



THE ANALYSIS OF CONCEPTUAL DEVELOPMENT OF STEM EDUCATION BY BIBLIOMETRY

Assist. Prof. Dr. Sinan Uğuz
Süleyman Demirel University, İsparta- Turkey
sinanuguz@sdu.edu.tr

Assist. Prof. Dr. Bekir Aksoy
Süleyman Demirel University, İsparta- Turkey
bekiraksoy@sdu.edu.tr

Assist. Prof. Dr. Okan Oral
Akdeniz Üniversitesi, Antalya- Turkey
okan@akdeniz.edu.tr

Abstract

Bibliometric methods were presented important information to define characteristic specifications of scientific studies. Especially, STEM education's (which has growing popularity in recent years) place in literature and defining of its development's direction have importance for people studying in this area. For this purpose, 2584 scientific article was scanned from Web of Science (WoS) database with STEM keyword between 1990 and 2017. HAMMER, which is a web based analyze server was used for bibliometric analysis. By using this software, results such as article count, most cited articles and authors, the authors with the most publications, the most popular journals were analyzed with STEM by relevant years.

Keywords: Bibliometric, STEM, Web of Science.

INTRODUCTION

Among the criteria that are considered when measuring the development levels of countries, science and technology that they produce take an important place. Considering also the input of the science produced to the country's economy, to catch up with the dizzying pace of current scientific studies is one of the responsibilities of countries not only of scientists. In the globalizing world, scientists are now signing scientific studies and projects between countries. Thanks to the internet, popular scientists, articles, or journals on a subject can be easily followed. The online structuring of traditional libraries regarding the access to information has made the access to information even easier. But it has also become important that scientists use the right methods to access the information they seek. At this point, bibliometry emerges as an important research area. Bibliometry is a research area of library and information science, in which bibliographic studies are carried out using quantitative methods (Pritchard, 1969). Bibliometry contributes to making important analyses regarding at what points the science was, is, and is going to be in scientific studies conducted. Bibliometric studies play an active role in determining the science policies of countries and many factors such as the number of publications, the number of citations, the characteristics of the published journals in the studies of the countries, and whether these publications are patented or not are addressed, examined and evaluated (Al et al., 2012). With the development of the internet technology, the concept of social network analysis has become an important issue. Various software for the social network analysis enables close observation of trends in the scientific world and allows the visualization of large datasets. Many variables such as publications, citations, common citation networks, authors or institutions cooperated with are examined in social network analysis studies conducted based on bibliometric data.

There are many bibliometric analysis studies in the literature. In the study of Yang and Liu (2017), biometric analyses were performed in SCI/SSCI indexes between 2000 and 2015 for flipped classrooms, in which course subjects were enriched with technological tools, such as video, etc.

Between 2011 and 2015, it was observed that the publication output tended to grow sharply. Çiftçi et al. (2016) aimed to create a map for scientific publications in the field of educational sciences and teacher education in Turkey. A bibliometric analysis was conducted with 7681 articles published in 32 different refereed journals between 2005 and 2014. As a result of the study, findings in the subjects such as "the average score of the author per article", "the frequency of the words in the headings", etc. were presented. In their study, Heradio et al. (2016) analyzed the most effective studies and the most investigated subjects related to virtual and remote laboratories. The bibliographic data of studies from Web of Science, Scopus, and GRC2014 were collected and analyzed with two important bibliometric approaches, scientific mapping and performance analysis. In their study, Fejes and Nylander (2014) performed analyses based on the bibliographic data obtained from articles sent to three popular journals in the field of adult education research between 2005 and 2012. In their study, Cheng et al. (2014) performed a bibliometric analysis of 324 articles on "workplace e-learning" published in academic journals and conference reports between 2000 and 2012 using the word analysis and text analysis methods. According to the study results, it was concluded that this subject could be divided into six basic research categories such as e-learning in the health sector and social media usage for e-learning. In their study, Hung and Zhang (2012) reviewed articles from the SCI/SSCI database on mobile learning, and twelve clusters and four fields were created using techniques based on text mining on article abstracts. In their study, Martin et al. (2011) analyzed new technological trends in education according to the data in the annual horizon report published between 2004 and 2014 and conducted a study on trends in this direction. Cancino et al. (2017) conducted a bibliometric analysis involving article studies in the field of computer and industrial engineering between 1976 and 2015. They aimed to reveal where the trend in this field would evolve in the future.

STEM (Science, Technology, Engineering, Mathematics) education is an educational approach that involves all the educational processes of science, technology, engineering, and mathematics from pre-school to higher education, in which different disciplines are related to each other and challenging academic concepts are combined with lessons in the real world (Aydeniz, Çakmakçı, and Ertepinar, 2015; Lantz, 2009). The acquisition of an interdisciplinary point of view by students starting from the first years of their education and putting into practice the theoretical knowledge, thanks to STEM education, increase more the importance given to STEM education nowadays. In this context, countries can gain the ability to compete in the new world economy by supporting the development of STEM literacy between school, society, work, and global enterprise. The need for STEM education should not only be regarded as an economic investment that countries make to the future. Nowadays, the use of many computer-based applications in making individual and societal decisions, understanding medical diagnoses, and many other occupational levels has made it inevitable to have knowledge of STEM (National Research Council, 2011).

The aim of this study is to carry out a bibliometric analysis of the scientific studies carried out in the field of STEM between 1990 and 2017; therefore, to help researchers who will conduct studies in the field of STEM, which is expected to have a place in the educational policy of our country, and to express an opinion about the course of future studies to be conducted on STEM.

METHOD

The WoS database was used for reviewing scientific studies on STEM education. "Stem" was selected for the keyword to search and search for studies between 1990 and 2017 was done. When the search was done only with the keyword "stem" in the search field at WoS site, it was observed that the term "stem" was included in other scientific fields such as medicine. In this case, studies only in educational sciences were filtered by selecting "Education, Educational Research" from the Web of Science categories. In this way, the number of articles from about 500.000 was reduced to 2584. The data were saved with the "Save to Other File Format" option to convert the obtained results into the format used by the analysis software. For the bibliometric analysis, an open-source HAMMER web-based analysis server established within the project named "Nails Project" developed by Kunutas et al.

(2015) was used. The “Nails Project” was developed to perform statistical and social network analysis on citation data. In large datasets, the links between articles can be analyzed, and articles in the scientific literature can be systematically mapped.

FINDINGS

The data on the number of publications related to STEM education are presented in the graph in Figure 1. It is observed that studies conducted between 1990 and 2005 do not exceed 10 per year. Especially after 2010, there has been a significant increase in the number of publications, and it is observed that the year when the highest number of publications was made is 2016. Since the date of the study is the middle of the year 2017, the figure in the graph is lower in 2017 than the year before. However, it is clear from the graph that it will exceed 2016 figures at the end of the year. This tendency in the number of publications explains that in the upcoming years, the number of studies on STEM education will increase.

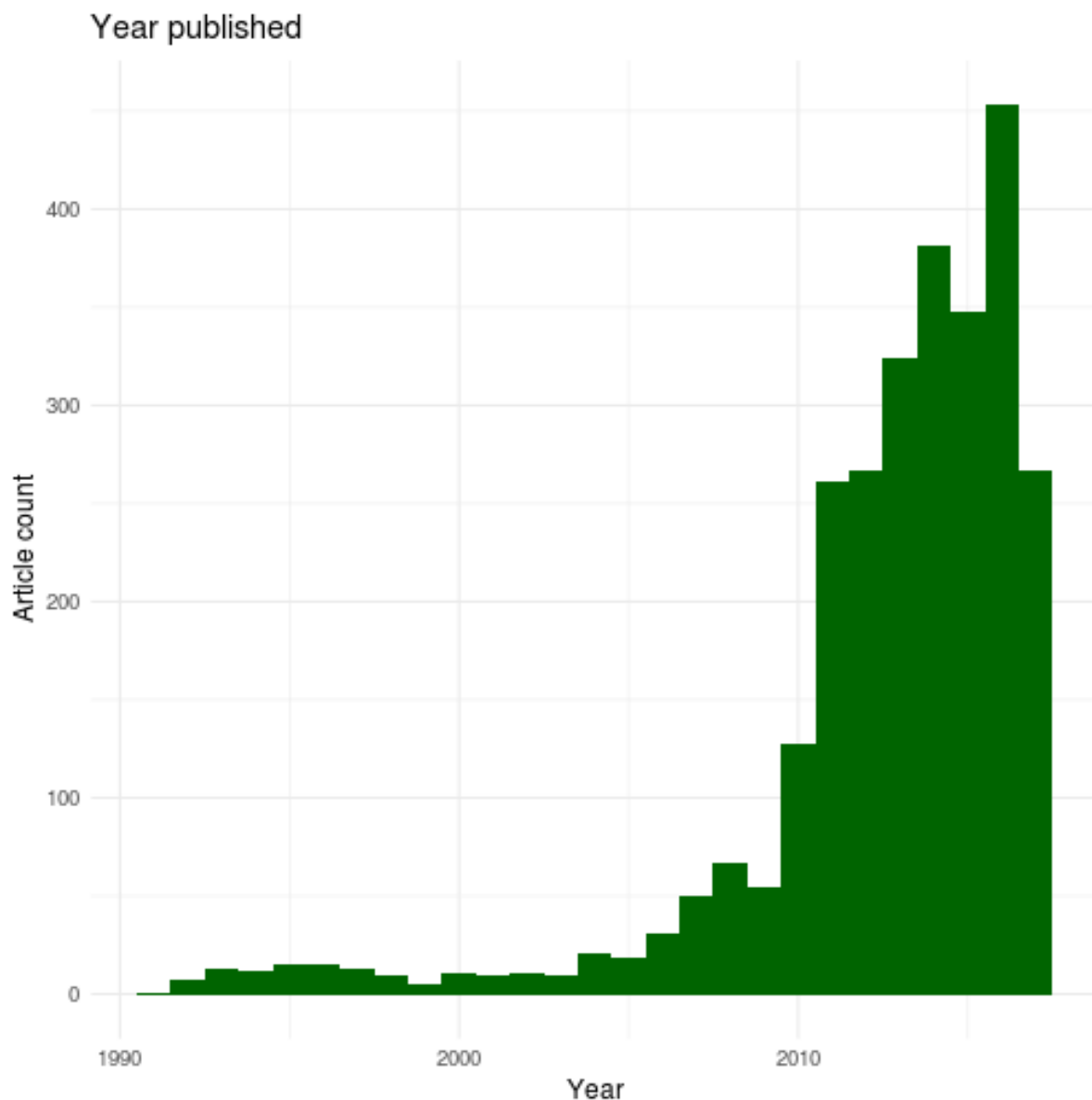


Figure 1: Distribution of the publications on STEM education by years

Authors who have the highest number of studies on STEM education are shown in the graph in Figure 2. Louis S. Nadelson from the University of Colorado is observed to be the author of the highest number of studies.

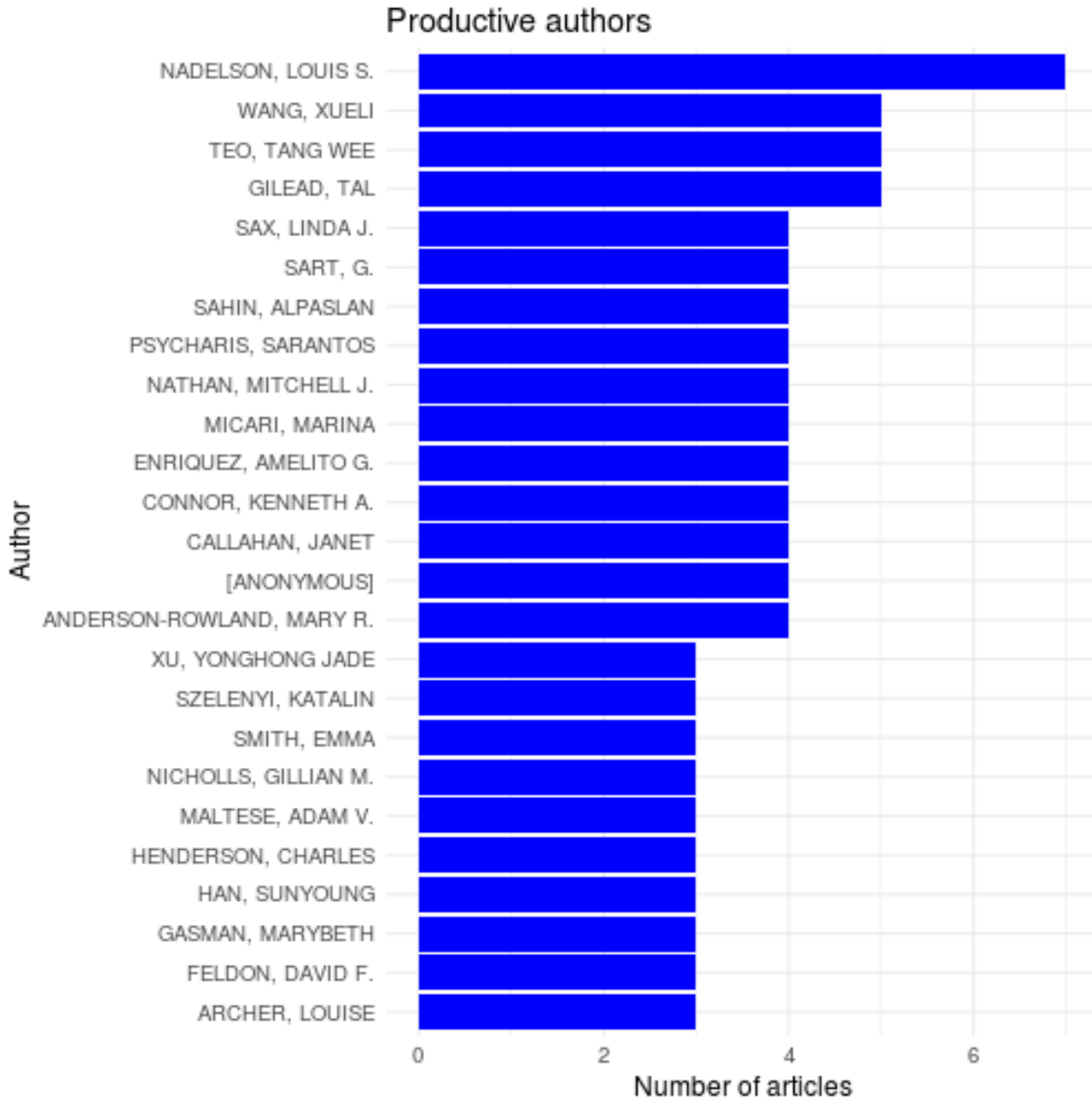


Figure 2: Authors with the highest number of publications in the field of STEM education

The graph in Figure 3 shows the authors who have been cited the most in STEM education. Charles Henderson and Adam V. Maltese are in the first two citation ranks.

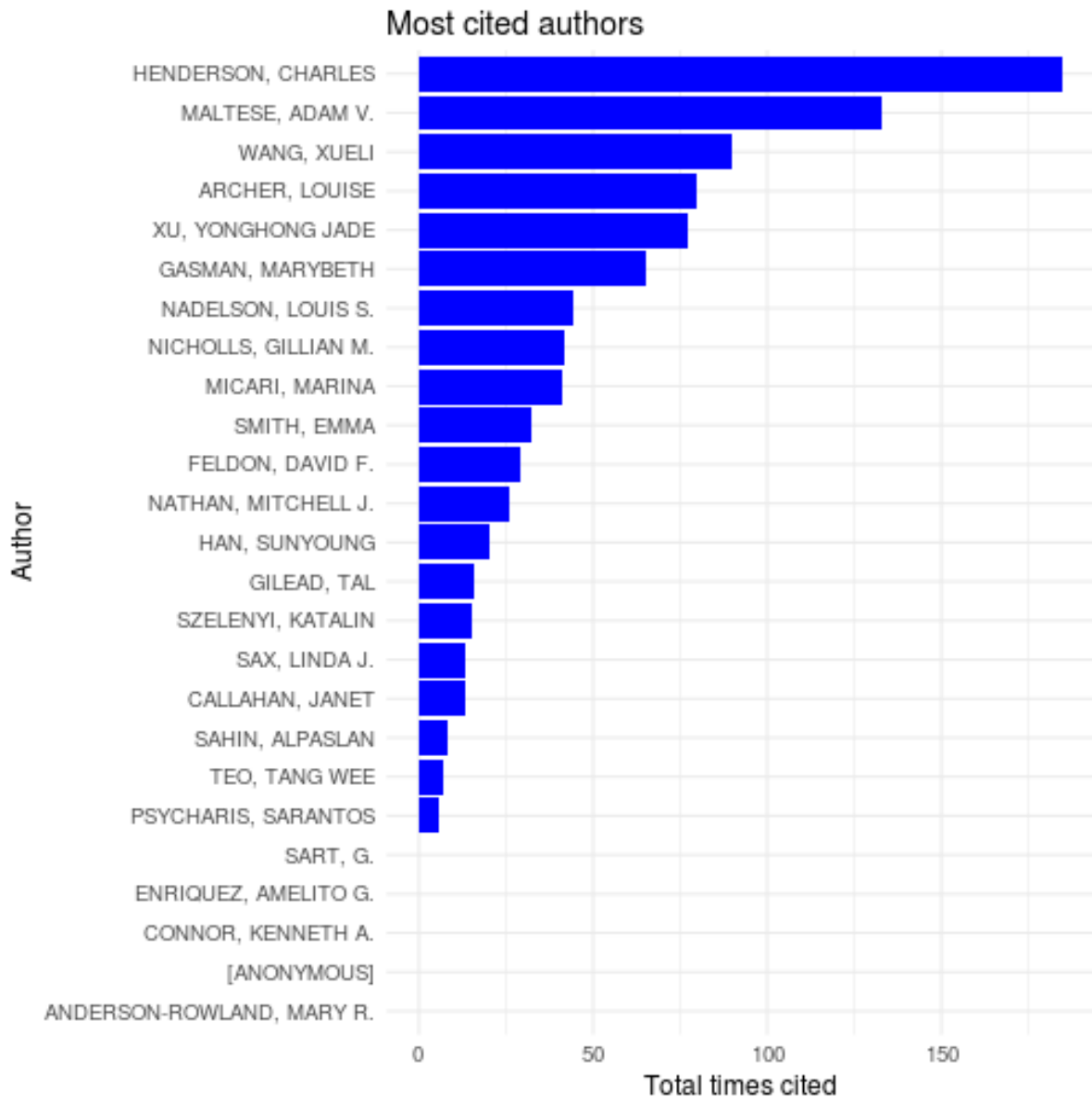


Figure 3: The most cited authors in STEM education

It is an important step which journal to send a scientific study after completing one because making a publication in the most popular journals on the subject studied will cause the study to be cited more, in other words, acknowledged more. This subject is a process that researchers are meticulously focused on and must be well analyzed before sending a study to a journal. As can be seen from the graph in Figure 4, it is observed that publications that are published by being presented as a report at a conference among studies on STEM education are the leading. Conferences popular in STEM education are seen from this graph. The ASEE (The American Society for Engineering Education) conference is observed to be the conference at which the most popular publications are presented. The "Journal of Science Education and Technology" and "International Journal of Science Education" are among the most popular journals.

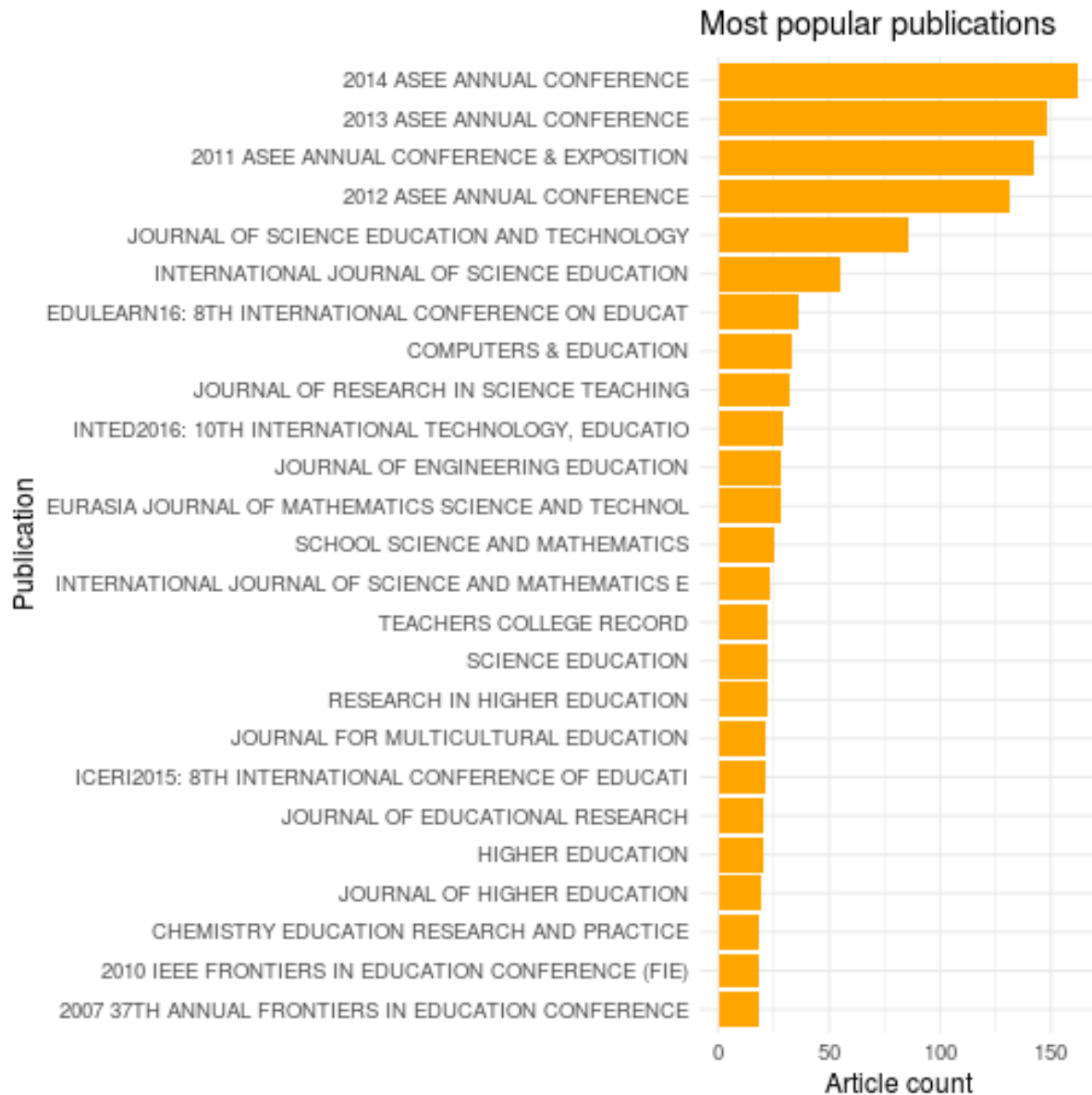


Figure 4: Journals that make the highest number of publications on STEM education

The most effective indicator of the reputation and importance of a journal in the scientific world is the impact factor. The most important variable that determines the impact factor is the number of citations received by publications of the journal. When the graph in Figure 5 is examined, the "International Journal of Science Education", "Journal of Engineering Education", and "Journal of Research in Science Teaching" are observed to be the three most cited journals on this subject.

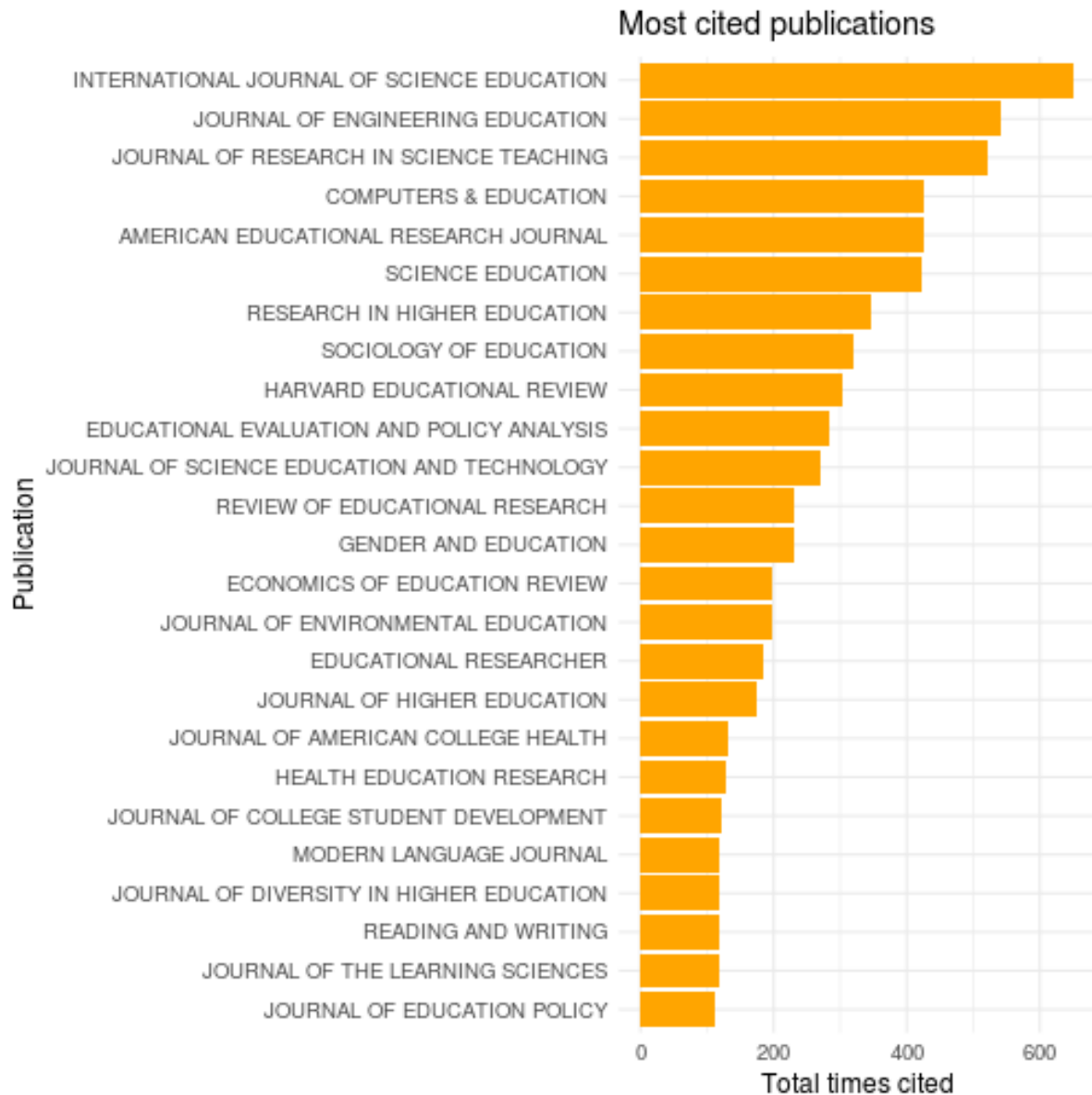


Figure 5: The most cited journals on STEM education

The use of the correct keywords to search for a scientific study in databases such as WoS is important for listing the most appropriate studies in the first order from thousands of results. In particular, searching without using the correct keywords will make it difficult for researchers who are foreign to the literature to reach the desired results. An analysis of popular keywords related to STEM education is presented in the graph in Figure 6. Keywords such as “Stem”, “Stem Education”, and “Education” are observed to be the most popular keywords.

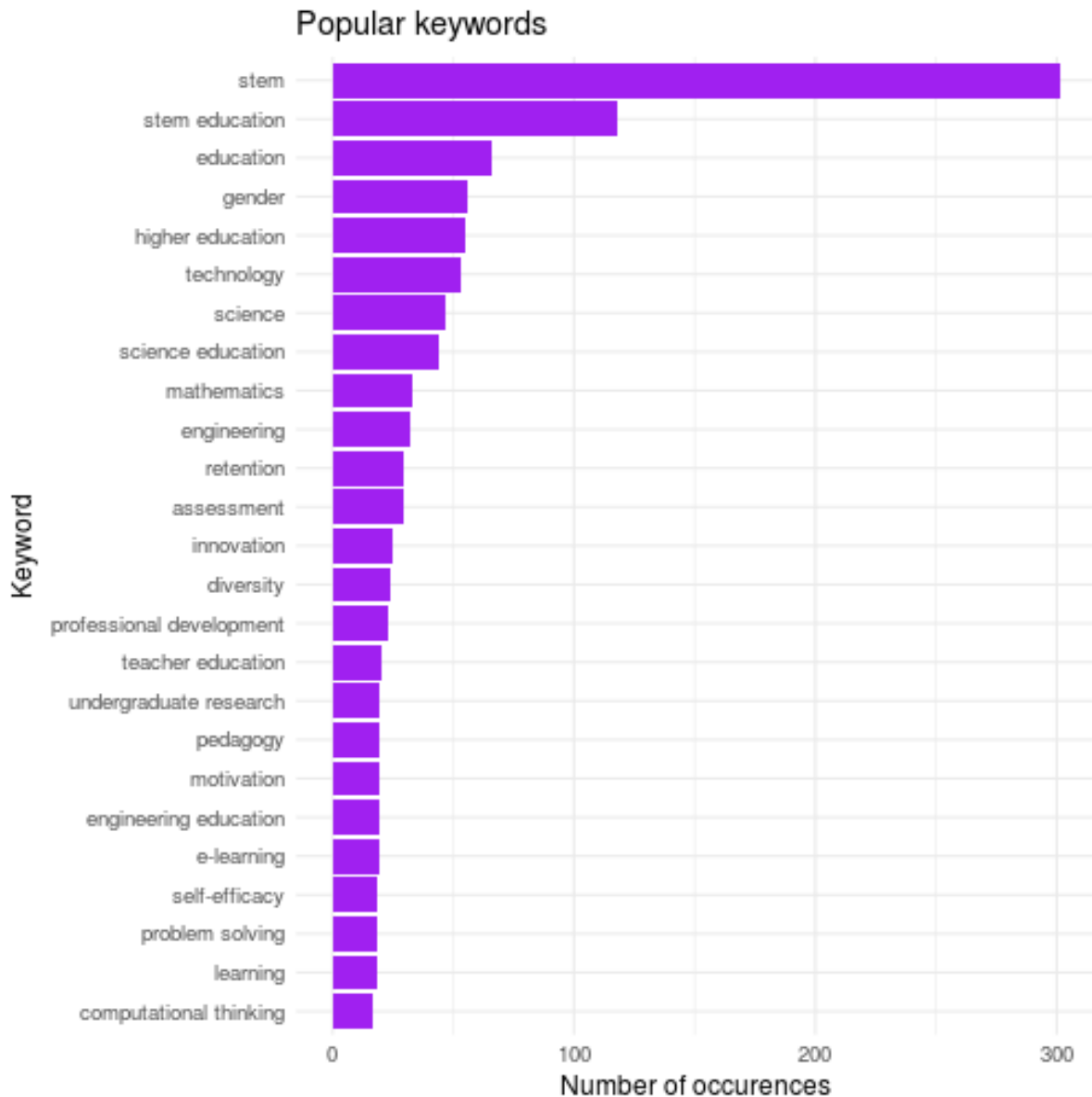


Figure 6: Popular keywords in the field of STEM education

Upon examining the graph in Figure 7, it is observed that the most cited keywords are “Stem”, “Science Education”, and “higher education”.

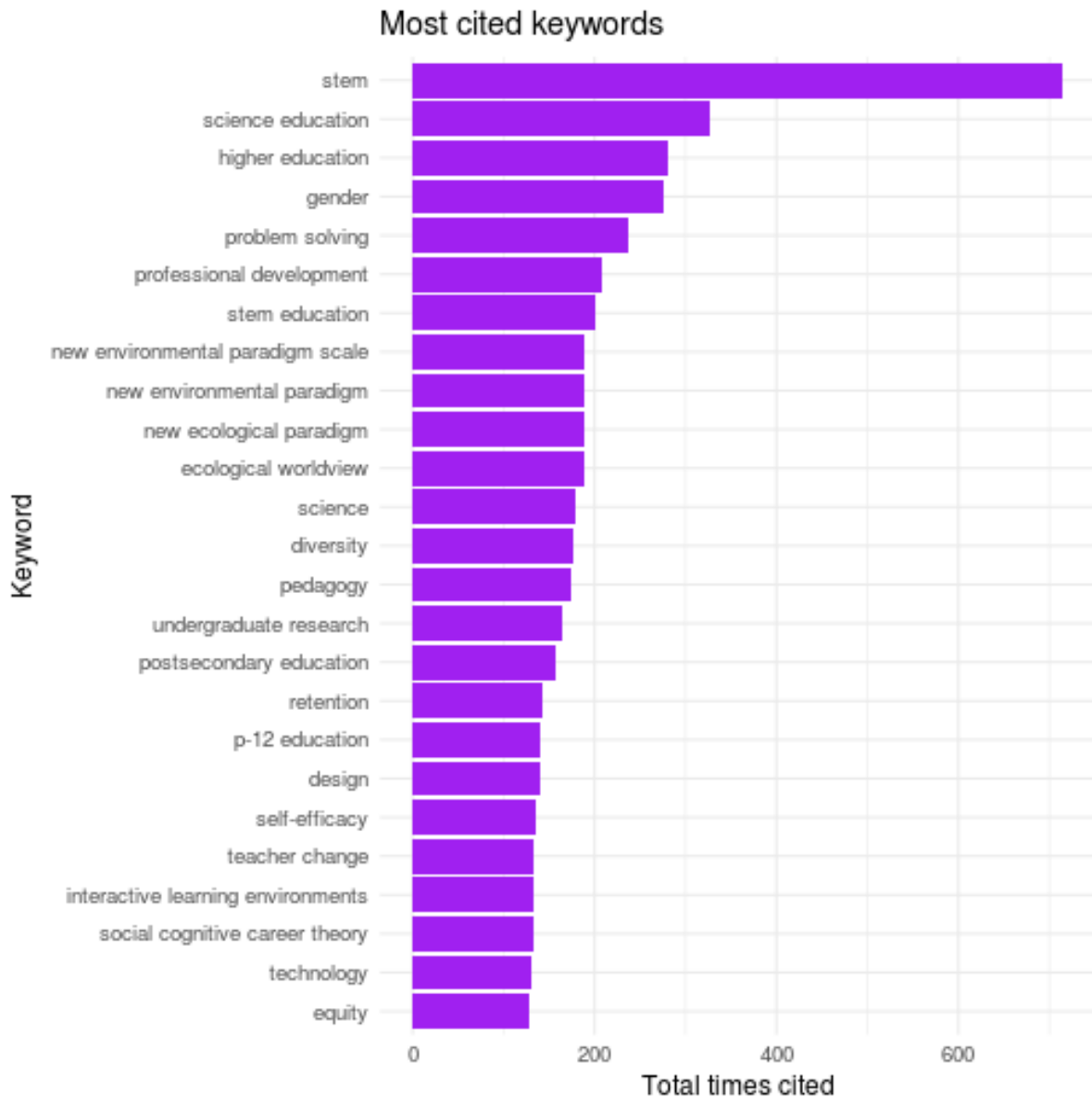


Figure 7: The most cited keywords in the field of STEM education

DISCUSSION AND CONCLUSION

Nowadays, the increase in the access to scientific databases with the development of the internet has also facilitated access to bibliographic information of scientific studies. Thanks to bibliometric methods, without the profound expertise in a scientific field, important information can be achieved about that field such as the number of publications and citations, characteristics of publishing journals, core publications, publishing trends, joint research themes, whether publications have a patent or not, and the aspect of research. Thus, analysis forms and social network analysis results give an in-depth view of the field of science being studied. In multi-disciplinary fields, the network analysis makes it possible to identify the interaction of citations and contributions from other disciplines. This allows the researcher to see how and from which publications the multi-disciplinary nature of the field is formed. In this respect, it is important to perform a bibliometric analysis on a multidisciplinary subject such as STEM. In this study, the bibliometric analysis and social network analysis of 2584 studies on STEM between 1990 and 2017 from the WoS database were performed. It is expected that the findings



obtained will guide researchers who will work on this subject. According to the findings obtained, it is thought that the STEM subject will continue to be popular in the next few years and it will rapidly show an increase especially after 2010. Researchers conducting scientific studies are advised to use the social network analysis software to get more closely acquainted with their own disciplines, because the rapid development of science, the diversity of study subjects, and the necessity of updating the nature of bibliometric studies make this obligatory.

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