Journal of Educational Technology and Instruction
e-ISSN: 2963-458X
2023, Vol. 2, No. 1, pp. 15-29

A Bibliometric Analysis of The Articles Published on Augmented Reality Between the Years of 2010-2021

Seher Aslanci[1*], Alp Bayrak[2]

[1]Alanya Alaaddin Keykubat University, Türkiye
[2]Ministry of National Education, Türkiye

*Correspondence
Seher Aslanci
seher.aslanci@alanya.edu.tr

Received:
4 January 2023
Accepted:
20 February 2023
Published:
3 March 2023

Citation: Aslanci, S., & Bayrak, A. (2023). A bibliometric analysis of the articles published on augmented reality between the years of 2010-2021. *Journal of Educational Technology and Instruction, 2*(1), 15-29.

Abstract—This study presents the results of the bibliometric analysis of 862 articles scanned using the keyword "augmented reality" in the Wos database in the category of published articles in the field of education between the years 2010-2021. The data obtained was analyzed bibliometrically in order to find out the annual distributions of the published articles; the authors publishing the highest numbers of articles on the topic; the journals publishing the highest numbers of articles; the scientific productivity of the authors over time and their citation burst scores; the countries of the corresponding authors and their the scientific productivity; the map of author collaboration networks of the countries; word cloud; and the authors' collaboration network. The highest number of articles on augmented reality has been published in Computers and Education Journal. It has also been determined that the authors who published the highest number of articles on this subject are G. J. Hwang and Chin-Chung Tsai. Furthermore, the Spanish authors, who have contributed to the field with the highest number of articles on the topic, mostly published in collaboration with the researchers in their own countries, while the Slovakian authors have been the researchers with the highest rate of collaboration with the authors from other countries. As for the most frequently used keywords in the publications, it has been identified that education, augmented reality, and technology are the mostly preferred keywords.

Keywords: Augmented Reality, Bibliometric Analysis, R-Studio

1. INTRODUCTION

Technology is integrated into every aspect of our lives today and helps people in many domains of life. One of the important innovations brought by technology is augmented reality, which refers to the concept that enables the real-world environment and virtual environment to coexist (Azuma, 1997; Kirner et al., 2012; Uluyol & Eryılmaz, 2014; Yuen et al., 2011). As a different form of virtual reality (Azuma, 1997), augmented reality is a technology that helps the user to add pre-prepared virtual objects to real environments via a camera or augmented reality glasses (Çınar & Akgün, 2015). It should be noted that augmented reality is not something created from scratch, but rather, it refers to the environments created through supporting the existing real environment (Erbaş & Demirer, 2014). The concept of augmented reality is visualized as presented in Figure 1.

As shown in Figure 1, the concept of reality refers to our direct interaction with the real world without the need for any tool or hardware, while the concept of virtuality defines a completely digital world (Milgram et al., 1994). Augmented reality, on the other hand, is in the middle of these two environments, where the real environment and the virtual environment are used simultaneously, but it is situated closer to the real environment (Carmigniani et al., 2010; Yuen et al., 2011). As indicated in Figure 1,

virtuality increases from left to right while reality decreases (Babur, 2016). At this point, augmented reality acts as a link that connects the gap between the real environment and the virtual environment (Chang et al., 2010; Özçakır, 2017). Augmented reality enables virtual objects to be transferred to real environments (Önder, 2016).

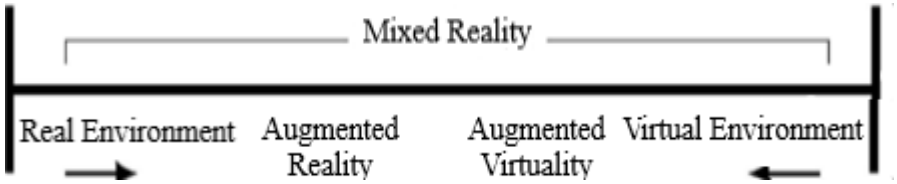


Figure 1. Reality-Virtuality Continuity (Milgram, Takemura, Utsumi & Kishino, 1994)

Augmented reality is used in different fields, particularly in the field of education (Abdüsselam & Karal, 2012; Kaufmann & Schmalstieg, 2003). Augmented reality has been a powerful educational tool because it allows animations with the help of virtual objects, is sensitive to user movements, and eliminates the difficulties in accessing costly objects (Woods et al., 2004).

Augmented reality, which makes it possible to transfer reality to educational environments through technological devices such as computers, tablets or ,smartphones (Billinghurst, 2002; Uluyol & Eryılmaz, 2014), has a wide range of application areas in teaching and learning environments (Yuen et al., 2011). Augmented reality helps students to interact with the real world as well as the virtual environment, to learn concepts and to develop their skills (Kirner et al., 2012). In educational environments, since augmented reality enables students to discover virtual objects individually and provides the opportunity to apply them one-on-one, it leads to the increased interest of students in teaching and learning environments (Kaufmann & Schmalstieg, 2003). The use of virtual objects along with the real environment facilitates students' understanding of complex and abstract concepts (Arvanitis et al., 2007), and increases their interest and motivation (Abdüsselam & Karal, 2012; Chen & Tsai, 2012; İbili & Şahin, 2013) while enabling them to progress in their learning in accordance with their own speed and needs (Kirner et al., 2012). With augmented reality, it is possible to integrate the objects or to create environments that are difficult or inaccessible in real life in teaching environments (Yuen et al., 2011; Wu et al., 2013). Augmented reality has also been reported to be effective in teaching phenomena that are not to directly observable, in imbodying abstract concepts, and in avoiding potentially dangerous situations (Arici et al., 2019; Walczak et al., 2006).

2. METHODS

Adopting the bibliometric analysis method, the study aims to identify the bibliometric features of the articles published in the journals in the category of "Education Educational Research" obtained as a result of the scanning conducted using the keyword "augmented reality" in the WoS database. Bibliometric analysis shows the focal points and the researched topics in a field, and enables researchers to evaluate the published studies in the field (Zupic & Čater, 2015) through reliable and unbiased analyses (Aria & Cuccurullo, 2017) while providing mapping of science (Aria & Cuccurullo, 2022).

2.1 Sampling

The data of the research consists of published research articles containing the keyword "augmented reality" by the journals in the category of "Education Educational Research" in the WoS database in the period between 2010-2021. In line with the purpose of the study, the research published in other document types such as review studies, editorial material, meeting reports, book chapters, books, theses, and conference papers were excluded from the study. The articles to be included in the analyses were determined to have the publication date starting from 2010. Science Citation Index (SCI), Social Science Citation Index (SSCI) and Art & Humanities Citation Index (A&HCI) international citation indexes are considered to be the most important sources in bibliometric studies. Accordingly, Web of Science Core Collection was chosen as the database to conduct the present research since it provides access to the above-mentioned international indexes and is also compatible with the bibliometrical analysis system run through the R-Studio program (Aslanci, 2022; Aslanci & Bayrak, 2022; Güzeller & Çeliker, 2017; Karaca & Akbaba, 2021; Kurtuluş & Tatar, 2021a, 2021b; Kurtuluş & Yılmaz, 2022).

2.2 Data Collection

In the process of data collection for the study, a total of 27528 articles were reached as a result of the scan with the keyword "augmented reality" by selecting the "all field" option in the WoS database. As the next step, in accordance with the purpose of the study, the determined criteria for inclusion were implemented by selecting "Education Educational Research" as the category section of the publication in the database. As a result, 1891 publications were obtained. Next, the publication type was determined as article, which resulted in 1019 articles. And finally, the year range was limited to 2010-2021, and the data sample to be included in the analyses was created with a total of 862 articles. This obtained sample of 862 articles were then analyzed to identify the distribution of the articles published annually; 3-D area charts; the authors with the highest number of published articles; the list of the journals that published the highest number of related articles; the corresponding authors' productivity over time and their citation burst values; the countries and the number of articles published by the corresponding authors; the map of author collaboration networks of the countries; word cloud; and the authors' collaboration network.

2.3 Data Analysis

R-Studio program was used to analyze the sample of the articles obtained within the scope of the study. The R program, which contains many bibliometric analysis packages, can be accessed at https://cran.r-project.org/. The data of the study was transferred to biblioshiny, a web interface of the R program, and analyzed statistically. These package programs, which are used in bibliometric analysis, have been considered to be very useful for quantitative research (Aria & Cuccurullo, 2017). In fact, bibliometric analyzes performed by using the R program increase the amount of the findings obtained while providing enriched representations.

In the study, the articles accessed as a result of the restrictions made using the Web of Science Core Collection data were obtained as follows. Since the selection consisted of 862 articles and the system allowed a maximum of 500 articles to be downloaded at one time, the data of the study was downloaded in two groups. First, the "export" option

was selected and the "bibtex" format was chosen. Recording options "1-500 records" were selected in the opened window and the first data group file was downloaded by selecting "Save content (Full Record)". Then, by repeating the same procedures, "Records between 501-862" were selected and "Save Content (Full Record)" was selected and the second data group file was downloaded. Next, the data files downloaded in two separate groups were combined into a single data file format for analysis. Then, "bibliometrix" in the R-Studio program was run and the biblioshiny web interface was accessed. Finally, the edited data file was uploaded to the "data" section and the data was analyzed.

3. RESULTS

The findings of the statistical analysis of the 862 articles on augmented reality obtained as a result of the criteria implemented are presented in Table 1.

Table 1. Demographic Information of Research Data

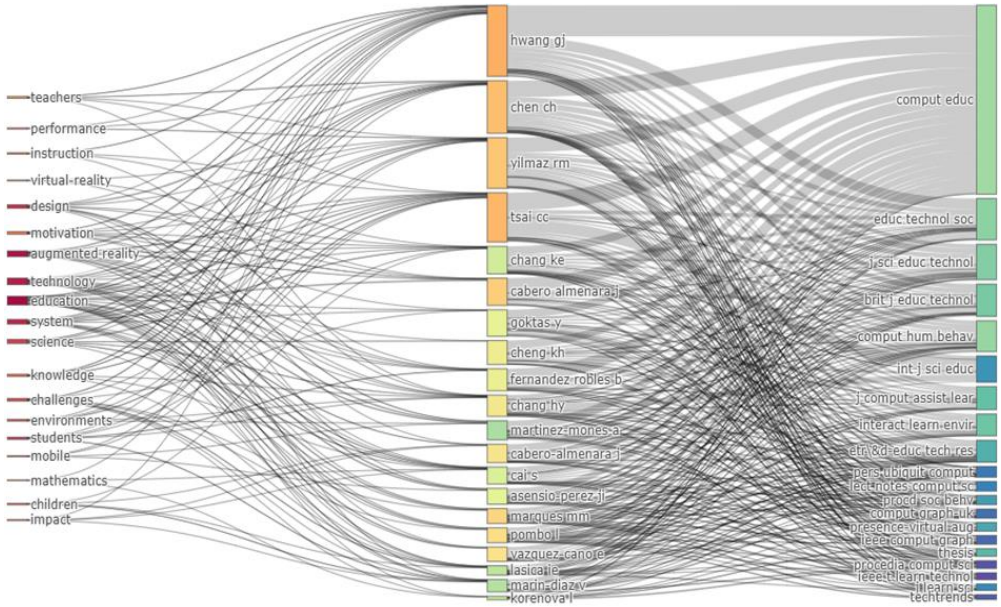
Key Findings of the Data	Results	Key Findings of the Data	Results
Timespan	2010-2021	Authors	2068
Sources (Journals, Books, etc)	246	Author Appearances	2503
Documents	862	Authors of Single-Authored Articles	136
Average year of publication	4.03	Authors of multi-authored Articles	1932
Average citations per Articles	17.66	Single-authored Articles	150
Average citations per Year per Articles	2.849	Articles per Author	0.417
References	25780	Authors per Articles	2.4
Keywords Plus	738	Co-Authors per Article	2.9
Author's Keywords	2157	Collaboration Index	2.71

As displayed in Table 1, the search in the WoS database following the implementation of the criteria result in 862 articles published between 2010-2021 in 246 different journals. It can also be seen that 2086 authors in the field contributed to the relevant research 2503 times, while the number of articles per author is found to be 0.417. In addition, approximately 2.4 authors collaborated per article and the cooperation index is 2.71. The distribution of these 862 articles in the field according to the grouped years is presented in Table 2.

Table 2. Number of Articles Published by Years

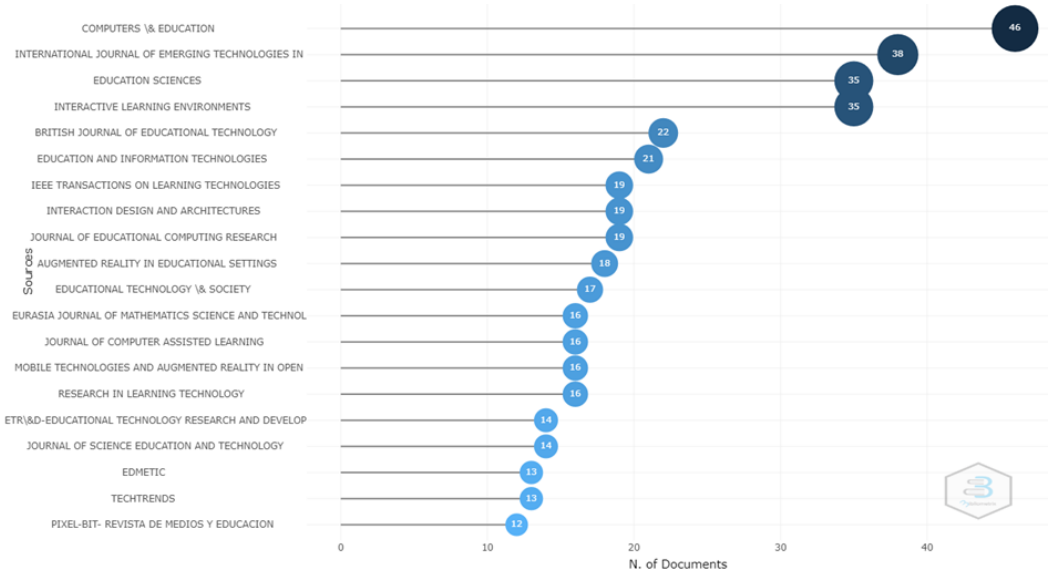
Years	Number of Articles (f)	Percentage (%)
2010-2012	35	4.06
2013-2015	111	12.88
2016-2018	281	32.60
2019-2021	435	50.46

The findings in Table 2 show that the first article in the field was published in 2010. In addition, when each grouped year interval is examined, it is clearly seen that the highest number of articles was published in 2019-2021 (f=435) and that about half of the publications in the field were published in these last three years. The 3-D area charts presented in Graph 1 show the relationships between the authors, the keywords, and the journals.



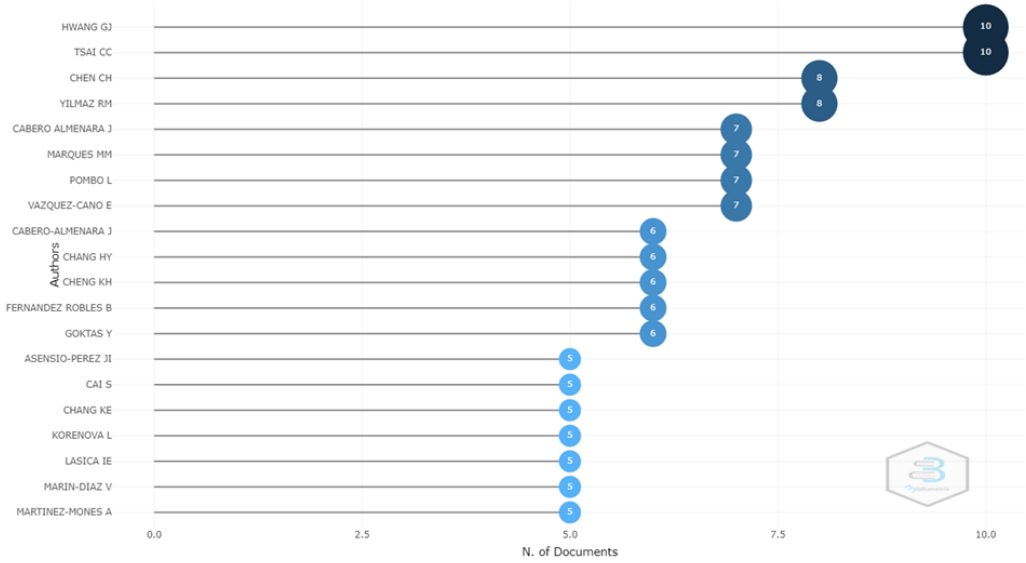
Graph 1. Tree Fields Plot

The Sankey diagram displayed in Graph 1 shows the connections of the authors, listed in the middle column, with the best journals, listed in the right column, as well as with the most frequently preferred keywords, shown in the left column. According to the findings, the most preferred keyword in the field is "augmented reality", which has been used by most of the authors listed in the middle of the graph. In addition, the rectangular boxes in the middle show the authors with articles published in prestigious journals; and accordingly, the author in the middle column of the diagram, G. J. Hwang, has the largest rectangular area size compared to the other authors, which indicates to have the highest rate of contribution to these journals. The findings also point out that the majority of the authors who publish articles in the relevant area have mostly chosen Computers & Education Journal for publication. Graph 2 presents the top 20 journals that have published the highest number of articles on augmented reality.



Graph 2. The Journals with the Highest Numbers of Published Articles

The first twenty journals that published the most articles on the subject area are listed in Graph 2 in descending order based on the number of published articles on the topic. When each of these journals is examined separately, it is seen that Computers & Education is the journal with the highest number of published articles on the topic with 46 articles. Following this journal, the journals with the highest numbers of publications are International Journal of Emerging Technologies in Learning (f=38), Education Sciences (f=35), Interactive Learning Environments (f=35), and British Journal of Educational Technology (f=22). It can be concluded that the top five journals with the highest number of publications in this subject area have published 20.42% of all the articles on the topic. Graph 3 displays the top 20 authors with the highest number of published articles on augmented reality.

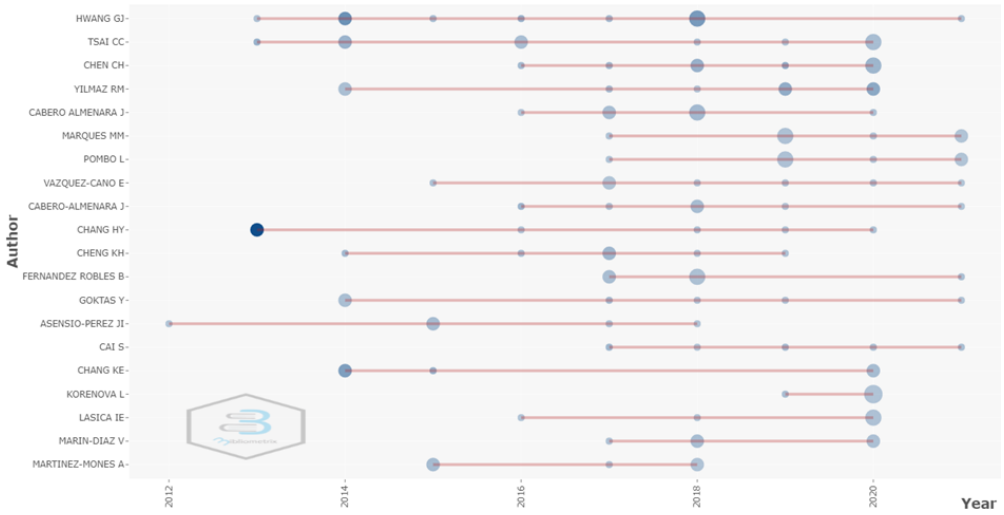


Graph 3. Authors with the Highest Numbers of Articles Published on Augmented Reality

In Graph 3, the top twenty authors with the highest number of articles published are listed in descending order based on the number of articles published on the topic. Accordingly, it is seen that the most productive authors on augmented reality are Gwo-

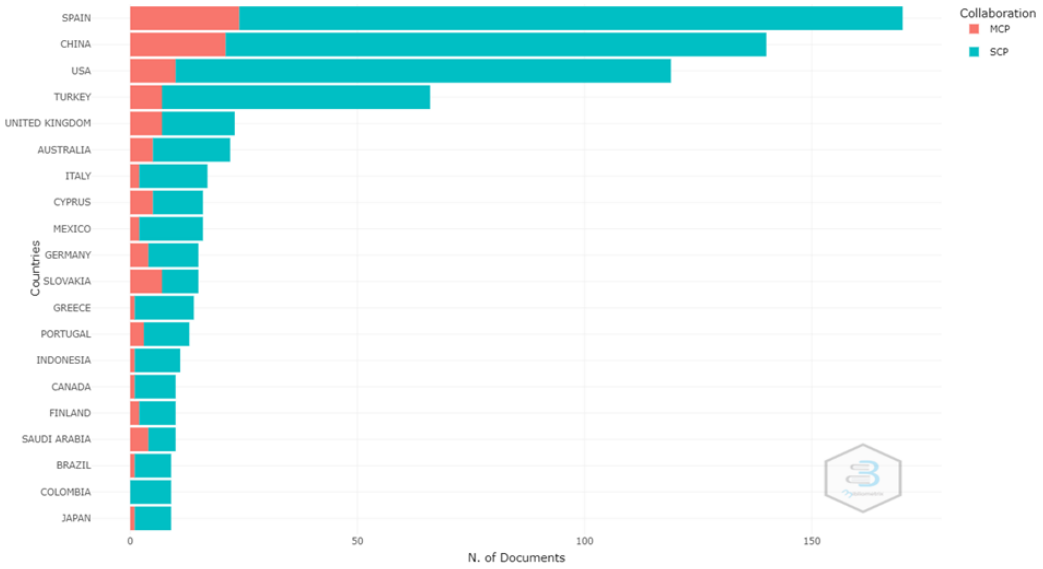
e-ISSN: 2963-458X
2023, Vol. 2, No. 1, pp. 15-29

Jen Hwang and Chin-Chung Tsai, who have an equal number of articles with 10 articles each. The first of these researchers works at the National Taiwan University of Science and Technology in Taiwan and the other at the National Taiwan Normal University in Taiwan. In Graph-4, the scientific productivity and the citation burst values of the authors over time are shown.



Graph 4. The Authors' Scientific Productivity over Time and Their Citation Burst Values

When the results on the author productivity and citation burst values in Graph 4 are analyzed, it can be stated that Gwo-Jen Hwang, who has the longest line length and thus, who is in the top rank in terms of productivity, is the author who has been active for the longest time in the field. Also, Lilla Korenova, who was active in the field for the shortest time between 2019-2020, is found to be the author with the largest circle diameter as she is the author who published the highest number of articles in one year with 4 articles in 2020. In addition, it can be seen that Hsin-Yi Chang has the highest citation average per article with an average of 88.4 citations for the 2 articles published in 2013. Graph 5 shows the countries of the corresponding authors.



Graph 5. The Countries of the Corresponding Authors and The Number of Articles

e-ISSN: 2963-458X
2023, Vol. 2, No. 1, pp. 15-29

Graph 5 displays the countries of the corresponding authors and the number of articles published. In the graph, the red horizontal column opposite each country represents the SCP (Single Country Publications) value, which indicates the number of published articles by the authors from that country in collaboration with their colleagues in their own country; whereas the blue horizontal column shows the MCP (Multiple Country Publications) value, which indicates the number of the published articles by the authors in collaboration with their colleagues from different countries. The total number of articles for each country is equal to the sum of the SCP and MCP values. According to the results, the country that has contributed to the field with the highest number of articles is Spain (f=170), which is at the top. It is also noteworthy that Spain is followed by China (f=140), USA (f=119) and Turkey (f=66), respectively. Table 3 presents more detailed information on these results.

Table 3. The Numbers of Articles, SCP and MCP Values and MCP Ratios by Countries

Country	Articles	Frequency	SCP	MCP	MCP Ratio
Spain	170	0.19814	146	24	0.1412
China	140	0.16317	119	21	0.1500
USA	119	0.13869	109	10	0.0840
Turkey	66	0.07692	59	7	0.1061
United Kingdom	23	0.02681	16	7	0.3043
Australia	22	0.02564	17	5	0.2273
Italy	17	0.01981	15	2	0.1176
Cyprus	16	0.01865	11	5	0.3125
Mexico	16	0.01865	14	2	0.1250
Germany	15	0.01748	11	4	0.2667
Slovakia	15	0.01748	8	7	0.4767
Greece	14	0.01632	13	1	0.0714
Portugal	13	0.01515	10	3	0.2308
Indonesia	11	0.01282	10	1	0.0909
Canada	10	0.01166	9	1	0.1000
Finland	10	0.01166	8	2	0.2000
Saudi Arabia	10	0.01166	6	4	0.4000
Brazil	9	0.01049	8	1	0.1111
Colombia	9	0.01049	9	0	0.0000
Japan	9	0.01049	8	1	0.1111

Table-3 shows that Spain (SCP:146, MCP:24) ranks at the top with the highest number of published articles with a total of 170 articles, yet, it has a low MCP ratio. This is because the authors in this country have mostly preferred to collaborate with their colleagues in their own countries. The country with the lowest MCP rate, on the other hand, is Colombia (MCP: 0), and it can be said that the authors of this country prefer to conduct studies only on a national basis. However, Slovakia (MCP:0.4767), which ranks as the eleventh in terms of the number of articles, is the country with the highest MCP ratio. Similarly, Saudi Arabia (MCP:0.4) appears to be the second country with the highest MCP ratio despite being ranked the seventeenth based on SCP and MCP scores. These rates indicate that the authors in these countries tend to collaborate more internationally. The results also show that Cyprus (MCP:0.3125) and the United

Kingdom (MCP:0.3043) are among the countries with high MCP ratios. Figure-2 presents the geographical representation of the collaboration intensity map of the countries.

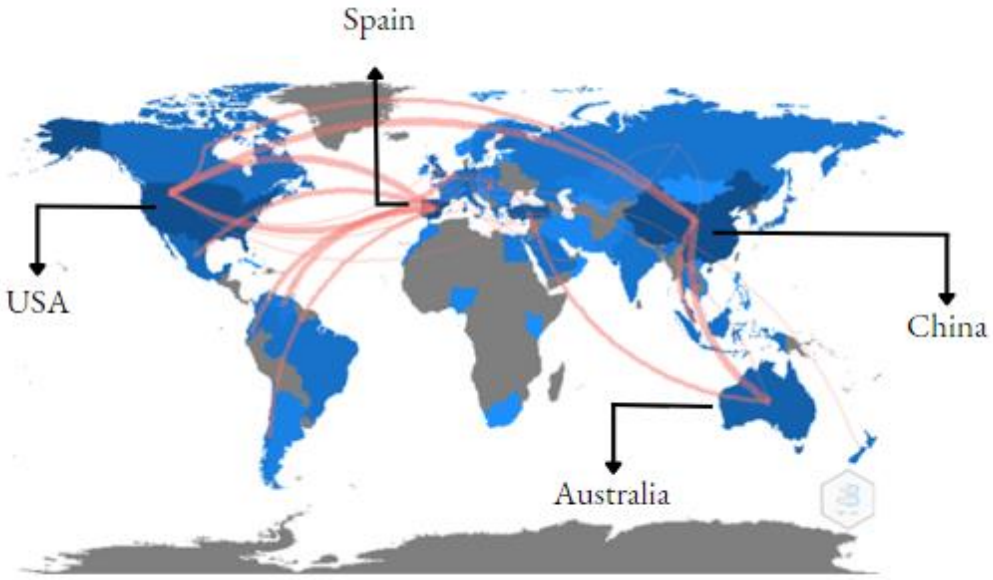


Figure 2. Collaboration Map of the Countries

The map displayed in Figure 2 shows blue and gray colored regions. There is a linear ratio between the intensity of the blue color and the collaborations done by the relevant country. That is, the more the country collaborates, the darker the blue color gets; however, the blue color gets lighter when the number of collaborations of the relevant country decreases. If the gray color is dominant, this indicates that there is no collaboration in that region. The results indicate that the three countries with the highest collaboration rates are Spain, China and the USA. In addition, when the thickness of the curve is examined, it can be stated that China-Australia (6 collaboration), China-USA (6 collaboration) and Spain-USA (6 collaboration) are the countries that have collaborated with each other the most frequently. Figure-3 shows the word cloud for the most frequently used keywords in the published articles on augmented reality.

Figure 3. Word Cloud of the Keywords

The word cloud is one of the data mining methods and shows the most used keywords in the relevant field area by positioning it in the largest size, in the center. Yet, when the frequency of use decreases, the keyword moves away from the center and decreases in size. Accordingly, as can be seen in Figure-3, the keyword "education" (f=180), which is in the most central position and has the largest size, is the keyword with the highest frequency of use. This word is followed by the keywords "augmented reality" (f=146) and "technology" (f=84), respectively. Figure 4 shows the collaboration network of the authors studying on augmented reality.

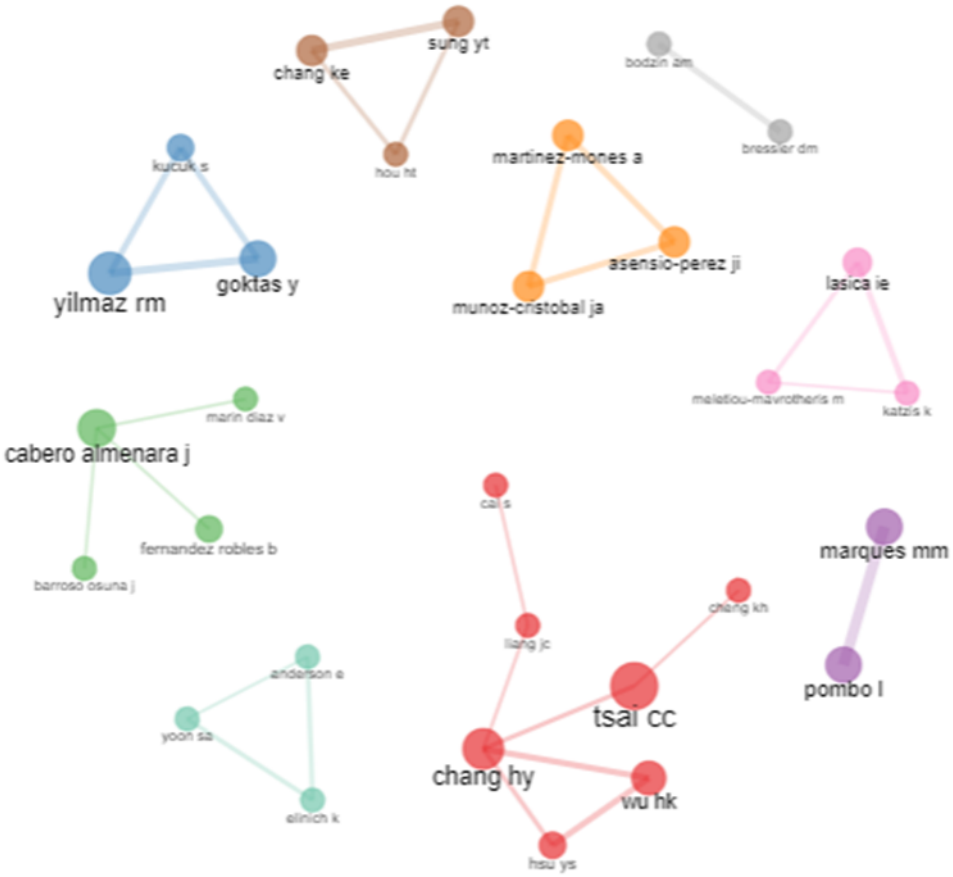


Figure 4. The Authors' Co-Occurrence Network

Considering the collaboration network of the authors displayed in Figure 4, it is clearly seen that the network has nine different color sets. The authors who collaborated in their studies and who published articles on similar topics are placed in the same color cluster. In addition, when the thickness of the connecting lines is examined, it is seen that M. M. Marques and L. Pombo are the authors with the thickest connecting lines. This shows that these two authors have been collaborated closely in conducting their research.

4. DISCUSSIONS AND CONCLUSION

In line with the purpose of the study, the search using the keyword "augmented reality" was conducted by selecting "Education Educational Research" category in the WoS database and a total of 862 articles published between the years 2010-2021 were obtained. In order to identify the correlations in the publications related to augmented reality, bibliometric analysis was performed using R-Studio program. The findings of the

analyses show the number of articles published annually; 3-D area chart; the authors with the highest numbers of published articles; the list of the journals that published the highest number of related articles; the authors' scientific productivity over time and their citation burst values; the countries of the corresponding authors and the number of the published articles; the collaboration networks of the countries and of the corresponding authors; and the Word Cloud of the keywords used in the published articles. According to the results obtained, it has been observed that approximately half of the articles on the relevant topic were published in the three-year period between 2019-2021. Furthermore, it has been revealed that there has been a steady increase in article publication on the topic since 2010. This finding points out that there has been an increased research interest in augmented reality recently.

Analyzing the journals that have published articles on augmented reality, it has been found that there are 246 different journals in the field and the highest number of publications belongs to the journal Computers & Education (f=46). This is followed by International Journal of Emerging Technologies in Learning (f=38), Education Sciences (f=35), Interactive Learning Environments (f=35), and British Journal of Educational Technology (f=22), respectively. Therefore, it could be suggested that considering these journals for future publications will likely increase the visibility of the articles.

The authors with the highest number of published articles on the topic have been found to be G. J. Hwang and Chin-Chung Tsai. While the articles by Hwang focus more on augmented reality, mobile learning, flipped classroom and game-based learning; Tsai's research has been mostly on augmented reality, Technological Pedagogical Content Knowledge (TPACK), web-based learning, and science education. It has also been revealed that G. J. Hwang is the author who has the longest duration in terms of scientific productivity in the field. Furthermore, it has been determined that H. Y. Chang is the author with the highest citation burst score. This score is not the result of the high number of citations received, but is determined in relation to the density of the citations in the relevant year. The results also indicate nine different clusters in the authors' collaboration network. When the authors are grouped in the same cluster, this points out that these authors study on similar topics. Among these authors, C. C. Tsai and H. Y. Chang are the most well-known authors and have three co-published articles. It has also been identified that the highest rate of collaboration is located in the red-coloured cluster consisting of researchers from the same country.

Analyzing the results regarding the countries of the corresponding authors, it can be seen that although Spanish researchers published the highest number of articles, they have a relatively low MCP ratio as they mostly collaborated with the researchers in their own countries. The findings show that the country with the highest MCP ratio is Slovenia, which indicates that Slovenian researchers mostly collaborate with researchers from foreign countries in their publications. In addition, the findings show that Spain, China and the USA are the three countries that have collaborated the most frequently with China-Australia (6 collaboration), China-US (6 collaboration) and Spain-US (6 collaboration).

Finally, according to the results obtained on augmented reality, it has been found in the word cloud that the most frequently used keywords are education, augmented reality and technology, respectively. As a result, it is believed that it would be more efficacious for authors who want to work on the topic to prefer these keywords in their studies. The suggestions for researchers who want to focus on augmented reality in their research are as follows:

1. As the data analyzed in our study was obtained from the WoS database, other databases such as Scopus, and ProQuest can also be used.
2. This study is limited to the research published as articles. Further studies could be conducted by including other publication types such as thesis, book, book chapters, and review studies and the findings could be compared.
3. In future research, different time intervals could be determined in order that the trends and the changes in the published research on augmented reality could be compared.
4. In this study, the articles published in the category of "Education Educational Research" on augmented reality have been included. Future studies can be carried out by choosing different categories.

5. REFERENCES

Abdüsselam, M. S., & Karal, H. (2012). The effect of mixed reality environments on the students' academic achievement in physics education: 11th grade magnetism topic example. *Journal of Research in Education and Teaching,* 1(4), 170-181.

Aria, M., & Cuccurullo, C. (2017). Bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics, 11*(4), 959-975.

Aria, M., & Cuccurullo, C. (2022). *Science mapping analysis with bibliometrix R- package: An example*. Retrived June 30, 2022 from https://bibliometrix.org/documents/bibliometrix_Report.html

Arici, F., Yildirim, P., Caliklar, Ş., & Yilmaz, R. M. (2019). Research trends in the use of augmented reality in science education: content and bibliometric mapping analysis. *Computers & Education,* 142, 103647. https://doi.org/10.1016/j.compedu.2019.103647

Arvanitis, T. N., Petrou, A., Knight, J. F., Savas, S., Sotiriou, S., Gargalakos, M., & Gialouri, E. (2007). Humanfactors and qualitative pedagogical evaluation of a mobile augmented reality system for science educationused by learners with physical disabilities. *Personal and Ubiquitous Computing, 13*(3), 243–250.

Aslanci, S. (2022). Inquiry-based learning: A Bibliometric Analysis. *Scientific Educational Studies, 6*(1), 1-25. https://doi.org/10.31798/ses.1068633

Aslanci, S. & Bayrak A. (2022). Realistic Mathematics Education: A Bibliometric Analysis. *Shanlax International Journal of Education* 10 (4), 52-62. https://doi.org/10.34293/education.v10i4.5174

Azuma, R. T. (1997). A survey of augmented reality. *Presence: Teleoperators & Virtual Environments, 6*(4), 355-385.

Babur, A. (2016). *The effects of using of augmented reality, simulation and real object on learning achievements, motivation and psychomotor performance* [Unpublished doctoral dissertation]. Sakarya University.

Billinghurst, M. (2002). Augmented reality in education. *New horizons for learning, 12*(5), 1-5.

Carmigniani, J., Furht, B., Anisetti, M., Ceravolo, P., Damiani, E., & Ivkovic, M. (2010). Augmented reality technologies, systems and applications. *Multimedia Tools and Applications, 51*(1), 341–377. https://doi.org/10.1007/s11042-010-0660-6

Chang, G., Morreale, P., & Medicherla, P. (2010). Applications of augmented reality systems in education. In *Society for Information Technology & Teacher Education International Conference* (pp. 1380-1385). Association for the Advancement of Computing in Education (AACE).

Chen, C. M., & Tsai, Y. N. (2012). Interactive augmented reality system for enhancing library instruction in elementary schools. *Computers & Education, 59*(2), 638-652. https://doi.org/10.1016/j.compedu.2012.03.001

Çınar, D., & Akgün, Ö. E. (2015). The Use of Augmented Reality in Coursebook Design: A Sample of English Language Coursebook. VII. National Postgraduate Education Symposium Proceeding book, 98-103.

Erbaş, Ç., & Demirer, V. (2014). Augmented Reality in Education: Google Glass Case. *Journal of Instructional Technologies & Teacher Education, 3*(2), 8-16.

Güzeller, C.O., & Çeliker, N. (2017). Gastronomy from past to today: A bibliometrical analysis. *Journal of Tourism and Gastronomy Studies, 5*(2), 88-102. https://doi.org/10.21325/jotags.2017.114

İbili, E., & Şahin, S. (2013). Software Design and Development of an Interactive 3D Geometry Book Using Augmented Reality: ARGE3. *Afyon Kocatepe Üniversitesi Fen ve Mühendislik Bilimleri Dergisi, 13*(1), 1-8

Karaca, A. & Akbaba, B. (2021). Bibliometric research on citizenship education:Analysis of studies between 1980-2020 *Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi, 21*(3), 788-804. http://dx.doi.org/10.17240/aibuefd.2021.21.64908-904375

Kaufmann, H., & Schmalstieg, D. (2003). Mathematics and Geometry education with collaborative augmented reality. *Computers & Graphics, 27*(3), 339-345. https://doi.org/10.1016/S0097-8493(03)00028-1

Kirner, T. G., Reis, F. M. V., & Kirner, C. (2012). Development of an interactive book with augmented reality for teaching and learning geometric shapes. In *7th Iberian Conference on Information Systems and Technologies (CISTI 2012)* (pp. 1-6). IEEE.

Kurtuluş, M.A., & Tatar, N. (2021a) A bibliometrical analysis of the articles on environmental education published between 1973 and 2019. *Journal of Education in Science Environment and Health* 7 (3), 243-258. https://doi.org/10.21891/jeseh.960169

Kurtuluş, M. A., & Tatar, N. (2021b) An Analysis of Scientific Articles on Science Misconceptions: A Bibliometric Research. Elementary Education Online, 20(1), 192-207. https://doi.org/10.17051/ilkonline.2021.01.022

Kurtuluş, M. A., & Yılmaz, S. (2022). STEM eğitim çalışmalarına farklı bir bakış: Bibliyometrik haritalama. Fen Bilimleri Öğretimi Dergisi, 10 (2), 386-405. https://doi.org/10.56423/fbod.1172514

Milgram, P., Takemura, H., Utsumi, A. & Kishino, F. (1994) Augmented Reality: A class of displays on the reality-virtuality continuum. *Telemanipulator and Telepresence Technologies*, vol 2351, 282-292. https://doi.org/10.1117/12.197321

Önder, R. (2016). Augmented Reality Applications in Education: Aurasma and Color Mix. In *Akademik Bilişim Konferansı*.

Özçakır, B. (2017). *Fostering spatial abilities of seventh graders through augmented reality environment in mathematics education: A design study,* [Doctoral dissertation]. Middle East Technical Universty.

Uluyol, Ç., & Eryılmaz, S. (2014). Examining pre-service teachers' opinions regarding to augmented reality learning. *Gazi Üniversitesi Gazi Eğitim Fakültesi Dergisi, 34*(3). 403-413. https://doi.org/10.17152/gefad.88379

Walczak, K., Wojciechowski, R., & Cellary, W. (2006). Dynamic interactive VRnetwork services for education. *Proceedings of ACM Symposium on Virtual Reality Software and Technology*, 277–286. https://doi.org/10.1145/1180495.1180552

Woods, E., Billinghurst, M., Looser, J., Aldridge, G., Brown, D., Garrie, B., & Nelles, C. (2004). Augmenting the science centre and museum experience. *In Proceedings of*

e-ISSN: 2963-458X
2023, Vol. 2, No. 1, pp. 15-29

the 2nd international conference on Computer graphics and interactive techniques in Australasia and South East Asia (pp. 230-236)

Wu, H. K., Lee, S. W. Y., Chang, H. Y., & Liang, J. C. (2013). Current status, opportunities and challenges of augmented reality in education. *Computers & Education, 62*, 41-49. https://doi.org/10.1016/j.compedu.2012.10.024

Yuen, S. C. Y., Yaoyuneyong, G., & Johnson, E. (2011). Augmented reality: An overview and five directions for AR in education. *Journal of Educational Technology Development and Exchange (JETDE), 4*(1), 119-140.

Zupic, I., & Čater, T. (2015). Bibliometric methods in management and organization. *Organizational Research Methods, 18*(3),429-472.

e-ISSN: 2963-458X
2023, Vol. 2, No. 1, pp. 15-29

Author Biographies

Seher ASLANCI	Associate Professor, Alanya Alaaddin Keykubat University, Faculty of Education, Türkiye. E-mail: seher.aslanci@alanya.edu.tr ORCID: https://orcid.org/0000-0002-5749-0958
Alp BAYRAK	Teacher, Ministry of National Education (MEB), Türkiye. E-mail : alpbayrak.30@gmail.com ORCID: https://orcid.org/0000-0003-0263-5360