The Use of Technology in Geography Education Research: A Bibliometric Analysis

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Abstract—In recent years, as well as in various other fields, developments in technology have gained a prominent place in the field of geography education. The purpose of this study is to identify the trends in the use of technology in research on geography education and to provide guidance to researchers in this field. In this regard, a detailed search was conducted for the studies published in the Web of Science database. As a result of the search, a total of 621 academic studies, which analyse the use of technology in geography education research, in Education Educational Research Category was accessed. The metadata of academic studies were downloaded from the Web of Science database and analysed with the software MS Excel and VOSviewer. The findings obtained from the study demonstrated an increase in the number of publications and citations over the years, and it was identified that the number of publications and citations increased more rapidly as of 2006 in comparison to previous years. When the geographical distribution of the studies was analysed, it was revealed that most of the studies were conducted in the UK, followed by the USA, Brazil, Australia, and China. According to keyword analysis, the most popular topics in recent years are geographic information technologies, online learning, virtual reality and visual communication technologies.

Keywords—geography, geography education, technology, bibliometric

1 Introduction

Geography is a science that studies the interactions between human beings and nature; and holds a significant place in the education system of every society since it studies spatial changes such as climate change, natural disasters, urbanization and migrations both locally and globally [1]. According to Özdel [2], geography education improves the individuals' awareness of citizenship, allowing them to learn better about where they live and to benefit from that place more. Understanding the connections between the complex events of the modern world, providing solutions to natural and human problems, and planning a sustainable future are possible through geography education [3, 4]. According to Gönülaçar and Öztürk [5], through the science of geography, social studies course aims that the students get to know the place where they live

in the best way possible and benefit from it in a more conscious manner. The concept of space is one of the most basic concepts in geography education and it is necessary to provide students with spatial thinking skills [6]. Collins [7], emphasises the significance of spatial thinking in the judgments to be made on critical situations, emergencies, diplomatic decisions, and similar issues for a country; and draws attention to the fact that the economic power of countries is maintained particularly by individuals who have spatial literacy and skills related with geographical reasoning [7].

In their study, Metoyer and Bednarz [8], examined the effects of geospatial technologies and concluded that there was a relationship between spatial thinking and geographical thinking. In this context, geography education holds a critical place for the development of individuals' spatial thinking skills, their better understanding of the environment they live in, the development of their awareness of citizenship awareness and, linked with all of these, the support for economic and social development [1, 2, 5]. Another aspect of geography education is the implementation of geospatial technologies [7]. According to Solari et al., [9] geospatial technologies casued a digital revolution in geography education and enabled students to better understand the world and find solutions to geographical problems by improving their 21 century skills. Geospatial technologies include Geographic Information Systems (GIS), Global Positioning System (GPS), remote sensing technologies, and digital spheres such as Google Earth [7, 10, 11]. According to Nielsen et al., [12] geospatial technologies, which used to be owned only by well-financed state institutions and research universities, are now used for various purposes such as detecting traffic density on roads, determining roads and routes, and displaying the 3D version of any given place in the world. According to Kholoshyn et al., [13] since geographic information systems are not only a part of science and business world, but also an integral part of daily life, mastering this technology by particularly younger generations is considered a necessity. Literature review reveals that many scholars have studied different aspects of geographic information systems [11, 12, 14, 15, 16, 17, 18, 19, 20], and this presents the significance of geographic information technologies for several fields.

1.1 Research on geospatial technologies in geography education

The literature review reveals that the use of geographic information technologies improves various skills in individuals. Patterson [18] stated that the use of Google Earth in geography teaching improved students' geographic awareness, critical thinking, analysis and questioning skills. Huang [21], on the other hand, revealed in his study that integrating spatial technologies into field trips in primary education increased students' mapping skills and geographical knowledge. Nielsen et al., [12] examined the need for the use of geospatial technologies in K-12 curricula and how these technologies improve students' problem-solving skills. Metoyer and Bednarz [8] suggested that there was an important relationship between spatial thinking and geographical thinking and in order to develop these skills, a teaching model integrated with geospatial technologies should be developed. Collins [7], examined the effects of both paper and digital map technology on spatial thinking skills, and based on the findings she obtained, she identified that both paper and digital maps helped students improve their

spatial skills. Presenting a different perspective, Ridha and Kamil [11] addressed limitations regarding the use of geospatial technologies. The authors emphasised that for the use of geospatial technologies, it was necessary that the schools have technological equipment, and the geography teachers possess sufficient knowledge and skills [11]. In a similar line as Ridha and Kamil [11], Osborne et al., [17] stated that geography teachers should receive a good level of training on geographic information technologies during their pre-vocational training processes. It is necessary that the school facilities are appropriate for the use of geographic information technologies, and it is also important to integrate the courses related to the teaching of these technologies into the curricula of geography teacher training.

2 Purpose of the research

The literature review reveals that there are studies that include various aspects of the use of geospatial technology in geography education. While some studies focus on the effect of using geographic information technologies in the geography teaching process on the development of students' geographical knowledge and skills, some research focus on the use of geographic information technologies in the teaching process, teacher knowledge and competence, infrastructure, and facilities of schools, etc. focused on its limitations [11, 13, 15, 16, 17, 22, 23]. With the digital transformation process and the ever-developing geographic information technologies, there are undoubtedly many studies on the use of technology in geography education and the interest in studies on this subject is increasing day by day. Therefore, the aim of this study is to determine the trends in the use of technology in geography education research and to guide researchers who want to work in this field. For this purpose, answers to the following questions were sought.

The academic studies conducted on the use of technology in geography education:

1. What is the level of change in publication and citation rates by years?
2. How is the distribution by article language?
3. What is the level of distribution by countries and bibliometric coupling?
4. What is the level of distribution by document type?
5. What are the most frequently preferred keywords by authors in their research?

3 Methodology

This study employs bibliometric analysis method to determine the trends in academic studies on the use of technology in geography education and to offer an insight to researchers. Findings obtained with the bibliometric analysis method contribute to scientific progress in a particular field [24]. In addition, identifying the roles of authors, institutions and similar stakeholders that contribute to the scientific progress process in the field allows the determination of areas of interest in research and the evaluation of new developments. It also allows the identification of collaborators such as authors and institutions that can carry out academic work together in the future [24, 25, 26, 27].

Through certain features of the bibliometric analysis method, thousands of academic studies can be analysed in depth [28, 29]. According to Ellegaard and Wallin [30], through this method trends over many years in various fields can be observed. Taking into consideration all the advantages and features of the bibliometric analysis method, it is seen that it bears the potential to direct the studies in the coming years through identifying the trends in the academic studies on the use of technology in geography education. Therefore, bibliometric analysis method was preferred in this study.

3.1 Data collection

The data included in the study was accessed via the Web of Science database on 21.04.2021 (https://www.webofknowledge.com). Through Web of Science advanced search section, a query was made primarily with the search string TI= (technology* AND geography education OR geography teaching OR geography curriculum OR geography teaching programs OR geography education programs OR geography learning OR geography lesson OR geography course) and a total of 1540 academic studies were accessed that presented a match with the keywords on technology and geography education. These 1540 academic studies feature in "SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI" indexes. In the second stage, the same search string was used with a filter feature of Web of Science Categories: Education Educational Research and a total of 621 academic studies were accessed that are indexed by "SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI". In order to analyse these 621 academic studies, the data were downloaded in csv, text document and plain text formats and processed for data analysis. The data of this study were limited to academic studies that are indexed in the Education Educational Research category in the Web of Science database until the date of 21.04.2021.

3.2 Data analysis

The analysis of the data was concluded firstly using MS Excel, a time series graph was created to visualise the change of the increase in the number of academic studies and citations by years, polynomial regression analyses were executed to demonstrate the changes in the increasing trends statistically. For the analysis of the bibliometric data, VOSviewer bibliometric analysis software developed by Van Eck and Waltman [31, 39] was used. VOSviewer provides cross-country publication collaboration, academic publication collaboration between authors and important/trend key terms in the studies under review, etc. it is a tool that uses text mining to visualize links between scientific studies that contain features (https://www.vosviewer.com).

4 Findings

This part of the study presents the findings obtained from bibliometric analyses.

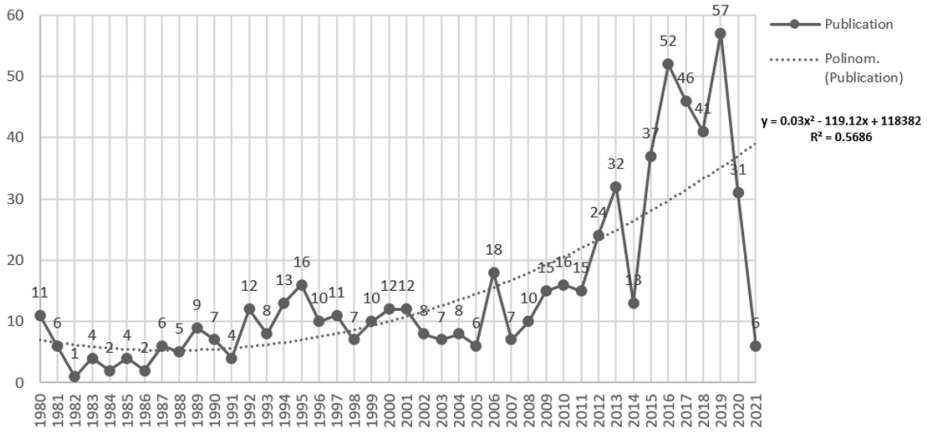

Fig. 1. Number of publications by year

Source: Web of Science; Figure created by the author using Excel.

As Figure 1 presents, the first published works on the use of technology in geography education research were in the 1980s, and a total of fifty academic studies were published between the years of 1980 and 1989. Revealing an increase in the following years, a total of 98 academic studies were published between 1990 and 1999. Between 2000 and 2009, a total of 103 academic studies were published and, 333 studies were published between 2010 and 2019 revealing an increase in the tendency for the studies on the use of technology in geography education. It was also identified that a total of 37 academic studies were conducted between 2020 and 21 April 2021. The highest number of studies in geography education was carries out in 2019 (n=57), while the fewest number of studies was conducted in 1982 (n=1). The polynomial regression values were examined to analyse the trends of increase of the studies between 1980 and 2021, and this value was identified as R^2=.5686. It was concluded that the number of publications increased by an average of 57% between 1980 and 2021.

From the 1980s to the 2000s, the continuous development of technology, the increase in the number of academic publishers and journals, and the continuous development of geographic information technologies affected the increase in the number of publications on this subject. In addition, depending on the phenomenon of publish or perish, which is a phenomenon in the academic world, it has affected the production of more publications in this field, as in other fields. While all these factors support the regression results, it is thought that there will be an increase in the number of publications on the use of technology in geography education in the coming years, when all factors are considered, including global climate change, disasters, the increase in the need for geographic information technologies, as well as the acceleration of the digital transformation process after Covid-19.

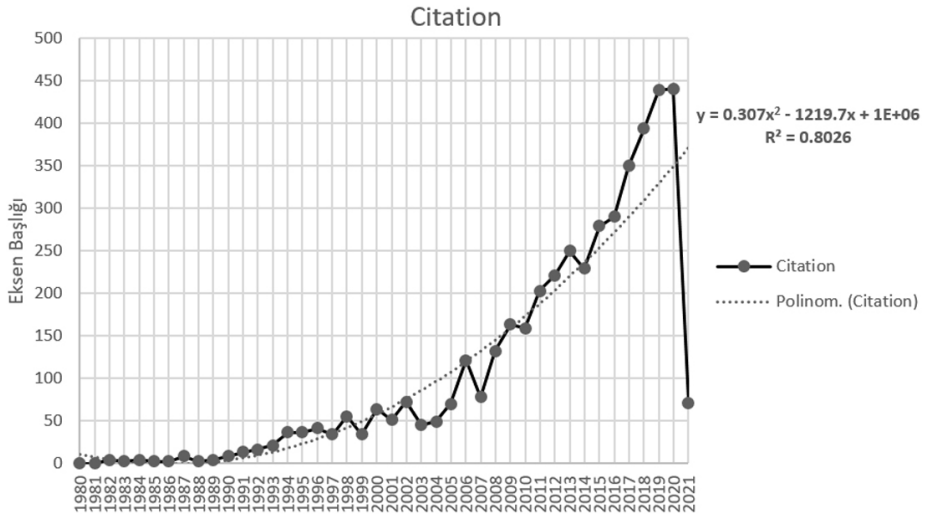

Fig. 2. Number of citations by year

Source: Web of Science; Figure created by the author using Excel.

As Figure 2 presents, a total of 4493 citations were made to all studies between 1980 and April 21, 2021. The findings reveal that that no reference was made to the studies until the year of 1982. Between 1980 and 1989, a total of 28 citations were made, with an average of 2.8 citations per year. A total of 294 citations were made between 1990 and 1999, with an average of 29.4 citations per year. A total of 845 citations were made between 2000 and 2009, with an average of 84.5 citations per year. The highest number of citations which was revealed as 2814 was made between 2010 and 2019, with an average of 281.4 citations per year. Only a total of 512 citations were made between 2020 and 21 April 2021. In 2006, the number of citations exceeded 100 for the first time, and a total of 120 citations were made during this year. The graph reveals that there has been a perpetual increase in the number of citations over the years, and the year 2020 is noted as the year in which the highest number of citations was made with a total of 441. The polynomial regression value in the citation increases of the studies between 1980 and 2021 was identified as R^2=.8026. It was concluded that the number of citations increased by an average of 80% between 1980 and 2021. The average number of citations per year between 1980 and 2021 was calculated as 106.97. The distribution of studies by languages is given in Table 1.

Table 1. Distribution of academic studies by language

Languages	Records	%
English	544	87.601
Portuguese	50	8.052
Spanish	15	2.415
French	3	0.483
Turkish	3	0.483

(Continued)

Table 1. Distribution of academic studies by language *(Continued)*

Languages	Records	%
Czech	2	0.322
Chinese	1	0.161
Indonesian	1	0.161
Russian	1	0.161
Slovenian	1	0.161

The analysis of academic studies on the use of technology in geography education research reveals that most of the studies were conducted in English, and the proportion of studies in English among all languages is 87.6%. Following English, Portuguese is used in a total of 50 academic studies constituting 8% of all. A total of 15 studies were written in Spanish and their distribution among languages is 2%. In French and Turkish languages, there are three studies constituting 0.4% each. There are two studies in Czech language with a percentage of 0.3%. In Chinese, Indonesian, Russian and Slovenian languages, one study was carried out for each, and the percentage of each language is revealed as 0.161%. The findings reveal that English was mostly preferred in the studies on the use of technology in geography education research. The distribution of academic studies by country is given in Table 2.

Table 2. Distribution of academic studies by country

Countries	Records	%
England	183	29.469
USA	107	17.23
Brazil	51	8.213
Australia	44	7.085
China	24	3.865
Spain	22	3.543
Indonesia	21	3.382
Canada	20	3.221
New Zealand	18	2.899
South Africa	17	2.738
Romania	16	2.576
Turkey	14	2.254
Ireland	11	1.771
Netherlands	11	1.771
Singapore	9	1.449
Scotland	8	1.288
Czech Republic	7	1.127
Germany	7	1.127
Cuba	6	0.966
Greece	5	0.805
Slovakia	5	0.805
Wales	5	0.805

The analysis of the distribution of academic studies by country reveals that the highest number of studies was conducted in the United Kingdom (n=196). When the distribution of studies in the United Kingdom is analysed by regions, it is revealed that a total of 183 studies were conducted in England, 8 in Scotland and 5 in Wales. With a total of 196 studies the United Kingdom has a share of 29.4% among all countries. The second country with the highest number of studies is the USA with a total of 107 studies and a share of 17.2% among all countries. Brazil is the third country with the highest number of studies, with 51 studies which constitute 8.2% of all. While Australia is the fourth country with 44 studies (7%), the People's Republic of China ranks fifth (3.8%) with 24 studies. In Spain a total of 22 studies were conducted, in Indonesia 21, in Canada 20, in New Zealand 18, in South Africa 17, in Romania 16, in Turkey 14, in Ireland and the Netherlands 11. The findings reveal that most of the studies were carried out in Europe and North America. The bibliometric coupling between countries is given in Figure 3.

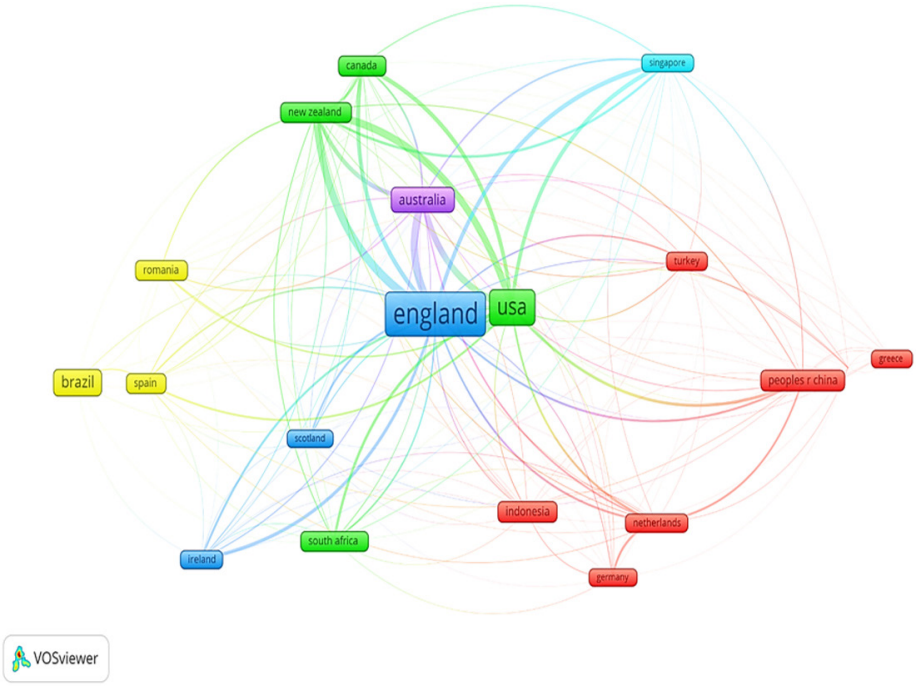

Fig. 3. Bibliometric coupling between countries

Source: Web of Science; Figure created by the author using VOSviewer.

The minimum number of publications from a country was determined as five. With the criteria set as at least five publications for each country, a total of 21 countries were clustered in six different clusters. Links in academic studies between countries are stronger in the same colour clusters, and there are eight countries in the red cluster (Czech Republic, Germany, Greece, Indonesia, Netherlands, China, Slovakia, and Turkey). The four countries in the green cluster are the USA, Canada, New Zealand, and South Africa. In the blue cluster with three countries there are Ireland, Scotland,

and England. Similarly, in the yellow cluster there are three countries which are Brazil, Romania, and Spain, and in the purple cluster there is only Australia. Similarly, in the turquoise cluster, it is seen that there is only Singapore. The distribution for the most cited countries is given in Table 3.

Table 3. Countries with the highest number of citations

Country	Citations	Total Link Strength
England	1481	5285
USA	1038	4485
New Zealand	726	2405
Australia	535	2147
Canada	533	1087
Turkey	284	179
Singapore	239	970
Finland	126	568
Netherlands	110	718
Chile	98	418
Romania	90	223
Ireland	86	541
South Africa	66	504
North Ireland	51	142
Spain	45	359
Peoples R China	37	569
Scotland	29	234
Israel	27	10
Wales	24	293
Jamaica	20	26
Brazil	13	87
Greece	12	55
Denmark	12	56
Lesotho	11	99

The country with the highest number of citations for its academic studies is revealed as England, and it is also identified as the country with the highest link strength. Other countries with higher number of citations that are over 200 are the USA, New Zealand, Australia, Canada, Turkey, and Singapore. Similarly, following the UK, the countries with the highest link strength are listed as the USA, New Zealand, Australia, Canada, and Singapore, respectively. When the average citation is analysed according to the number of publications in the country, it is identified that these countries are Australia, Canada, Chile, Singapore, and Turkey, respectively. The higher the link strength of a country, the higher the citation and publication cooperation with other countries. The citation and publication cooperation of the UK and the USA with other countries is very high.

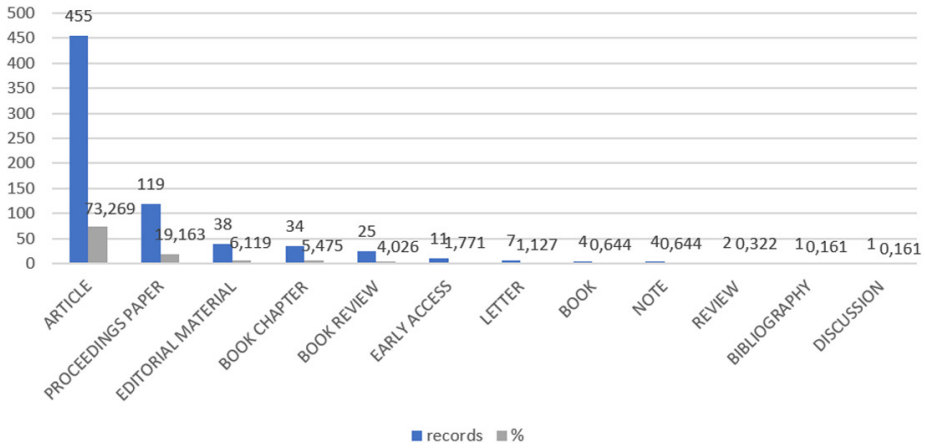

Fig. 4. Distribution of academic studies by document type

Source: Web of Science; Figure created by the author using Excel.

A total of 455 (73.2%) of the academic studies on the use of technology in geography education research, are identified as articles, 119 (19.1%) were papers and 38 (6.1%) were editorial materials. As Figure 4 demonstrates, a total of 34 studies (5.4%) are book chapters and 25 studies (4%) are book review. The most used keywords by the authors are given in Figure 5.

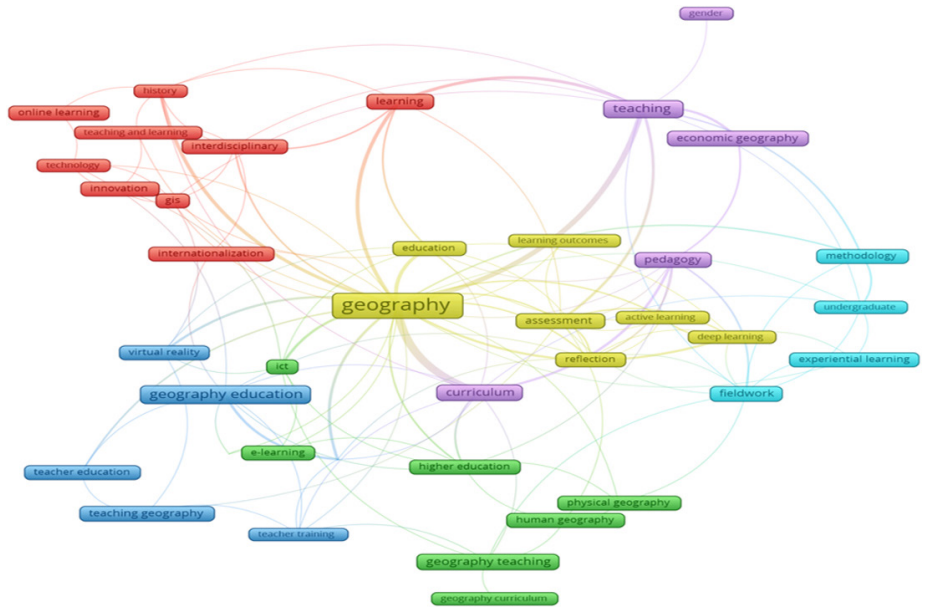

Fig. 5. Keywords most used by authors

Source: Web of Science; Figure created by the author using VOSviewer.

Provided that each keyword is repeated at least five times, a total of 41 of the 1272 keywords have reached the threshold. The keywords are grouped in six different clusters. The nine keywords in the red cluster are listed as GIS (Geographic Information System), history, innovation, interdisciplinary, internationalization, learning, online learning, teaching, and learning and technology, and it is seen that the studies that feature these keywords focus on online education and geographic information systems technologies. There are eight keywords in the green cluster, and these can be listed as blended learning, e-learning, geography curriculum, geography teaching, higher education, human geography, physical geography, and ICT (Information and Communication Technologies). The keywords in the green cluster reveal that there is a tendency towards academic studies on e-learning environments and blended learning through the use of information and communication technologies in geography teaching studies at the higher education level. There are seven keywords in the blue cluster. These keywords can be listed as geographical education, geography education, problem-based learning, teacher education, teacher training, teaching geography and virtual reality. There are seven keywords in the yellow cluster, and these can be listed as active learning, assessment, deep learning, education, geography, learning outcomes and reflection. The words in the yellow cluster reveal that there are tendencies towards measurement and evaluation in geography education and, active learning and deep learning. The purple cluster features keywords such as curriculum, economic, geography, gender, pedagogy, and teaching. The last cluster, which is the turquoise, features experiential learning, fieldwork, methodology and undergraduate.

5 Results and discussion

A total of 621 academic studies on the use of technology in geography education that are indexed by Web of Science indexes were found between 1980 and 21.04.2021. The number of publications and citations related to the use of technology in geography education demonstrates an increase over the years. It is identified that the number of publications and citations displayed a slow increase between 1980 and 2005, and a faster increase can be seen in the number of publications and citations after 2006. From the 1980s to the 2000s, the continuous development of technology, the increase in the number of academic publishers and journals, and the continuous development of geographic information technologies are thought to be effective in the phenomenon of publish or perish. It is thought that it has affected the increase in the number of publications on the use of technology in geography teaching, as in every field in the academic world. There is a strong positive relationship between the number of publications and the number of citations, and the academic studies conducted on the subject and the citations support each other. This confirms the tendency towards the use of technology in geography education. It is believed that the use of technology in geography education will gain more significance depending on the increasing number of publications and citations in the following years. Sönmez et al., [32] in their bibliometric analysis study, examining the publications on geography education, revealed that the number of publications and citations indexed by Web of Science increased over the years. In a similar line, the bibliometric analysis study by Melo and Queiroz [33], on geographic information systems between 2007 and 2016 revealed an increase in the number of publications over the years. In his

study on academic studies on spatial analysis between 1950 and 2019, de Queiroz [34], revealed that the number of publications indexed by Web of Science increased rapidly as of the 2000s in comparison to previous decades. When the findings of bibliometric analysis studies on different areas in the field of geography, geographic information technologies and education in the literature are examined, it is seen that the number of publications and the number of citations has increased over the years. As Huggett [35] stated, considering the increase in the number of researchers and scientific studies, and the rapid progress in science in recent years, bibliometric studies are of great significance in terms of identifying trends in the scientific field in a subject or field. In this context, it is thought that the findings obtained from this study will be a guide for new studies.

88% of the academic studies on the use of technology in geography education are conducted in English, while 8% are carried out in Portuguese and 2% are conducted in Spanish. Sönmez et al., [32] in their bibliometric analysis study on geography education, examined the distribution of academic studies by languages and obtained similar findings. When the findings of both bibliometric studies are taken into consideration, it can be concluded that English is the most preferred language in conducting research on geography education.

When the geographical distribution of academic studies on the use of technology in geography education is analysed, it is revealed that most of the studies are conducted in England, followed by the USA, Brazil, Australia, and China, respectively. It is also revealed that in certain countries no studies were conducted, and that academic studies on this subject in North Africa, the Middle East, Central Asia, Eastern Europe, and the Caucasus scarce in quantity. In their bibliometric analysis study on geography education research, Sönmez et al., [32] revealed that most of the studies were conducted in the USA, followed by England, Australia and Turkey. Melo and Queiroz, [33], in their bibliometric analysis on geographic information system studies, revealed that the countries with highest number of studies are the USA, Canada, Brasi, England, the Netherlands, Germany, Spain, China, Turkey and Iran. According to the bibliometric analysis they conducted on research on global remote sensing, Zhuang et al., [36] stated that, the largest number of studies were carried out in the USA, China, the United Kingdom, and that research was carried out extensively in countries such as Canada, India, Australia, France, Italy and Germany. Li et al., [37], in their bibliometric analysis study, revealed that the highest number of academic studies were conducted in the USA, the United Kingdom, China, Australia, Spain and Italy. Similarly, in their bibliometric analysis study on economic geography studies, Zhu et al., [38] revealed that the countries that conducted the most academic studies were the United Kingdom, the USA, and China. They also noted that Western European countries such as Germany, Sweden, Italy, the Netherlands, and Spain produced more scientific studies than other countries. In their study on bibliometric analysis of scientific production, Ellegaard and Wallin, [30] revealed that the highest number of studies were conducted in the USA, China, Spain and England. The USA, the United Kingdom, Western European countries, Australia, and China are the countries with higher number of conducted studies. It is revealed that studies on the use of technology in geography teaching are conducted in North America, Western European countries, Australia, and China, and it is also observed that there are very few academic studies on this subject in North Africa, Middle East, Central Asia, Eastern Europe, and Caucasus countries. It is recommended that more research be conducted on geography teaching in North Africa, Middle East, Central Asia, Eastern Europe, and Caucasus countries.

According to the results of keyword and text mining analyses carried out with VOSviewer bibliometric analysis software, it is identified that online learning, interdisciplinary geography education, interdisciplinary approach in undergraduate education/teacher education, virtual reality, geographic information systems, information and communication technologies are trending subjects for research on technology use in geography education. Moreover, it is also revealed that, there is tendency towards research that focus on interdisciplinary geography education, sustainable development, learning outcomes, student achievement, geographical skills, motivation as well as studies that aim for acquisition of spatial thinking skills. In addition to the topics addressed in the body of research carried out in recent years, it is thought that academic studies that measure and analyse the effects of recent technologies such as mixed reality, STEM, artificial intelligence, and learning analytics on skills such as geographical skills, geographical thinking skills, spatial thinking skills as well as other learning outcomes can be conducted further.

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