subject can conduct content analysis with the documents that make up the data file and reach detailed results about the methodology and findings of these studies. Researchers who want to study on the subject can expand their study data by searching different databases.

Scientific Ethics Declaration

The author declares that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the author.

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