

OPEN ACCESS

Manuscript ID:
EDU-2023-11024483

Volume: 11

Issue: 2

Month: March

Year: 2023

P-ISSN: 2320-2653

E-ISSN: 2582-1334

Received: 18.11.2022

Accepted: 20.02.2023

Published: 01.03.2023

Citation:

Aydemir, G., Orbay, K.,
& Orbay, M. (2023). A
Bibliometric Analysis
of Geometry Education
Research Based on Web
of Science Core Collection
Database. *Shanlax
International Journal of
Education*, 11(2), 1–9.

DOI:

[https://doi.org/10.34293/
education.v11i2.4483](https://doi.org/10.34293/education.v11i2.4483)



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A Bibliometric Analysis of Geometry Education Research Based on Web of Science Core Collection Database

Gizem Aydemir

Amasya University, Turkey

 <https://orcid.org/0000-0002-7642-4139>

Keziban Orbay

Amasya University, Turkey

 <https://orcid.org/0000-0002-7642-4139>

Metin Orbay

Amasya University, Turkey

 <https://orcid.org/0000-0001-5405-2883>

Abstract

Geometry has an important place in mathematics education because it forms the basis of mathematical thinking and allows us to see the emergence of logical theory. As in all fields, academic journals, which are among the official communication languages of science, play an important role in the construction, dissemination and use of scientific knowledge in the field of geometry teaching. With reference to this fact, the aim of the study was to examine articles published in the field of geometry teaching and indexed in SSCI (1975-2020) and ESCI (2015-2020) in the Web of Science Core Collection database by bibliometric analysis method. 109 articles related to geometry teaching (72 within the scope of SSCI and 37 within the scope of ESCI) were reached for the given periods. According to the findings of the research, while there has been a recent interest in geometry education within the scope of SSCI and ESCI, the number of articles still published is limited. Therefore, in mathematics teaching, geometry teaching lags behind areas such as arithmetic and algebra. Especially in recent years, it is noted that the keyword "Van Hiele Levels" and the keywords of innovations that technology brings to geometry education such as "Dynamic Geometry", "Virtual Reality", "Geogebra" and "Geometry Thinking" are frequently used in articles in the field of geometry teaching. It is observed that, while quantitative research methods are widely preferred in studies within the scope of SSCI in the field of geometry teaching, qualitative research methods are preferred within the scope of ESCI.

Keywords: Geometry Education, Bibliometric Analysis, Web of Science.

Introduction

Geometry has an important place in mathematics education because it both forms the basis of mathematical thinking and allows us to see the emergence of logical theory (Fujita et al., 2017; Herbest et al., 2017). However, in mathematics teaching, geometry teaching lags behind arithmetic and algebra fields. In addition, the reverse definition and formula-based processing of geometry courses to the logical structure indicates that less attention is paid to geometry training (Seah & Horne, 2020; Silfverberg, 2019). This encourages researchers to study geometry intensively. With each passing day, the value of scientific studies is increasing, especially studies that reveal the problems faced by students, teacher candidates and teachers in the field of geometry teaching and focus on how it should be by offering solutions with the teaching understandings required by the age (Birni, 2016; Noor & Alghadari, 2021).

Advances in information technologies have made it possible to access information easily and have increased the amount of information available by doubling every day (Fire & Guestrin, 2019). However, it is very important to extract the information obtained, to ensure that it does not remain as a pile of data that does not benefit with resource security and up-to-dateness. Therefore, classifying data rather than working with mass data allows to analyze better and access the accurate, reliable and adequate information needed (Civera et al., 2020; McGrail et al., 2006; Van Dalen, 2021). One of the methods that can be used for this purpose is bibliometric analysis, which was first described by Pritchard (1969). Bibliometric studies include the ones that reveal the current state, orientation and development of studies related to a branch of science (Donthu et al., 2021).

Today, articles published in journals scanned in citation indexes in the Web of Science Core Collection database (from now on, WoS) are predominantly accepted in the academic community and as a result, this database is often used in bibliometric analyses (Birkle et al., 2021; Li et al., 2018; Prancutè, 2021). The main components of the WoS database include "Science Citation Index Expanded" (SCIE), "Social Sciences Citation Index" (SSCI), "Arts & Humanities Citation Index" (A&HCI) and "Emerging Sources Citation Index" (ESCI) since 2015 (Clarivate Analytics, 2021).

A literature review showed that bibliometric studies on mathematics education were present (Fanjul et al., 2013; Hwang & Tu, 2020; Özkaya, 2018), but bibliometric study in the field of geometry teaching was not found. Therefore, the aim of the study was to examine the articles indexed in SSCI (1975-2020) and ESCI (2015-2020) in relation to the "geometry teaching and learning area" by the bibliometric analysis method.

The research problem (RQ) was determined as "What are the results of bibliometric analysis based on WoS database of articles published on geometry training?". The sub-problems are listed as follows, and each sub-problem is examined separately in both SSCI and ESCI;

- RQ1: What is the distribution of articles published in the field of geometry education by publication years and countries?

- RQ2: Which keywords stand out in articles in the field of geometry education?
- RQ3: What is the distribution of articles published in the field of geometry education according to research methods?

Methods

This study conducted a bibliometric analysis of a specific category from a literature database. The data were collected from the SSCI (1975-2020) and the ESCI (2015-2020) in the WoS on February 25, 2021. Only "articles" and "reviews" document types were taken into account, categorized under the term "papers" throughout the study. The WoS database has three sub-categories in the field of education. Of these, "Education & Educational Research" and "Special Education" categories are covered by SSCI, while "Education and Scientific Disciplines" is covered by SCIE. In order to be inclusive in the study, all three sub-categories were included in the study. Using the Advanced Search menu, scans were performed in the title, abstract section and keywords determined by the authors. Each search was conducted separately by selecting the relevant menus (More Setting) within the scope of "SSCI+SCIE" and "ESCI". The search code was entered as follows:

WC= (Education & Educational Research OR Education, Scientific Disciplines OR Education, Special) AND TS= ("geomet edu*" OR "geomet* teach*" OR "edu* of geomet*" OR "teach* of geomet*" OR "learn* geomet*" OR "geomet* of learn*")*

The scan conducted within the scope of SSCI and SCIE found 4 articles in "Education, Scientific Disciplines" and one article in "Education, Special" category. However, although these articles provided search codes, they were excluded from evaluation because they were not directly related to geometry training. On the other hand, there were 73 studies in the "Education & Educational Research" category, 1 of which was excluded from the evaluation because it was a Book Review. As a result, 72 articles were included in the study within the scope of SSCI. 22 of the 72 articles are open access and there are no compilation articles.

There were 38 studies in the "Education & Educational Research" category in ESCI, one of

which was editorial material. Therefore, 37 articles were included in the research within the scope of ESCI. 17 of the 37 articles are open access and there are no compilation articles.

A total of 109 articles scanned in SSCI and ESCI journals were studied in the WoS database. For the articles obtained; bibliometric analysis was carried out on the year of publication, country/region (hereafter referred to as “country” for simplification), spelling language, average number of authors, keywords used and methods of research.

Data obtained from the WoS were exported to VOSviewer 1.6.13, which was used to analyze and visualize bibliometric maps related to scientific affairs (Van Eck & Waltman, 2010).

Findings and Discussion

In this section, findings on research problems will be given and the results obtained will be interpreted.

Findings and Discussion for RQ1

The change of articles published in the field of geometry education within the scope of SSCI and ESCI in the WoS database is given in Figure 1-2. Since the first article in the field of geometry was published in 1982 within the scope of SSCI in Figure 1, the initial reference year of 1981 was taken and given in five-year slices.

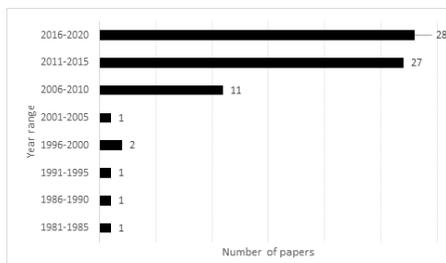


Figure 1 Trends in the Number of Geometry Education Related Papers in the SSCI between 1981 and 2020

As evident in Figure 1, it is seen that almost nonexistent articles were published in the journals scanned in SSCI in the field of geometry education until 2006, but in the following years, there was an increase in the number of publications. Within the scope of ESCI, more articles were published in 2017

and 2020 than in other years, but this number was limited to 4-5.

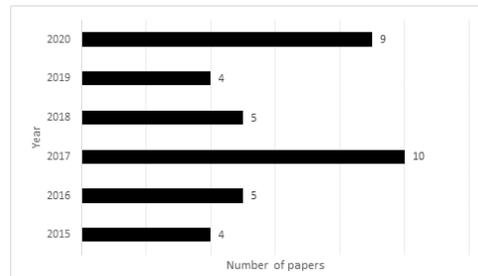


Figure 2 Trends in the Number of Geometry Education Related Papers in the ESCI between 2015 and 2020

The top ten most productive countries in the field of geometry education within the scope of SSCI and ESCI are given in Table 1.

Table 1 Top 10 Most Prolific Countries of Geometry Education Related Papers

SSCI		ESCI	
Country	Number of papers	Country	Number of papers
USA	19	Italy	5
Taiwan	11	Spain	5
Turkey	10	USA	5
South Africa	6	Turkey	4
Spain	6	Canada	3
China	4	Australia	2
Japan	3	England	2
Australia	2	Indonesia	2
England	2	Colombia	2
Israel	2	South Africa	2

As seen in Table 1, USA (26.38%) is the country that contributes the most to geometry education under SSCI, followed by Taiwan (15.27%) and Turkey (13.88%) respectively. Within the scope of ESCI, while Italy, Spain and USA (13.15%) are in the lead, they are followed by Turkey and Canada. On the other hand, in terms of the languages in which these articles are published, English is used as the dominant language, especially with 84.72% within

teaching has come to the forefront, especially using technology-supported software.

Findings and Discussion for RQ3

The distribution of articles published in the field of geometry education according to research methods is given separately in Table 4-5 for SSCI and ESCI.

Table 4 Distribution of Geometry Training Articles by Research Method for the SSCI

Research Method		Number of papers	% of Total papers
Quantitative	Experimental Research	24	33.33
	Scale Development	6	8.33
	Descriptive Research	4	5.55
	Relational Research	3	4.16
	Causal Comparison	2	2.77
	Mixed	Sequential Mixed Patterns	11
Qualitative	Case Study	9	12.50
	Document Analysis	3	4.16
	Metaanalysis	2	2.77
	Case Study	2	2.77
	Ethnographic	2	2.77
	Phenomenological (Fact Science)	2	2.77
	Clinical Interview	1	1.38
	Embedded Theory	1	1.38

When Table 4 is examined, it is seen that “quantitative research methods” are preferred compared to 54.16% (n=39) in the research methods of the articles within the scope of SSCI. It is stated that the most preferred pattern of quantitative research methods is “experimental research”. 29.16% (n=22) “qualitative research methods” are used in the researches. It is seen that the most

preferred pattern from qualitative research methods is “situation study”. It is seen that only “sequential mixed patterns” are used from mixed research method patterns.

Table 5 Distribution of Geometry Training Articles by Research Method for the ESCI

Research Methods		Number of papers	% of Total papers
Quantitative	Experimental Research	9	24.32
	Scale Development	3	8.11
	Relational Research	1	2.70
Qualitative	Literature Screening	5	13.51
	Case Study	3	8.11
	Action Research	3	8.11
	Observation	3	8.11
	Sample Case	2	5.41
	Methodological Review	2	5.41
	Semi-Structured Interview	2	5.41
	Mixed	Sequential Mixed design	4

When Table 5 is examined, it is seen that “qualitative research methods” are preferred compared to 54.05% (n=20) in the research methods of the articles within the scope of ESCI. It is stated that the most preferred pattern of qualitative research methods is “literature screening”. “Quantitative research methods” were used in 35.134% (n=13) of the researches. It is seen that the most preferred pattern of quantitative research methods is “experimental research”. It is seen that only “sequential mixed patterns” are used from mixed research method patterns.

On the other hand, the classification of geometry training articles according to sample or study groups was made separately for SSCI and ESCI and given in Table 8-9.

Table 6 The Distribution of Geometry Training Articles by Sample/workgroup is for the SSCI

Sample/Study Group		Number of papers	% of Total papers
Student	Elementary School Students	4	5.55
	Middle School Students	21	29.16
	High School Students	13	18.06
	University Students	6	8.33
Teacher		11	15.28
Student + Teacher		4	5.55
Scientific resources and textbooks		6	8.33
Researchers, mathematicians		2	2.78

As clearly seen from Table 6, it is seen that the most studies in the field of geometry education within the scope of SSCI are carried out with “middle school students” with a rate of 29.16% (n=21). It is seen that the least studies were studied with the sample group of “researchers, mathematicians” with a rate of 2.78% (n=2) in the articles covered by the study.

Table 7 Distribution of Geometry Training Articles by Sample/study Group for the ESCI

Sample/Study Group		Number of papers	% of Total papers
Student	Kindergarten Students	2	5.41
	Elementary School Students	3	8.11
	Middle School Students	6	16.27
	High School Students	3	8.11
	University Students	2	5.41
Teacher	Prospective Teacher	3	8.11
Teacher	Teacher	10	27.02
Teacher + Student		2	8.11

Scientific Resources and Textbooks	5	13.51
Researcher	1	2.70

When Table 7 is examined, it is seen that the most work in the field of geometry education within ESCI is done with 43.24% (n=16) students, but when categorized, the most work is done with “teacher” category with 27.02% (n=10). Teachers are followed by “middle school students” with 16.216 (n=6). It is seen that the sample/study group is “scientific resources and textbooks” in 13.513 % (n=5). It is revealed that “elementary school students”, “high school students”, “prospective teachers” have a rate of 8.108% (n=3); “kindergarten students” and “students + teachers” and “university students” who are included in the sample group along with the students have a rate of 5.405% (n=2). In the articles within the scope of the study, it is seen that the least studies are studied with the “researcher” sample group with a rate of 2.702 % (n=1).

Conclusion

Within the scope of the research, when geometry training articles were analyzed according to the years of publication, it was concluded that the most articles were made in 2020 with the number of publications within the scope of SSCI and 10 publications in 2017 within the scope of ESCI. It can be said that his articles on geometry education within the scope of both SSCI and ESCI have increased in recent years, albeit in a limited number.

Within the scope of the research, when geometry training articles are analyzed by countries of origin, it is seen that the USA ranks first with 19 publications in SSCI, while the most studies within ESCI are addressed to 5 publications in Italy, Spain and USA. Within the publication languages, English is a dominant language, but it is seen that the WoS database opens the door to languages and countries used in large geographies such as Spanish other than English, especially within the scope of the ESCI database created as a result of regional expansion policies.

When the geometry training articles within the scope of the research were analyzed according to the average number of authors, it was concluded

that there were 23 publications with two author that counted the highest number within the scope of SSCI. It was concluded that there were 2 publications with six authors that counted the lowest number. With 12 publications within the scope of ESCI, articles with the two authors and three authors are in the first place. In this case, it can be said that the articles in the field are preferred as multi-authored within the scope of ESCI as well as within the scope of SSCI. Kutluca et al. (2018) in their study in the field of mathematics education supports this situation, while Fanjul et al. (2013) found mostly “single author” supporting this situation.

When analysis of geometry training articles according to their keywords in the WoS database, 13 different articles within the scope of SSCI naturally found the keyword geometry. Similarly, when the geometry training articles under ESCI were analyzed, the keyword geometry was found in 15 different articles. In addition, the keywords “dynamic geometry” and “geogebra”, which bring a new approach to geometry education with the development of technology in both SSCI and ESCI articles, are also noted as a result of the analysis. When the year-long densities of keywords are examined with the VOSviewer program, it is concluded that words such as “geogebra”, “dynamic geometry software” and “technology” have come to the fore in recent times.

In the WoS database, it was concluded that geometry training articles were carried out with quantitative research method and experimental studies were more intensive than quantitative research methods with 24 publications when analyzed according to research methods. Studies using quantitative research methods were followed by studies using qualitative research methods, and it was concluded that the case study, which is one of the qualitative research methods with the number of 9 publications, was more preferred. It was concluded that qualitative research methods were preferred in the research method of 20 of the 37 articles within the scope of ESCI in the WoS database when the analysis of geometry training articles within the scope of ESCI was carried out. It was determined that the most preferred model of qualitative research methods was literature screening with 5 publications.

It was concluded that the most preferred quantitative research method with the number of 9 publications is experimental research. It was concluded that the least mixed research methods were used in both SSCI and ESCI articles and that only the sequential mixed pattern type was used, and that there was no diversity in mixed research methods. While studies conducted by Hwang and Tu (2020), and Çetinkaya and Biber (2020) supported the results of the study carried out within the scope of SSCI; studies conducted by Şahin and Başgül (2019), Kutluca et al. (2018) also supported the results of the study carried out within the scope of ESCI.

When analyzed according to the working groups/ participants of geometry teaching articles and those in the WoS database, 44 of the 72 articles within the scope of SSCI were studied with the students. With the number of 21 publications, it was concluded that the most studies were carried out with middle school students. It was concluded that the least preferred sample/study group with 2 publications were researchers and mathematicians. Within the scope of ESCI, it was concluded that 16 of the 37 articles were done with students, but when categorized, it was determined that the most work was done with the teacher with the number of 10 publications. Teachers are followed by middle school students with 6 publications. It was determined that the least studies were conducted with the “researcher” sample group with the number of 1 publication in the articles within the scope of the study. In the articles covered by both SSCI and ESCI, it was concluded that the most studies were carried out with the students. The results obtained by Tereci and Bindak, (2019); Hwang and Tu, (2020); Cetinkaya and Biber (2020) also support this result.

As a result of the study, it is suggested that qualitative and mixed studies related to the field of geometry education and the number of studies to be carried out with the sample/study group other than the students can be increased; bibliometric analyses can be made in the field of geometry education in scientific studies other than articles (thesis, books, papers, etc.); and database platforms can be increased.

Limitations

This study had a few limitations. First, only bibliometric data from the WoS was used; as a result, several important papers might have been missed in this study. Second, this study analyzed ‘articles and reviews’ document types, since it was believed that the dataset predominantly represented the industry standard, even though other datasets are emerging. Based on the limitations listed above, future study might expand the coverage of databases to include others, such as ERIC or Scopus.

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Author Details

Gizem Aydemir, Amasya University, Turkey, **Email ID:** gaydemir397@gmail.com

Keziban Orbay, Amasya University, Turkey, **Email ID:** keziban.orbay@amasya.edu.tr

Metin Orbay, Amasya University, Turkey, **Email ID:** metin.orbay@amasya.edu.tr