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A Bibliometric Research On Astronomy Education in Turkey and The Worldwide

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Abstract

This study aims to examine 152 articles in the field of astronomy education between 1972 and 2019 published in the Web of Science Core Collection (WOS) database by bibliometric analysis method. In this context, all the data corresponding to "astronomy education" in the Web of Science Core Collection databases were taken from the WOS database and various analyses were carried utilizing the R-Studio program and all bibliometric data of the studies were obtained. As a result of the analysis, the number of articles on the specified years, the average number of citations per year, the most published journals and the most prominent authors, the citation burst values of the authors, the countries, and the cooperation states of the corresponding authors, the most cited articles, the word cloud, and the word tree structures are also examined in the sub-titles of common citation and cooperation networks. According to the results obtained, it can be said that the interest in the subject area has been increased after 2011. It was determined that the articles were mostly published in the Journal of Astronomy and Earth Sciences Education, and the author who conducted the most studies was David H. McKinnon. The most cited study was found to be an article written by Plummer and Krajcik in 2010. In the written articles, it is shown that the countries most open to cooperation are India and Sweden. In addition, in the summary and keyword analysis of the studies, the most used words are "students" and "knowledge" after "science" and "astronomy". When the common citation network graph is analyzed, it is shown that Vosniadou, Bailey, and Trumper have made many citations for the subject area. In light of the results obtained, it is believed that this study will guide researchers focused on astronomy education.

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Introduction

Astronomy is one of the well-known branches of science. The Sun, the Moon, and the stars have always attracted the attention of human beings throughout history. Humankind, who previously gave various meanings to objects in the skydome, later carried out astronomy studies that contained scientific goals. Nowadays, it is possible to encounter frequent astronomical news about astronomical bodies such as comets, exoplanets, newly discovered stars, natural or artificial satellites, and space exploration missions by mass media devices. Such news is interesting for people of all ages, especially children and young people, and motivates them to learn about astronomy. (Martinez Pena & Gil Quilez, 2001). On the other hand, although astronomy is one of the oldest disciplines, it can be said that studies on astronomy education started with Sputnik (1957), which was launched into space in 1957. Because during this process, developed countries such as the United States of America (USA) and the Union of Soviet Socialist Republics (USSR; hereafter Russia) have made radical changes in education policies and curriculum in order not to fall behind in the space sciences race (Bishop, 2003; Marhe, 2002; Waller 2011). Astronomy education is a field; that embracing pedagogical researches that examine the methods used today to teach astronomy subjects, and astronomy education aims to develop these methods (Pasachoff & Percy, 2005). Astronomy education not only allows students to improve their scientific thinking skills but also helps students gain the ability to look at facts and events limited to the earth from a wider perspective by using concepts such as size, temperature, pressure, and magnetic field helps them gain this ability (Ampartzaki & Kalogiannakis, 2016; Padalkar Ramadas, 2011).

The concepts of astronomy are among the subjects that elementary and middle school students most curious about and want to learn (Bishop, 2003). Studies show that decreasing interest in science lessons increases again owing to astronomy (Pasachof & Percy, 2005). Astronomy education, which is taught as a separate course at middle and high school levels in many national curriculums, is given within the scope of science courses in our country. (Percy, 1996), When the middle school and elementary school science program which renewed in 2018 examined, it is seen that more importance is given to the subjects related to astronomy and space suggesting that astronomy subjects should be included among the first subjects to be taught at the beginning of the school year (MNE, 2018). According to a qualitative study conducted with teachers in Turkey, opinions have been determined that this new situation in the curriculum will contribute to science education despite all infrastructure and material deficiencies (Yetkiner, 2019). Astronomy has an interdisciplinary structure by its nature. Therefore, astronomy should be taught by a teaching method in which the astronomy topics are included in various subjects such as mathematics in elementary and middle school, as well as physics, mathematics, geography, biology, or history in high school (Pasachoff & Percy, 2005).

Astronomy subjects in science lessons attract quite an attention from students just like scientists. However, astronomy education is quite difficult in terms of the fact that most astronomy subjects are abstract. In the classroom or outside school activities, it is seen that observatories and planetariums are used in formal education for astronomy education (Borne, 2009; Percy, 1998). In the 21st century, interest in astronomy education researches has increased, particularly as a result of the integration of technology into education. Also, it is seen that the focus is on various subjects with strong educational aspects (Bailey, 2011; Blue, 2018). For example, Bailey and Slater (2003, 2005) studied more than 120 academic studies on astronomy education from 1948 to 2003. Considering the subjects of these studies, conceptual change in astronomy (Brewer, 2009); gravity (Agan & Sneider, 2004; Kavanagh & Sneider, 2007); moon phases and eclipses (Albanese, Danhoni Neves & Vicentini, 1997; Kavanagh, Agan & Sneider, 2005); and K-12 level astronomy lessons (Krumenaker, 2009) are observed as content.

How much of the astronomy and space sciences subjects are included by the scientific education programs applied in general or developed educational systems around the world and how students are getting affected by the theoretical or the activity-based applied teaching approaches are worth research. It is only possible to examine the education system of each country individually with a very comprehensive research project. However, this can be done through a more practical approach by examining the numbers and impact factors of research on "astronomy education". This study was carried out to examine the articles published in the field of astronomy education in recent years and the features of these articles. It was also carried out to contribute to potential astronomy education researches. In this study, "bibliometric analysis" was used. Firstly, the concept of "Bibliometry" is defined by Pritchard (1969) as "the application of mathematics and statistical methods into books and other communication tools." Bibliometry is an effective method to analyze the research trend of a specific area. By using the bibliometric analysis, it is possible to group publications according to their characteristics such as the number of citations, the name of the author, the name of the journal, the origin of the countries (or regions), the name of the institutions, the types of articles and the research fields.

Bibliometric analysis is a method that can render a scientifically reliable result in a researched thematic area and subject considering numerical relationships, trends, authors, social networks, collaborations. For example, there is no publication showing how much science education, which has an important place in the Turkish education system, includes astronomy-related activities and how effective these activities are yet. Also, for a wide range of time, no publication has been surveyed how much interest in science lessons developed after the changes to the curriculum. It is possible to find answers to such questions with this study. For example, according to Taner et al. (2017), there are 17 master's and 3 doctoral thesis studies at the education faculties of 19 universities focused on researching astronomy subjects related to science education between 2011 and 2017. In addition, a total of 17 articles were written, 4 of which were in foreign languages. There are only two articles that fully targeted the subject we questioned (Kurnaz et al., 2016; Tascan & Unal, 2015). To increase the number of such studies (thesis, articles, projects, festivals, congresses, seminars, etc.) in the world and Turkey and, the need to create a common archive with the inventory of scientific studies containing astronomy, it can be a preliminary study to contribute to both global and local researchers.

Methodology

A descriptive research model for the solution of the research problem was used in the study to determine the bibliometric properties of the articles corresponding to the keywords "astronomy education" in the Web of Science database. Descriptive research can be defined as the description of a specific event, phenomenon, or conditions of the situation. Each publication is considered as the data of the study, and these publications were examined by document analysis method (Buyukozturk et al., 2008). Research data consist of astronomy education articles published in different journals about the subject field at the Web of Science Core Collection between 1972 and 2019. Books, book chapters, reviews, editorial materials, and letter document types are not included in the study for the database survey related to the subject. Analyses were made only through article studies for the aim of the study. In the light of the data obtained about the subject field surveyed, it was seen that the first article in the database was published in 1972. Therefore, this date has been selected as the start date. Because 2020 is not over yet and it is thought that they might affect the result, the studies from this year have not been included in the study. The most important data sources for the bibliometric studies are international citation indexes, such as the Science Citation Index (SCI), Social Science Citation Index (SSCI), and Art & Humanities Citation Index (A&HCI). In this context, this research was conducted on the Web of Science Core Collection database, due to bibliometric analysis system run through the R-Studio program is compatible with this database, and being a database that provides access

to these indexes (Guzeller & Celiker, 2017; Kurtulus & Tatar, 2021). In the research, the surveying with the keywords of "astronomy education". Using article and time scales limitation, a total of 152 articles were reached for the aim of the research. The 152 articles related to the astronomy education field were reached by distribution per year, the average number of citations, the most published journals, the most published authors, the scientific productivity of the countries, the most cited sources, co-citation and collaboration networks, and text mining methods such as word cloud and word tree structures.

Search Procedure

R-Studio program was utilized for the results of the articles surveyed on research. The R environment provides many packages for bibliometric analysis via its official repository on https://cran.r-project.org/. These package programs used in bibliometry are useful for quantitative research (Aria & Cuccurullo, 2017). We used the R-Studio program for the bibliometric analysis because it provides more results and a more detailed presentation. Bibliometric analysis is an effective method for determining and evaluating countries, institutions, subject fields, journals, and particular research subjects (Huang et al., 2006).

The data file of the study prepared according to the criteria of the research from the Web of Science Core Collection database was obtained by selecting the following options respectively: export, other file formats, records from (1-500), record content (Full Record and Cited References). Because the data file contains 152 articles in the study, the data file was obtained by selecting the "bib text" option. Then, the bibliometric package was downloaded and activated via the R-Studio program. The "bibliometrix" package was run via R-Studio. Then, R-Studio program was directed to the bibliometry analysis page via an address. In here, the "bib text" file was uploaded to the data section and analyzed. Figure-1 includes the diagram of the study.

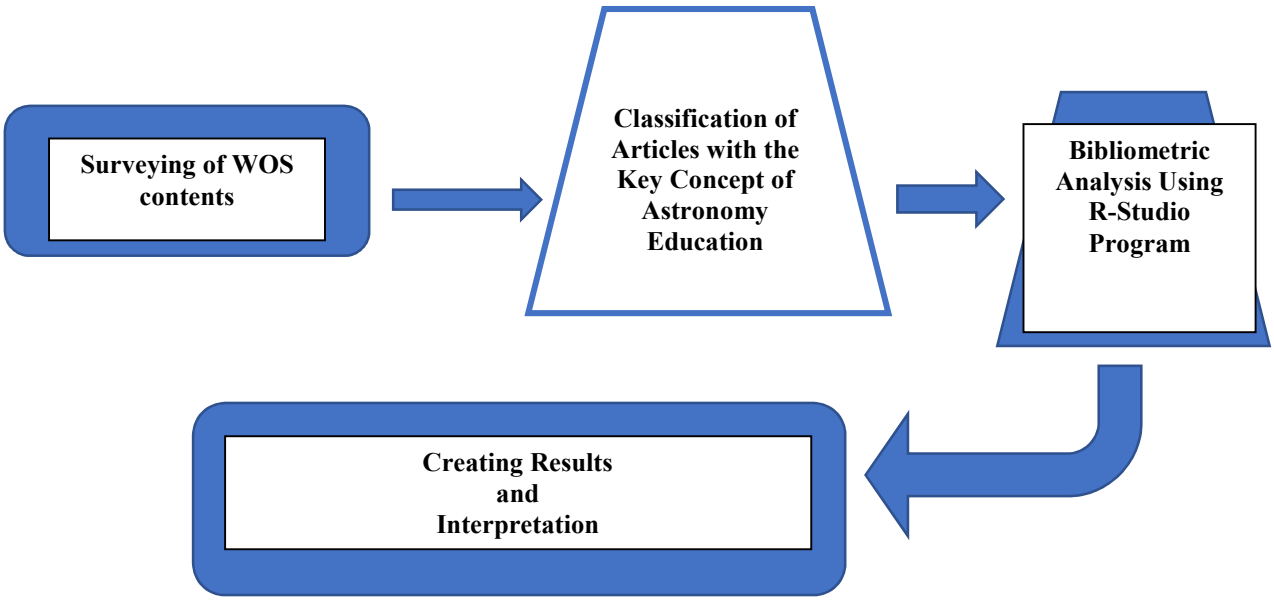

Figure 1. *The Diagram of the Study*

Findings

Information on total 152 articles related to astronomy education is shown in Table-1 by years.

Table 1
Number of articles by years

Year	Number of Articles (f)	Percent (%)
1972-1981	10	6.58
1982-1991	4	2.63
1992-2001	24	15.79
2002-2011	26	17.10
2012-2019	88	57.90

When the table is examined, it can see that the highest number of publications related to astronomy education is between 2012 and 2019 (f = 88). It is seen that studies related to astronomy education increased after 2011. The average number of citations for the subject field is shown in Figure-2.

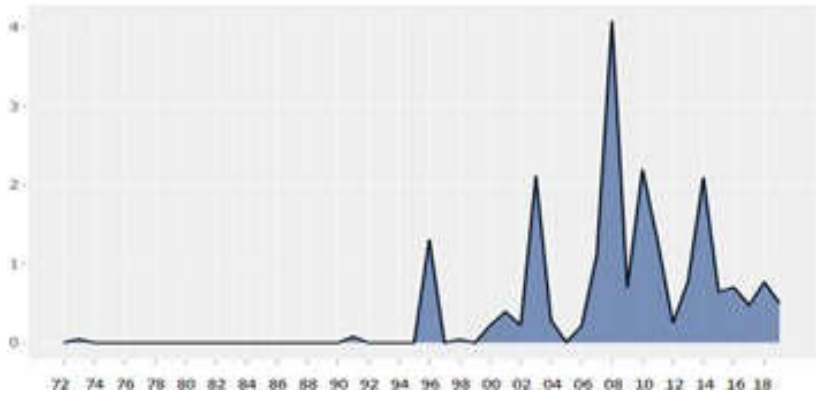

Figure 2. The average number of citations by years

When Figure-2 is examined, it is seen that the highest average number of citations per year is in 2008. Figure-3 shows in which journal the authors published according to the key concept in the center.

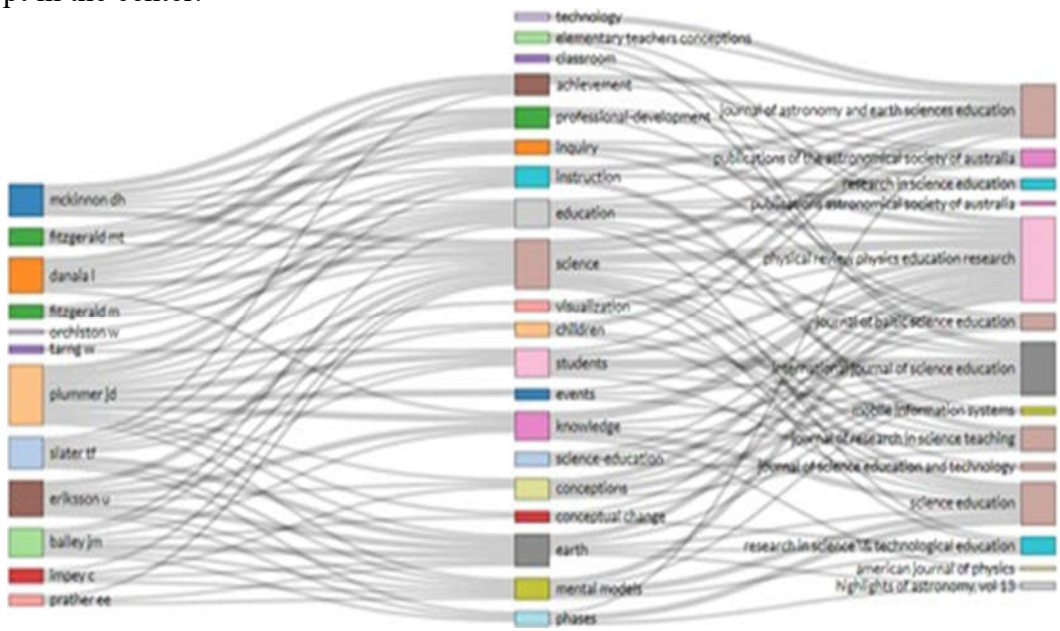

Figure 3. Field graph for the concept in the center

When the figure is examined, it is seen that even though it is directly related to the subject of astronomy publishing in journals on the concepts of “world” and “universe” are too few. The top 20 journals with the most papers published are shown in Figure-4.

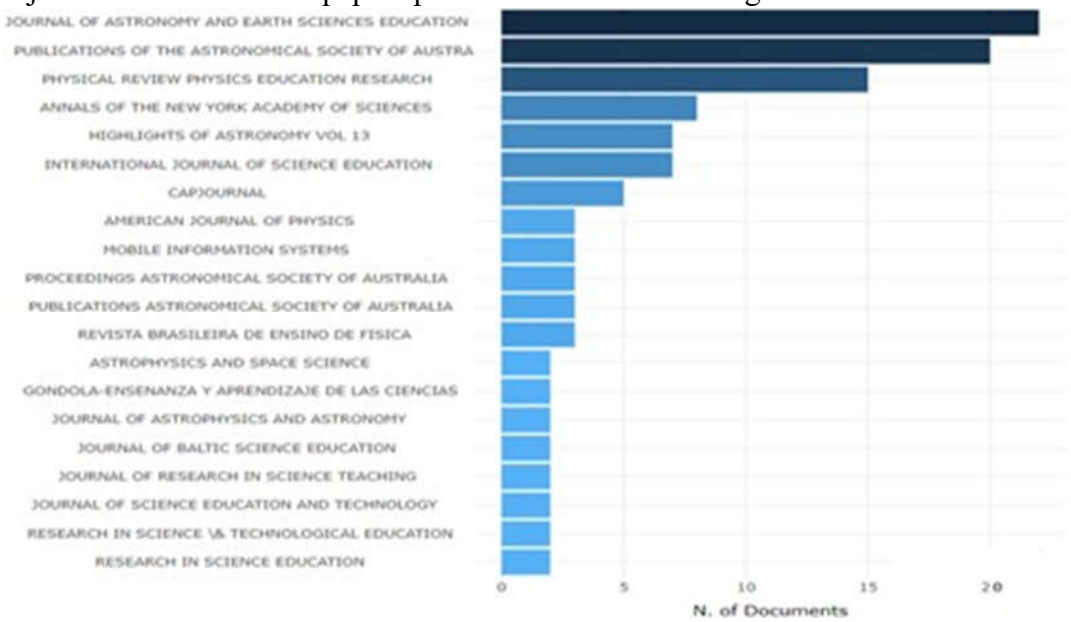

Figure 4. Most published journals about the subject field

The top 20 journals with the most papers published are shown in Figure-4. It can be seen that the most published journals of the studies conducted by surveying the concept of "astronomy education" are the Journal of Astronomy and Earth Sciences Education (f = 22), Publications of The Astronomical Society of Australia (f = 20), and Physical Review Physics Education Research (f = 15). Figure-5 includes the most published authors about the subject field.

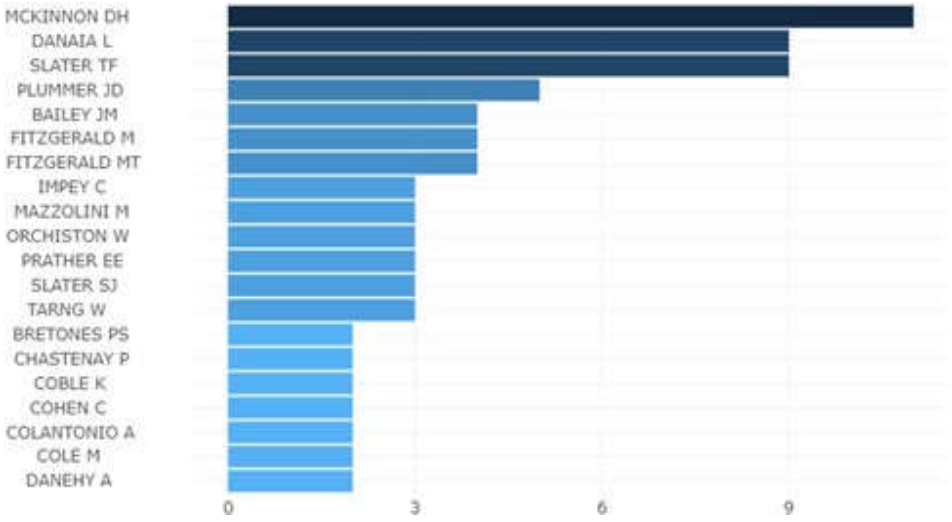

Figure 5. Most published authors about the subject field

When Figure-5 is examined, it is seen that the most published authors regarding the concept of “astronomy education” are David H. McKinnon (f = 11), Lena Danaia (f= 9), and Timothy F. Slater (f = 9). The first researcher is working at Edith Cowan University in Australia, the second researcher is at Charles Sturt University in Australia, and the last

researcher is at Wyoming University in the USA. Figure-6 includes to citation burst values of the authors.

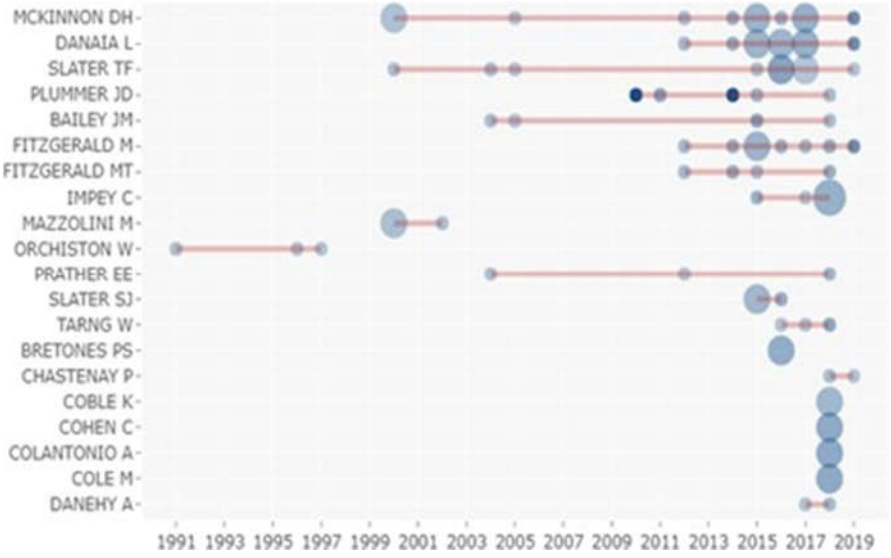

Figure 6. Citation burst values

Considering the citation burst values of the authors, the author with the highest citation burst between 2010 and 2018 is J.D. Plummer (5.91). Plummer is not the most cited author. This situation is caused by it being the most cited, during the citation burst year. It is seen that D.H. McKinnon is one of the leading names in the astronomy education field during the 19 years between 2010 and 2019. This situation is understandable from his continuous citation between 2000 and 2019. Table-2 includes authors with the highest four citation burst values.

Table 2
Citation burst values of authors and start-finish years

Authors	Burst	Start	Finish
J.D.Plummer	5.91	2010	2018
L.Danaia	2.50	2012	2019
M.Fitzgerald	2.50	2012	2019
D.H.McKinnon	2.50	2000	2019

When Table-2 is examined, it is seen that the researcher, who is the first in the citation burst value ranking, has a high burst value compared to other researchers. Figure-7 includes the countries of the corresponding authors.

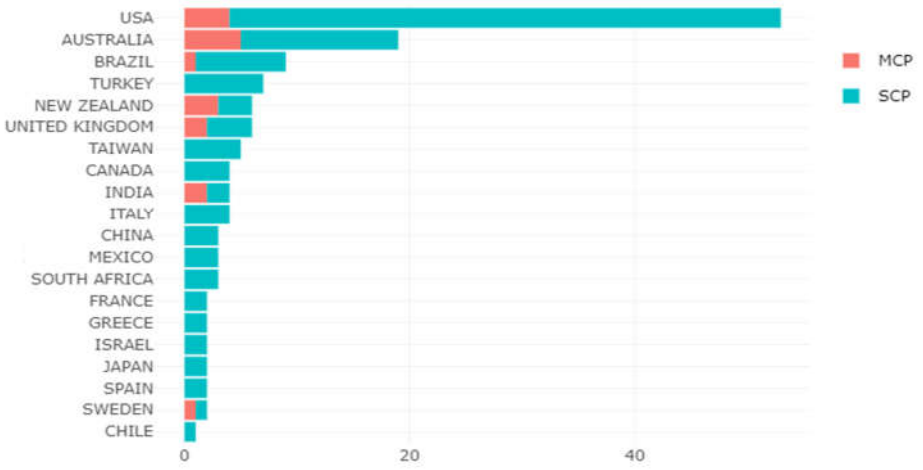

Figure 7. Corresponding author-article graph

In Figure-7, the countries of the corresponding authors who conducted the study are seen. The section called Single Country Publications (SCP) shows the number of publications published by the authors as a single country, and the section called Multiple Country Publications (MCP) shows the number of papers published in multiple countries. When the countries of the corresponding authors are examined, it is seen that the USA has 53 articles (SCP:49, MCP: 4) in total.

It is also seen those 19 articles (SCP: 14, MCP: 5) in Australia, and 9 articles (SCP: 8, MCP:1) in Brazil. Turkey is in the fourth rank with 7 articles. (SCP: 7 MCP: 0) (Table-3).

Table 3
The most productive countries of corresponding authors

Country	Article	Frequency	SCP	MCP	MCP Rates
USA	53	0.37589	49	4	0.0755
AUSTRALIA	19	0.13475	14	5	0.2632
BRAZIL	9	0.06383	8	1	0.1111
TURKEY	7	0.04965	7	0	0
NEW ZEALAND	6	0.04255	3	3	0.5
UNITED KINGDOM	6	0.04255	4	2	0.3333
TAIWAN	5	0.03546	5	0	0
CANADA	4	0.02837	4	0	0
INDIA	4	0.02837	2	2	0.5
ITALY	4	0.02837	4	0	0
CHINA	3	0.02128	3	0	0
MEXICO	3	0.02128	3	0	0
SOUTH AFRICA	3	0.02128	3	0	0
FRANCE	2	0.01418	2	0	0
GREECE	2	0.01418	2	0	0
ISRAEL	2	0.01418	2	0	0
JAPAN	2	0.01418	2	0	0
SPAIN	2	0.01418	2	0	0
SWEDEN	2	0.01418	1	1	0.5
CHILE	1	0.00709	1	0	0

Table-3 includes the top 20 countries according to the number of articles. According to the table, although the USA ranks first in the number of articles, it has a low MCP rate. Among the twenty countries; it can be seen that in 9th place India and 19th place Sweden have the

highest MCP rates. This shows that India and Sweden are more open to international collaboration, or to work with authors from different countries. Figure-8 shows the article production of the countries.

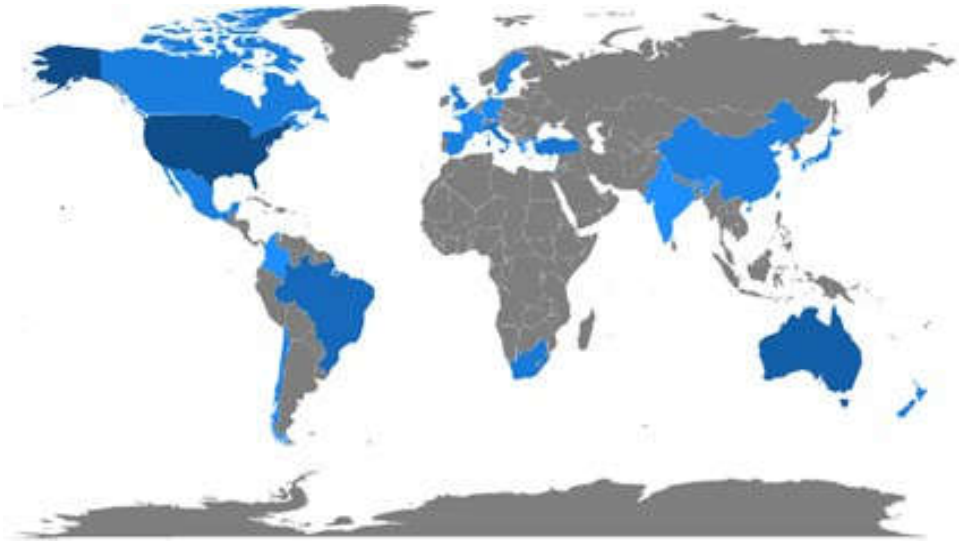

Figure 8. Scientific productivity of countries

When Figure-8 is examined, the colors from dark blue to light blue on the map show the number of publications. It is understood that the number of articles decreased gradually from dark blue to light blue. In gray countries, there are no articles in the surveyed database. When the quantitative data part of the map is examined, the USA ranks in the top with 119 studies, Australia ranks 2nd with 39 studies, and Brazil ranks 3rd with 21 studies. Turkey ranks 6th with a total of eight studies. As a result of the analysis, although there is a historical background related to astronomy, no studies about Russia's astronomy education were found according to the database analysis made with the study criteria. Figure-9 includes the most cited countries.

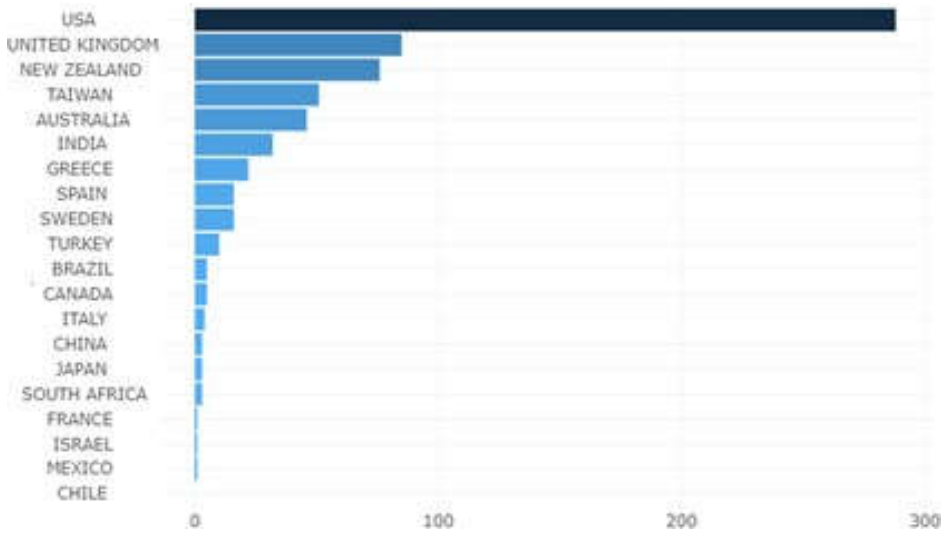

Figure 9. Most cited countries

When Figure-9 is examined, it is seen that the most cited countries on the subject are the USA (f = 288), England (f = 85), and New Zealand (f = 76). The most cited studies are included in Figure 10.

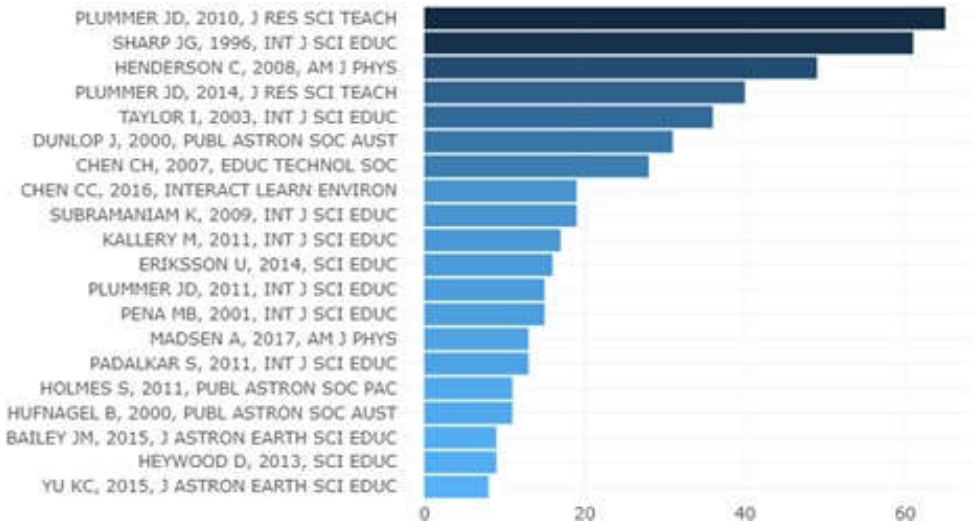

Figure 10. Most cited studies

When Figure-10 is examined, it is seen that the studies with the most citation about the subject of astronomy education on the globe are studies of Plummer and Krajcik (2010) with 65 citations, and Sharp (1996) with 61 citations, and Henderson (2008) with 49 citations. Figure-11 shows the graph of the most used keywords in the articles.

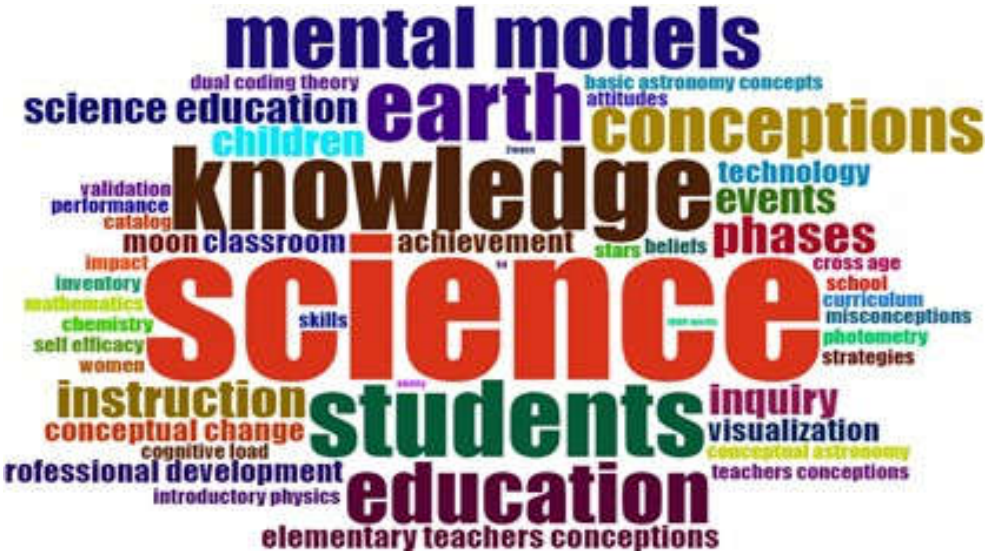

Figure 11. Word cloud

Word Cloud is one of the text mining methods that shows the most used words in a text or paragraph. The word in the center shows the most used word on the subject field. The size of the words and their proximity to the center shows the words used on to the subject field. As the word size decreases and moves away from the center, it indicates that the word is used less frequently. When Figure-11 is examined, the most used keywords on the subject of astronomy education are science (f = 19), knowledge (f = 11), students (f = 10), earth (f = 9), and education

(f = 8). In Figure-12, there is a graph showing the most used words in the summary section of the articles.

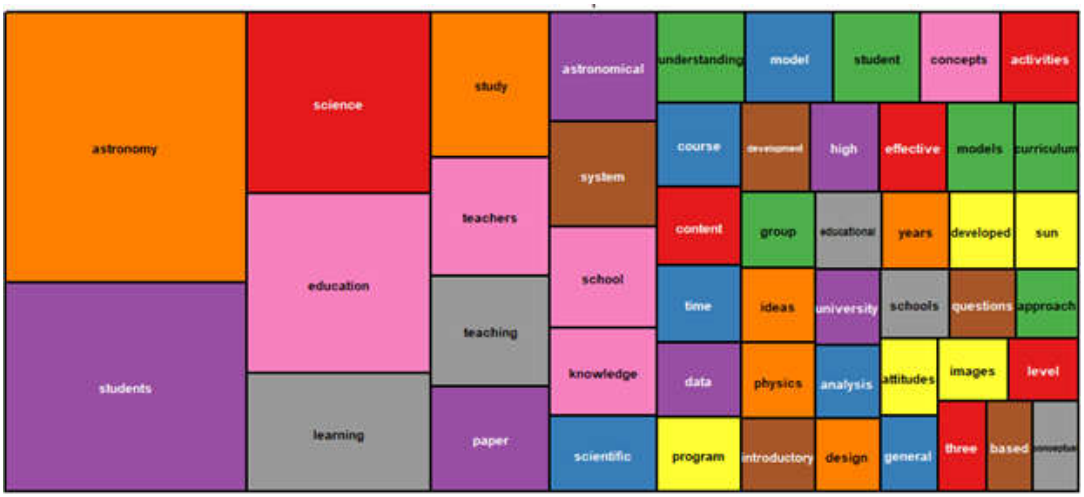

Figure 12. Map of the word tree

Word TreeMap, which is one of the text mining methods, shows the most used words in a text or paragraph. The words in Figure-12 show the most used words in the summary section of studies related to astronomy education. According to the graphic, the most used words are; astronomy (f=339), students (f=264), and science (f=174). Figure-13 includes the common citation network graph.

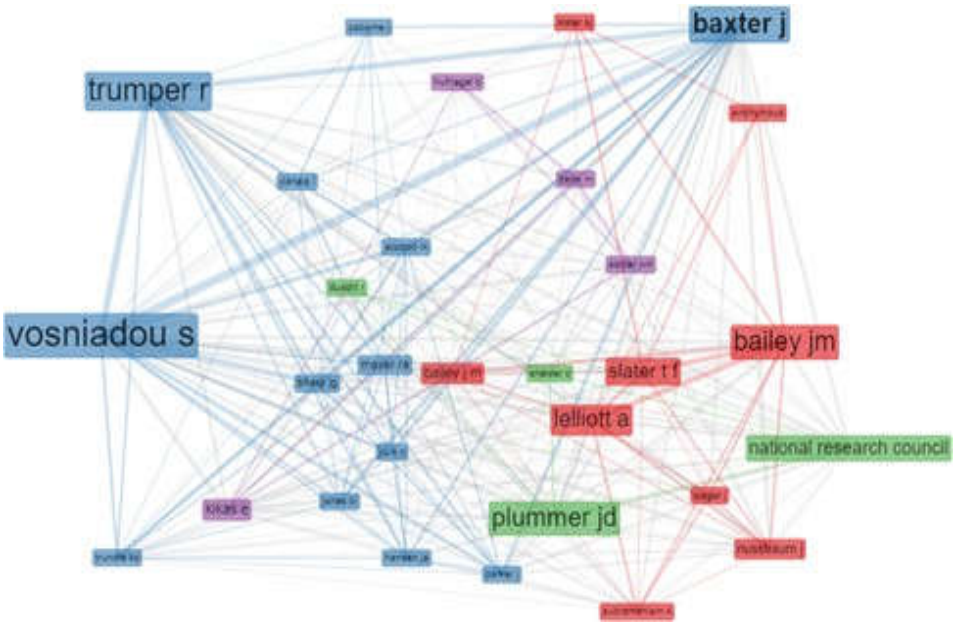

Figure 13. Common citation network graph

The figure contains a total of 30 authors. These authors were divided into four different clusters, and the clusters were shown in different colors. According to this graphic, it can be said that there are too many citations to the subject field for Vosniadou, Bailey and Trumper, and that the studies of these two authors produce basic works related to the subject field. Figure-14 shows the collaboration network of the authors.

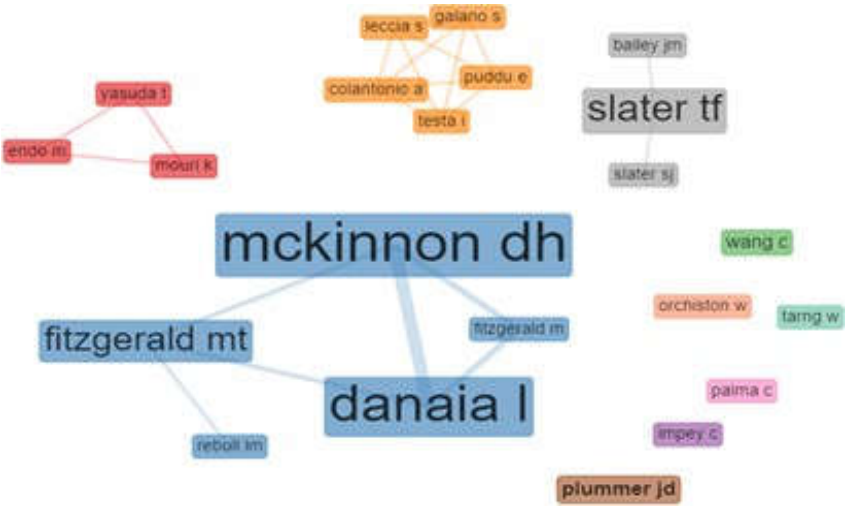

Figure 14. Collaboration network graph of authors

According to the graph, it can be said that the authors from the same cluster seen in Table-4 published in similar subjects.

Table 4
Author-cluster-centricity values for collaboration of authors

Author	Cluster	Author	Cluster
endo m	1	colantonio a	5
mouri k	1	leccia s	5
yasuda t	1	puddu e	5
fitzgerald m	2	testa i	5
danaia l	2	plummer jd	6
mckinnon dh	2	palma c	7
rebull lm	2	slater tf	8
fitzgerald mt	2	bailey jm	8
wang c	3	slater sj	8
impey c	4	tarng w	9
galano s	5	orchiston w	10

For example, when the studies of the first cluster authors in the table are examined, it is seen that the study fields are oriented towards the same subject field.

Discussion and Conclusions

Due to keyword limitations in the selection process of articles for the research in the WOS database, it was determined that the oldest article in the subject field was published in 1972. Between 1972 and 1978, only 10 articles were accessed in this database. It was observed that there was a serious stagnation in article production after this date. New studies on the same subject started to increase again with 4 articles published since 1991. These studies are; Published by J.H. Baxter (1991), W. Orchiston (1991), N. Dadhich (1991), and S. Ramadurai (1991). The time scale in which most studies were published is 2011-2019 (%57.90). It was deducted that 2018 is the year with the most studies published (f=22). Although one article was published in 2008, this year was noticed as the most cited year. The high number of citations in 2008 may be related to the declaration of 2009 as the International Year of Astronomy by the United Nations (UN).

It was seen that the most publishing author in the subject field was D.H. McKinnon. A total of 11 studies of this author were discovered within the scope of the research. In

McKinnon's studies; It was determined that he focused on teaching astronomy at different levels, developing teaching models, teaching interactive astronomy subjects. As a result of the studies done in the database with the research limitations, it is shown that Turkish researchers publishing the most on the subject field are H. Kalkan (f=2) and C. Turk (f=2). It was noticed that the researchers collaborated, and their interest in the subject was the same (Turk & Kalkan, 2015; Turk & Kalkan, 2018). The difference between the number of articles by the most published author on the subject, McKinnon, and Turkish researchers in this field can be due to the development levels of countries in education systems.

The highest citation burst value belongs to J.D. Plummer with the study named "Building A Learning Progression for Celestial Motion: Elementary Levels from an Earth-Based Perspective" published in "The Journal of Research in Science Teaching" in 2010. As know, the highest citation burst value is not about the most citation. This can be explained as a publication of a record number of citations in any year. One of the pioneers in the field, T.F. Slater's publication with the most burst citation is "iSTAR First Light: Characterizing Astronomy Education Research Dissertations in the iSTAR Database" published in "The Journal of Astronomy & Earth Sciences Education" in 2016. However, this study of the author did not exceed the values of the authors who rank the top four in the citation burst value. In the light of this research, it was determined that Turkish researchers could not enter the list of citation burst values. Even though Turkey ranks fourth in the scientific production ranking of countries, the studies could not enter the list of citation burst values because they did not receive enough attention.

Considering the data obtained related to Turkey, it is noteworthy that the ratio of collaboration with other foreign researchers is low. Turkey is on the list of countries that are not open to collaboration for the astronomy education subject fields with some other countries. This situation may indicate that the academic groups in Turkey give more importance to a national study. It was determined that researchers in the USA mostly work with researchers from Australia, Brazil, and Colombia. (For example; Cardenas Avendano, Moreno-Cardenas, Dominguez & Calvo Mozo, 2019; Rebull et al., 2018).

Although researchers included concepts such as "Earth," "Sun," "Universe," "Moon," "celestial motion" and "astronomical" in terms of astronomy, it is noticed that these concepts are not at the top of the list. Some studies that include concepts related to astronomy are as follows: Wilhelm, Cole, Cohen, and Lindell, 2018, Plummer, Wasko, and Slagle, 2011. When the key concepts at the top of the list are examined, it can be said that the researchers generally focus on the general education and teaching of science.

Considering the Q values of the journals published for 152 articles examined within the scope of the research, it was determined that 101 articles were in the range of Q1 and Q4. It is seen that 73 of the studies were published in Q1, 13 of them in Q2 and Q3, and 2 of them in Q4 journals. This situation may be interpreted as the studies on astronomy education pique the interest of important journals. Considering that 72% of the studies in the subject field are included in journals with the Q1 factor emphasizes the importance of astronomy education.

Suggestions and Limitations

Based on the findings of this study, some suggestions/limitations could be made for further research in the field:

1. Bibliometric analysis helps researchers to select areas for and to carry out research. Researchers could conduct bibliometric analysis with different keywords to identify the fundamental (or basic) research in the selected research area and also benefit from these publications. In addition, they could identify the journals that would be interested in publishing their research.

2. In this study, the Web of Science Core Collection database index was used. Further studies could use other indexes such as Scopus, ProQuest, particularly if other publication types such as theses, conference proceedings, or books are to be included in the analyses.
3. Further studies could be conducted using different limitations when searching for the articles. For example, the articles published only in specific journals or during specific periods could be selected for the analyses.

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