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TWENTY-TWO YEARS OF SCIENCE COMMUNICATION RESEARCH: A BIBLIOMETRIC ANALYSIS

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Abstract. *In recent years, the number of academic studies in the field of science communication has increased. It is important to make a general examination of the studies on science communication and to reveal their distribution according to years and countries in order to draw the framework of science communication studies. The main aim of this study was to analyze the science communication-based articles published in journals in the Web of Science (WoS) index in the last 22 years. Within the scope of the study, articles were scanned by typing keywords such as "topic", "title", "keywords" science communication from the WoS database and 322 articles were examined by bibliometric analysis method. As a result of the study, the articles published between 2000 and 2022 were examined according to years, countries, funding organizations, research area, publishing houses, country scores and citations. According to the results, most articles were published in 2022(N = 58); USA, UK, Australia, Germany ranked first with the number of articles and SAGE (N = 74) ranked first in publisher distributions. This study offers a global perspective on science communication and proposes a vision for future research.*

Keywords: *Bibliometrics analysis, journal articles, research trends, science communication, Web of Science (WoS)*

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Introduction

The dissemination of the research results of scientists and the presentation of these results in a way that society can understand scientific information has led to the emergence of the concept of science communication. Especially while the increase in the number of mass media mediates the spread of scientific knowledge, the need for individuals to closely follow the developments in the field of science has made this issue important. It is a known fact that the high level of scientific literacy of individuals has been increased with the spread of science communication.

As a result of the research conducted in the literature, the scarcity of bibliometric analyses in the field of science communication draws attention. It is predicted that the study carried out in order to reveal which studies have increased in the field of science communication and to determine the gap in this field will contribute to the field.

In this context, the scarcity of bibliometric analysis in the field of science communication makes this research important and original. In the study, a detailed review of science communication literature was conducted, and a structured analysis was employed to explain the findings. In the study, 322 articles were analyzed on science communication from the Web of Science database through the bibliometric analysis method, and their distribution was revealed by year, country, funding organization, research area, publishing house, country scores, and citations.

In the field of science communication, the distribution of countries by years, which topics come to the fore, research topics, distribution of organizations supporting research, publishing houses, country scores and citation distributions are important in terms of revealing the position of science communication in the international research. It is also important to reveal in which countries science communication is studied more in the international research, country scores and country citation distributions in order to show which countries are at the forefront in the field of science communication. This study will also contribute to the academic field in terms of revealing how science communication has a visual mapping in the international research.

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Science Communication

Science is a multidimensional concept with its social, cultural, democratic, and economic aspects (Burakgazi, 2017). The multidimensional nature of science requires that scientific studies be made systematic by freeing them from dependence on communities and individuals (Gregory and Miller, 1998). The role of communication is important in the dissemination of science and its transmission to society. Burns et al. (2003), who made the definition of science communication, state that there is an uncertainty in the academic literature about science communication and related concepts. Science communication is defined as the use of information, reliable information between scientists, politics, society, deciders, industry, and other stakeholders (Burakgazi, 2017). Science communication reveals a dynamic structure for the production, dissemination of information, influence from social and cultural elements and interaction. Undoubtedly, science is moving away from its purpose to the extent that it is not transmitted; therefore, science communication is seen as one of the basic conditions for the existence of scientific knowledge. In this context, spreading science and increasing the level of scientific literacy depends on creating and maintaining science communication with strategic elements. Creating a qualified society and rising to the level of modern civilizations depends on increasing the level of scientific literacy (Utma, 2017).

Although science communication is new as a concept in the field of communication, it dates back to the 19th century in terms of its field of study. Science communication has attracted the attention of researchers, politicians, and academics throughout history. Science communication also encourages individuals to participate in scientific discussions and policy. Science communication has become controversial, especially with the institutional, social, and technological changes and digitalization in the last few years (Babule et al., 2009). Rapid developments in Information and Communication technologies have made science communication more visible and traceable. While science communication has become widespread, especially through social media platforms, it can also be developed through various types of media, school education, seminars, museums and science centers, science clubs and competitions, various science events and science festivals (Burns et al., 2003). The sources of science communication are very diverse; newspapers and magazines, books, television, internet, science centers, museums, conferences, science festivals, etc. These communication tools contribute to establishing the relationship between scientists and scientific knowledge and society (Ozdemir & Kocek, 2020). Trench and Bucchi (2010) emphasized that science communication is developing in such a way that it intersects with social sciences, science education, mass communication, museum studies, academic and professional activities. If it is taken into account that scientists and society receive scientific developments from mass media (Hayes & Grossman, 2010), the importance of the media in terms of science communication becomes more obvious. Scientists are able to transmit their messages quickly and directly to different groups by using a wide variety of communication tools.

Scientific knowledge is an important issue that determines the development level of countries (Tiryaki & Karakus, 2022). Although scientific and technological developments develop rapidly or slowly depending on the development of each country, developments in the field of science and technology are now much faster and it is becoming more difficult to track them. In this direction, the transfer of scientific knowledge is also becoming faster in the 21st century (Burakgazi, 2017). Science communication is seen as a personal, national, cultural, and political need (Lewenstein, 2014). As much as individuals in society need science, countries also need science communication for their development. Burns et al. (2003) defined the purpose of science communication as a process with scientific awareness, understanding and scientific culture. The increasingly central position of science and the discussions about healthy and sustainable living have made science communication important (Murcott & Williams, 2012). It is widely accepted that it is necessary to have a sufficient level of scientific literacy in order to be an effective member of society in a rapidly changing world (Ozdem et al., 2010). In this context, the concept of scientific media literacy has also come to the fore today. The way to increase scientific media literacy among the people is increasing in direct proportion to the studies carried out by the countries on this issue. Parameters of science communication, such as creating an attitude supporting science among the public and the participation of the public in decision-making processes related to scientific and technological policies, can be possible with the establishment of an official science policy of a country and the existence of institutions that manage this process (Dursun, 2010). In this regard, every country should create, maintain and disseminate science policies to the extent possible.

Science, which started to become a part of cultural life with public lectures and conferences, started to appear in newspapers for the first time in the 19th century (Dursun, 2010; Nelkin, 1987). In this context, the concept of science communication began to gain importance, especially in the 1980s, and efforts to communicate scientific

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and technological developments to the public increased (Akoglu, 2011; Burns et al., 2003; Dursun, 2010). Studies on science policies as a country were first conducted by the USA. The science policy was established in the USA in 1945 and started to be implemented (Elmacı, 2015). Science communication education is included in undergraduate, graduate and doctoral programs of universities in many countries such as China, India, Australia (Gascoigne & Metcalfe, 2017). Knight Science Journalism scholarship, awarded by Massachusetts Institute of Technology (MIT) in the USA, provides seminars and laboratory trips for journalists throughout the academic year to gain science writing skills and allows them to follow advanced science courses (Hayes & Grossman, 2010). Journalism education for scientists has been organized, so that scientists understand the perspectives of journalists and explain their work in a way that the public will understand. In 1969, the Exploratorium Science Center in the USA and the Ontario Science Center in Canada were established (Burakgazi, 2017). The American Science Development Association has been providing scholarship opportunities to graduate science and engineering students in media organizations since 1975. Founded in 1979, Science Communication journal started to publish theoretical and empirical research in the field of science communication (Burakgazi, 2017). Since 1987 in the UK, scientists have been sent to media organizations with journalism scholarships every year. In Turkey, science policy studies gained momentum with the establishment of TUBITAK in 1963. TUBITAK's 2018-2022 Strategic Plan emphasises the importance of promoting a culture of science and technology. The establishment of the OECD in the development of science policies in Turkey has also increased the interest in scientific activities. The opening of 16 science centers in various cities in Turkey contributes to the dissemination of science to the public (Cakmakci & Gelmez-Burakgazi, 2020).

Increasing undergraduate, graduate and doctoral level courses in the field of science communication is also important for the dissemination of science communication. Science courses should be made effective, especially in compulsory basic education, which is considered as one of the two most important tools in ensuring the sensitivity of society to scientific data. When evaluated from the point of view of science journalism, it is thought that the fact that basic science courses at the faculties of communication are elective for students. It is important for journalist candidates working in the field of science communication to have a level of understanding of English, to know how to access scientific information and how to convey the information they have reached to society in a simple and understandable language, even if they are not scientists (Kurtulus, 1997). It is also possible to state that book, paper and article studies have increased in the field of science communication. Academic studies aimed at measuring the level of knowledge of students related to science communication have also increased. In a study conducted in this area, in order to examine biotechnology students' views on education in science communication, 69 biotechnology undergraduate students were asked to rank the importance of 12 components (mass, language, content, context, interaction, style, prior knowledge, narrative, mode, dialogue, theory). A curriculum survey was conducted followed by semi-structured interviews with 13% of 2nd year students. As a result of the research, it has been revealed that students do not value science communication enough (Edmondston et al., 2010). Mercer-Mapstone and Kuchel (2015), in their research conducted on the teaching of science communication skills at the undergraduate level at 4 universities ranked internationally in Australia, found that more than 50% of 12 basic communication skills are missing. In another study, a report prepared for the Australian Council of Deans of Science (ACDS) found that analytical, technical and problem-solving skills and science content knowledge were successfully taught, but communication skills lagged behind in oral, written and interpersonal communication types (McInnis et al., 2000). A UK-based study emphasized that expressing expectations when teaching communication in a science graduate program is important for quality learning (Divan & Mason, 2015). The results of these studies reveal that science graduates should be equipped with communication skills. In the study conducted by Aberšek and Aberšek (2010), it was stated that engineers need communication skills and should be trained in this regard. In this context, it has been determined that oratory and communication trainings are given to students studying in the engineering department in their research. As a result of the survey conducted after the training, it was determined that there was a remarkable improvement in the communication skills of the students (Cavas et al., 2013). Cavas et al., (2013) measured the scientific literacy level of science teacher candidates, revealed that the scientific literacy level of teacher candidates is high. Dagdan et al., (2015), in a qualitative study on pre-service teachers' use of social media-supported scientific communication, determined that they could not perform the tasks of producing new and original ideas, comparing and presenting the emerging ones with previous studies at the stages that require a higher level of knowledge and skills. In the study, which examined 1300 articles published in the field of science communication between 1997 and 2018, it was revealed that science education gave more importance to communication methods to reach the public. In the same study, the increase in the interest of the media in science revealed the increase in media-themed research. Considering the role of the media in interacting

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with the public, today the media is emerging as a basic component of science communication (Wu et al., 2019). According to the results of this study, it can be said that the media has an important role in the dissemination of science communication.

Considering that the society's need and curiosity for scientific knowledge have increased, it comes to the fore that scientists should also bridge the gap between society and science. Delivering the developments in the field of science and technology to ordinary people on the street is possible through science communication. In order for science to have a positive effect on society, there is a need for the scientific way of thinking to spread among the people. However, the further institutionalization of science in the 20th century has opened the distance between scientists and the public (Utma, 2017; Weingart & Guenther, 2016). Therefore, in order to close the distance between society and scientists, communication experts, scientists and the media state that science communication should not operate as a one-way approach, as in the public's understanding of science, but as a dialogue. In this field, since the 1990s, it has been stated that science should be discussed with the public and the public should understand science, and this approach has been called "public engagement with science" (Akoglu, 2010). Referring to the importance of dialogue in science communication, Kohen and Dori (2019) examined the articles published in 3 science communication journals and 3 science education journals published between 2000-2017. In the articles examined as a result of the research, it was determined that the importance of dialogue was emphasized in order to spread science communication. An important area where science educators and science communicators overlap is to increase the importance of science in society and involve various stakeholders in productive dialogues about science (Baram-Tsabari & Osborne, 2015). To enhance their communication effectiveness, scientists must comprehensively grasp and tactfully address the perspectives of interest groups, policymakers, businesses, and other key stakeholders involved in deliberations pertaining to decisions necessitating scientific expertise (Fischhoff & Scheufele, 2013). In this context, scientists should not hesitate to seek partnerships with talented communicators when communicating with the public (Bickford et al., 2012). An approach to dialogue-oriented public communication requires scientists to be prepared to carefully consider the needs of their audiences and listen to their concerns (Trench et al., 2014). In addition, scientists should be careful when communicating with the media, and they should consider that the results of their research increase their responsibilities towards society. The main issue in the field is the existing distance between scientists and the public, which hinders effective science communication. Although current solutions highlight the importance of dialogue and public engagement with science, the main limitation lies in the lack of effective two-way communication. Consequently, there is a need to enhance science communication practices to ensure the broader dissemination of scientific knowledge and its positive impact on society. Addressing this need, the present research establishes a general framework based on academic articles published in the Web of Science database, within the context of science communication.

This study includes data from 2000 to 2022, aiming to determine the subjects that have gained prominence in the field of science communication. By examining countries, funding institutions, research areas, publishing houses, country scores, and citations, valuable insights can be obtained regarding the evolution of the science communication field.

Research Aim and Research Questions

The aim of this study was to analyze the studies in the field of science communication and to reveal the trends in this subject. In this context, the research questions have been formed as follows:

1. What is the distribution of articles indexed in the Web of Science database on science communication by year
2. What is the distribution of the articles indexed in the Web of Science database on science communication by country?
3. What is the distribution of the articles indexed in the Web of Science database on science communication by funding agencies?
4. How has the distribution of articles indexed in the Web of Science database on science communication changed by research area?
5. What is the distribution of the articles indexed in the Web of Science database on science communication by publishers?
6. What is the distribution of the articles indexed in the Web of Science database on science communication according to country scores?

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7. What is the distribution of the articles indexed in the Web of Science database on science communication according to country citations?
8. What is the distribution of the articles indexed in the Web of Science database on science communication by keywords and what are the links of these keywords?

Research Methodology

General Background

This study aimed to reveal the bibliometric analysis of the articles published between 2000 and 2022 on science communication. The study was conducted through a literature review and it was researched whether there are similar studies in the field of science communication. It was decided to conduct the study due to the scarcity of studies and the fact that the years 2000-2022 cover a wide period of time. It is known that the best method in such studies is the bibliometric analysis method. In this context, the articles obtained from the Web of Science database were analyzed by bibliometric analysis method. In the field of science communication, the distribution of countries by years, which topics come to the fore, research topics, distribution of organizations supporting research, publishing houses, country scores and citation distributions are important in terms of revealing the position of science communication in the international research. It is also important to reveal in which countries science communication is studied more in the international research, country scores and country citation distributions in order to show which countries are at the forefront in the field of science communication.

Keywords related to science communication have been determined. It has been determined whether the keywords have changed over the years, and which topics and keywords have come to the fore. Within the scope of the study, the visuals of the prominent keywords in the field of science communication were also revealed with the VOSviewer programme. The distribution of keywords is also important in terms of showing which words are prominent in the field of science communication in the international research, determining which topics the academic community focuses on, and determining in which direction science communication has evolved. Within the framework of this approach, these determinations are important in terms of revealing the direction in which academic studies in the field of science communication have evolved. Bibliometric studies are effectively used to decipher trends and future perspectives between certain years. The bibliometric analysis method used to reveal the trends of the articles published in the Web of Science database in the field of science communication provides important data in terms of revealing the trends between years.

Instrument and Procedures

The Web of Science database has been used to determine the data related to science communication. Web of Science is a bibliometric database used to measure, evaluate and monitor scientific research. The database in question includes scientific articles and other studies published in scientific journals. WoS is a bibliometric database used to measure, evaluate and monitor scientific research. The database in question includes scientific articles and other studies published in scientific journals. It also includes research, methods and topics in various fields. With the Web of Science database, scientists can access article and journal evaluations such as the number of citations, impact factor and other criteria. It also includes research, methods and topics in various fields. With the WoS database, scientists can access article and journal evaluations such as the number of citations, impact factor and other criteria. In addition, scientists can discover new research areas by following publications and articles in a particular field (Scientific Publications, 2023). Bibliometric analysis can be employed to categorize aspects of science, such as the most contributing authors, journals, institutions, universities, and countries (Ellegaard & Wallin, 2015). Bibliometric analysis was performed in the research. Bibliometry is defined as performing statistical analysis of publications related to a subject by using data such as year, country, source, subject, citation, and author (Cobo et al., 2011). Bibliometric analysis is the name of a general process required for science mapping, field analysis and visualization (Chen, 2017). The bibliometric analysis method provides the necessary information from analysis methods, data, networks and maps to create scientific maps. With this method, the densities in data, networks and maps can be determined. At the same time, it is possible to determine the degrees of strength of relationships, qualities and connections of data (Cobo et al., 2011; Jan Eck & Waltman, 2010).

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The methodology developed and used by Tsai and Wen (2005) and Lee et al. (2009) was chosen to conduct the country analysis (Cavas, 2015). The accumulated score of each country was made according to the scoring made by Tsai and Wen (2005). In this form of scoring, "One point is given to each paper. If an article is published by more than one author, each from a different country, one point is divided into certain ratios for authorship from each participating country. For example, if an article is written by two authors, the first is a British author, the second is a US author, then the UK authorship for this particular article gets 0.6 points, while the US authorship gets 0.4 points." the expressed method has been used.

The Web of Science (WoS-webofscience.com) database was used to access the published articles for bibliometric analysis. Due to the reasonable availability of search filters, the keyword "Science Communication" has been used to find articles related to science communication in the search page of the database to access articles based on "Science Communication". After searching on "Science Communication", it was refined to get articles published from the year 2000. Also, editorial, mini-review, etc. articles are out of scope and this situation constitutes the limitation of the study. In addition, the criteria for including "Science Communication" in the "title", "abstract" or "keywords" of the studies were applied. The VOSviewer program was used to visualize the keywords. With the VOSviewer program, a bibliometric analysis of journals, analysis of specific subject areas, determination of word density in studies, analysis of website content and co-authorship can be done. The subject distributions of the journals, which vary according to the years, can be determined. Citation analyses of authors can be created. In the studies, the words that create density can be determined (Artsın, 2020). These determined elements can be revealed by visualizing with the VOSviewer program (McAllister et al., 2022).

Data Analysis

In the study, 322 articles found as a result of filtering were analyzed by the bibliometric analysis method. A bibliometric analysis approach was used to provide explanations about the content of 322 articles based on Science Communication. The frequencies of the data obtained by the bibliometric analysis method were determined.

Research Results

The articles obtained from the Web of Science database were analyzed and the following results were obtained.

Table 1
Distribution by Years

Years	Number of Articles	Years	Number of Articles
2022	58	2012	9
2021	46	2011	5
2020	49	2010	6
2019	38	2009	3
2018	18	2008	7
2017	23	2007	3
2016	23	2006	3
2015	12	2005	1
2014	11	2004	2
2013	4	2000	1

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When the distribution of the published articles by years is examined, 1 article was published in 2000 and 1 article in 2005. It is seen that the studies in this field started to increase after 2014. Between 2000 and 2013, the number of article publications varied, decreasing in some years and increasing in others. It was determined that the same number of articles were published in 2016 (*N* = 23) and 2017 (*N* = 23). It was determined that more than 50 articles were published in 2022. It is possible to say that the number of articles increased every year in the period from 2000 to 2022.

Table 2
Distribution by Country

Countries / Regions	Number of Article	Countries / Regions	Number of Article	Countries / Regions	Number of Article
USA	86	Portugal	9	Taiwan	2
UK	62	Japan	8	Argentina	1
Australia	36	Sweden	7	Azerbaijan	1
Germany	31	France	4	Botswana	1
Canada	20	Israel	4	Colombia	1
NewZealand	19	Mexico	4	Croatia	1
Italy	15	Austria	3	Finland	1
People's Republic of China (PRC)	15	Russia	3	Greece	1
South Africa	14	South Korea	3	Kenya	1
Netherlands	13	Belgium	2	Lithuania	1
Switzerland	13	Estonia	2	Malaysia	1
Denmark	12	Belgium	2	Pakistan	1
Spain	12	Kazakhstan	2	Thailand	1
Brazil	10	Norway	2	Zimbabwe	1
India	9	Singapore	2		

When the distribution of articles published by country is examined, it is seen that the USA (*N* = 86) comes to the fore. UK (*N* = 62) took the second place. Then there was a notable increase in Australia (*N* = 36) and Germany (*N* = 31). Although the number of article publications of Canada and New Zealand countries is close to each other, Canada (*N* = 20) and New Zealand (*N* = 19) have taken their places in the ranking with the article.

The number of articles published in Italy and the People's Republic of China is the same. It was determined that 15 articles were published in both countries. Likewise, it was determined that an equal number of articles (*N* = 13) were published in The Netherlands and Switzerland. An equal number (*N* = 12) of articles have been published in Denmark and Spain. An equal proportion (*N* = 9) of the articles have been published in India and Portugal. It is observed that an equal number (*N* = 7) of articles are published in Ireland and Sweden.

A total of 12 articles were published in France, Israel and Mexico in equal proportion (*N* = 4) in all three countries. A total of 9 articles were published in Austria, Russia and South Korea in equal proportion (*N* = 3), in all 3 countries. A total of 14 articles were published in Belgium, Estonia, Indonesia, Kazakhstan, Norway Singapore, Taiwan in equal proportion (*N* = 2) and in these 7 countries.

In the distribution of countries, it was determined that only one article was published in Argentina, Azerbaijan, Botswana, Colombia, Croatia, Finland, Greece, Kenya, Lithuania, Malaysia, Pakistan, Thailand, and Zimbabwe. The scarcity of articles published in the field of science communication in these countries is remarkable.

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Table 3
Country Distribution Scores

2000		2004		2005		2006	
Country	Score	Country	Score	Country	Score	Country	Score
USA	1	Netherlands	2	Italy	1	Canada	1
						Italy	1
						South Korea	0.6
						UK	0.4
2007		2008		2009		2010	
Country	Score	Country	Score	Country	Score	Country	Score
India	2	UK	2	India	1	Australia	1
PRC	1	Belgium	1	Switzerland	1	Canada	1
		PRC	1	USA	1	Croatia	1
		USA	1			Germany	1
		Canada	0.68			Mexico	1
		Australia	0.64			USA	1
		Netherlands	0.47				
		New Zealand	0.21				
2011		2012		2013		2014	
Country	Score	Country	Score	Country	Score	Country	Score
Denmark	1.6	India	2	UK	1	Australia	3
UK	1.4	USA	2	Italy	1	UK	2
Canada	1	PRC	1.17	Japan	1	USA	2
USA	1	Canada	1	USA	1	Canada	1.4
		Finland	1			Italy	1
		Singapore	0.72			Spain	1
		Greece	0.53			Switzerland	0.6
		Germany	0.47				
		Malaysia	0.11				
2015		2016		2017		2018	
Country	Score	Country	Score	Country	Score	Country	Score
UK	5.76	USA	3	USA	4.85	USA	4.34
PRC	2	UK	3.4	Australia	4	Switzerland	2.32
USA	2	Australia	3	UK	2.81	UK	1.6
Russia	0.8	Denmark	2	Japan	2	South Korea	1.53
Italy	0.79	Germany	1.93	South Africa	2	Brazil	1.47
Kazakhstan	0.33	Brazil	1.61	New Zealand	1.19	Denmark	1.4
NewZealand	0.32	Italy	1.6	India	1	New Zealand	1.4
		South Africa	1.47	Sweden	1	Japan	1.21
		France	1	Spain	1	Portugal	1
		Japan	1	Portugal	0.79	Australia	0.92
		New Zealand	1	Canada	0.68	Taiwan	0.6
		Switzerland	1	Indonesia	0.6	Canada	0.21
		Pakistan	0.6	Israel	0.47		
		Mexico	0.26	Germany	0.4		
		Argentina	0.13	Brazil	0.21		
2019		2020		2021		2022	
Country	Score	Country	Score	Country	Score	Country	Score
USA	8.21	USA	16.24	USA	11.07	USA	12.89
New Zealand	5.01	Germany	6.82	Germany	5.16	Germany	7.53
Australia	3.2	Australia	5.39	UK	4.98	Australia	5.07
Germany	2.68	UK	3.72	Australia	4.18	Netherlands	4.08
UK	2.23	Canada	2.66	Sweden	3	Spain	3.37
Denmark	2	South Africa	1.07	Spain	2.74	PRC	3

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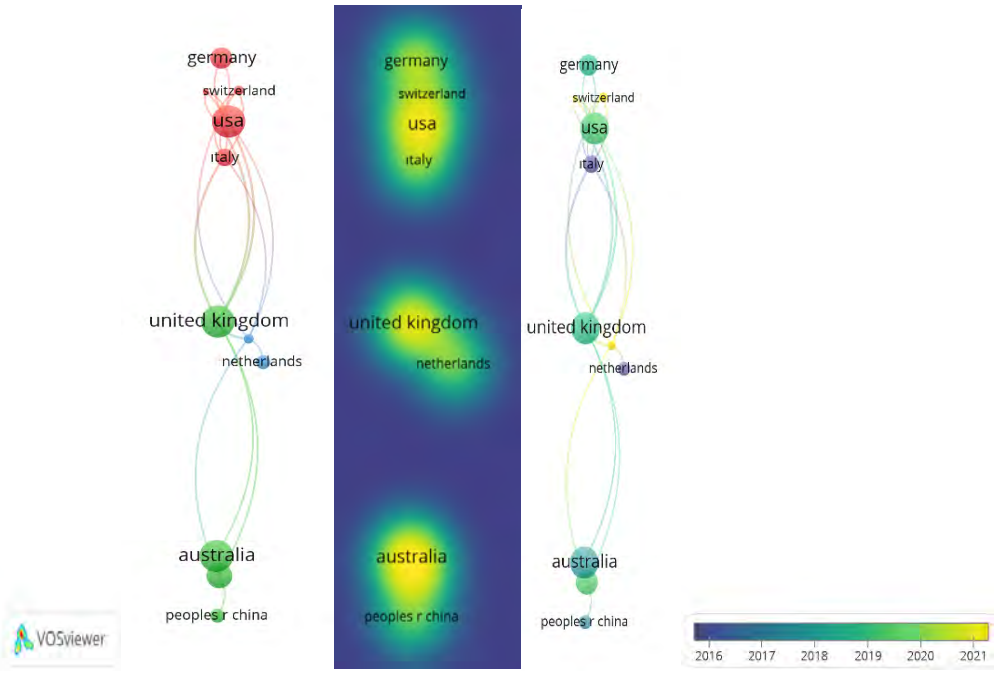
Canada	1.64	France	1	Canada	2.21	Brazil	2
Norway	1.4	Israel	1	Portugal	2	Denmark	1.64
South Africa	1.4	Italy	1	Italy	1.89	UK	1.51
Azerbaijan	1	Japan	1	PRC	1.58	Portugal	1.37
Colombia	1	Lithuania	1	Brazil	1	Switzerland	1.36
India	1	New Zealand	1	Denmark	1	New Zealand	1.06
Israel	1	PRC	1	Japan	1	Canada	1
Italy	1	Spain	1	New Zealand	1	India	1
Taiwan	1	Sweden	1	Estonia	0.61	France	0.6
Switzerland	0.92	Switzerland	1	South Africa	0.48	Indonesia	0.58
PRC	0.92	Netherlands	1			Mexico	0.4
Thailand	0.6	Zimbabwe	0.26			South Africa	0.4
Spain	0.58	Botswana	0.24			Italy	0.26
Brazil	0.53	Kenya	0.06				
Mexico	0.47						
Sweden	0.21						

In the last 7 years (between 2016 and 2022), the USA ranked first with 72.6 points in country score distributions. USA; increased its score, which was 1 in 2000, by 3 points in 2016, 4.85 points in 2017, 4.34 points in 2018, 8.21 points in 2019, 16.24 points in 2020, 11.07 points in 2021, 12.89 points in 2022. The USA has generally increased its score each year.

The UK is in second place with 31.81 points, Australia is in third place with 30.4 points and Germany is in fourth place with 25.99 points. Germany has surpassed other countries in the last 3 years (between 2020-2022). Germany scored 6.82 points in 2020, 5.16 points in 2021, and 7.53 points in 2022. Germany has increased its score in the last 3 years.

Australia has increased its score over the last 4 years (2019-2022). The countries with the lowest scores are; Greece (0.53), Thailand (0.6), Pakistan (0.6), Taiwan (0.6), Argentina (0.13), Ireland (0.43), Indonesia (0.58) and Kazakhstan (0.33). In line with these numerical data, USA, UK, Australia and Germany stand out as the countries in the first place in terms of the number of articles published in the field of scientific communication.

Figure 1
Distribution of Citations by Country



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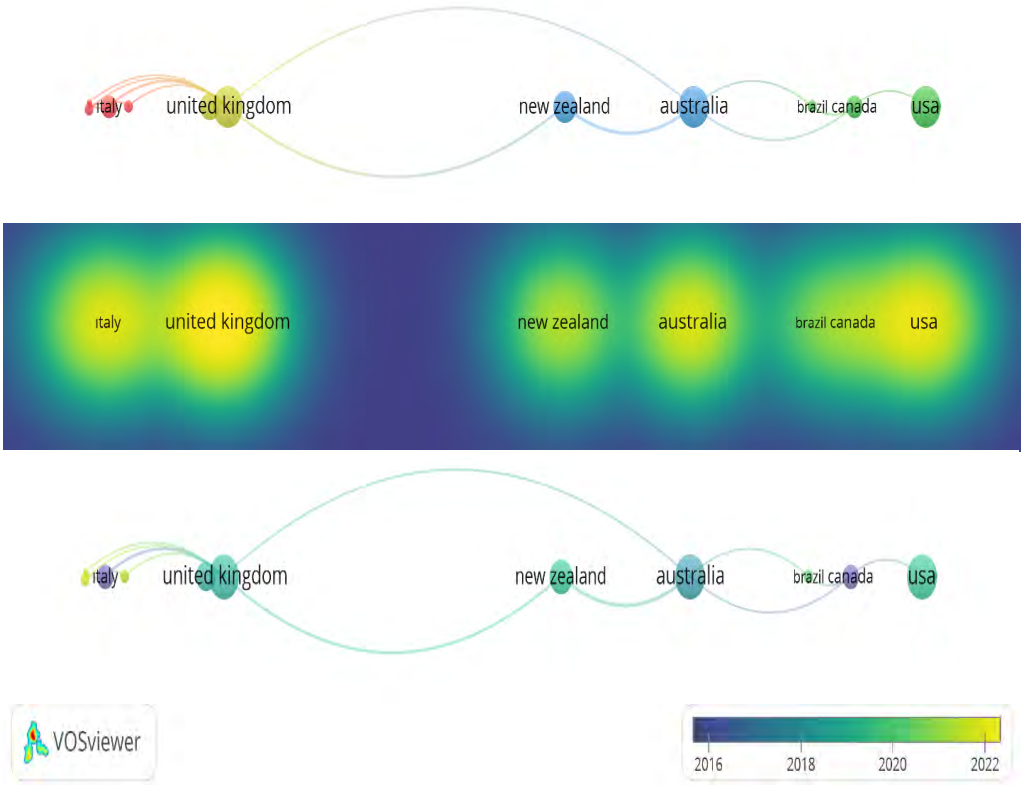
According to the results of the citation analysis, the USA, Australia, the UK and Germany come to the fore. (Vosviewer Analysis). Figure 1 also includes the most cited country names. Figure 2 shows the results of the analysis of the countries where the authors are located. When Figure 2 is examined, the authors mainly; The USA, Australia, the UK and New Zealand countries come to the fore. Therefore, the results of the author and citation analyses are consistent.

The USA received the most citations from Germany, Switzerland, and Italy. Germany; cited from Switzerland. Australia has received the most citations from the People's Republic of China country. The UK, on the other hand, has received citations from both sides, in other words, from Ireland, Italy, the USA and the Netherlands, Australia.

It can be stated that the countries that stand out in terms of the number of article publications also stand out in the number of citations. These countries are emerging as the USA, Australia, the UK and Germany. The high number of publications in the field of science communication brings about a high number of citations.

Figure 2
Country - Author Analysis



When the country-author analysis in Figure 2 is examined, the USA authors worked with Canadian authors, while the Australian authors worked with Canadian and New Zealand country writers. Country authors worked with Italy, New Zealand, Australia, Brazil, and Canada country authors. Among country authors, the USA, Australia and New Zealand show that country authors stand out and work solo.

After the 2020s, country writers from the USA, UK, Italy, Canada, Brazil, New Zealand, and Australia come to the fore.

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Table 4
Publisher Distribution of Articles

Publisher Names	Number of Article	Publisher Names	Number of Article
SAGE (USA)	74	American Society of Civil Engineers (ASCE) (USA)	1
Scuola Internazionale Superiore di Studi Avanzati-Advanced Studies (SISSA) (Italy)	64	Channel View Publications (UK)	1
Taylor & Francis (UK)	34	Duke University Press (USA)	1
Frontiers Media Sa (Switzerland)	20	European Food Safety Authority (EFSA) (EU)	1
Springer Nature (Germany)	20	Fuji Technology Press Ltd. (Switzerland)	1
Wiley (USA)	13	Fundaco Oswaldo Cruz (Brazil)	1
Elsevier (Holland)	11	Future Medicine Ltd. (UK)	1
MDPI-Publisher of Open Access Journals (Switzerland)	8	Intellect Ltd. (UK)	1
Indian Science Communication Society (ISCOS) (India	7	John Benjamins Publishing Company (Holland)	1
Academia Brasileira de Ciencias (ABC) (Brazil)	4	Khazar University (Azerbaijan)	1
Cogitatio Press (Portugal)	3	The Korean Earth Science Society (Korea)	1
Emerald Group Publishing (UK)	3	Opragen Publications (UK)	1
International Astronomical Union (IAU) (Japan)	3	Periodicum Biologorum (Croatia)	1
Korean Academy of Medical Sciences (KAMS) (Korea)	3	Sci Methodical Ctr-Sci Educologica (Lithuania)	1
Oxford University Press (UK)	3	Sciendo (Poland)	1
Palgrave Macmillan (UK)	3	Social Neuroscience (USA)	1
University of Valencia Botanical Garden (UV) (Spain)	3	Society for Technical Communication (STC) (USA)	1
American Society for Microbiology (ASM) (USA)	2	Tecnoscienza (Italy)	1
Amsterdam University Press (AUP) (Holland)	2	Tempus Publications (UK)	1
Cambridge University Press (UK)	2	TripleC (UK)	1
Canadian Journal of Communication (CJC) (Canada)	2	University Sultan Ageng Tirtayasa, Faculty of Teacher Training & Educatıon (FKIP), DSE (Indonesia)	1
Canadian Science Publishing (CSP) (Canada)	2	Unisa Press (South Arica)	1
Indian Academy of Sciences (India)	2	The University of Chicago Press (USA)	1
Mary Ann Liebert, Inc. (USA)	2	University of Wisconsin-Extension Journal Inc. (USA)	1
National Academy of Sciences (NAS) (USA)	2	University of the Orange Free State (South Africa)	1
National Association of Biology Teachers, Inc. (USA)	2	University of Calabria (Italy)	1
American Psychological Association (APA) (USA)	1	The White Horse Press (USA)	1

When examined in terms of the publishers where the articles were published, it was found that the highest number of articles were published in the USA with 14 publishers. A total of 103 articles were published in USA publishing houses. With this number, the USA reveals that it has the highest number of publishers in the field of science communication. Italian publishers took the second place with 66 articles.

It was determined that a total of 51 articles in the field of science communication were published by British publishers. A total of 29 articles were published by Swiss publishers, while 20 articles were published by German publishers.

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It was determined that 14 articles were published by Dutch publishers, while 9 articles were published by Indian publishers. 5 articles were found worthy of publication by Brazilian publishers. It was determined that 4 articles were published by Korean publishers. In other words, in the same issue, a total of 4 articles were published by Canadian publishers.

3 articles were published in Portugal, 3 articles in Japan, 3 articles in Spain. It was determined that 2 articles were published by South African publishers. 1 article was published in Croatia, 1 article in Poland and 1 article in Azerbaijan. When evaluated in line with these results, it was determined that most articles were published by USA publishers. This country is followed by Italy, UK, Switzerland, Germany and the Netherlands.

Table 5
Refine by Research Areas (Categories)

Research Areas	Number of Article	Research Areas	Number of Article
Communication	177	Cell Biology	2
History Philosophy of Science	62	Genetics Heredity	2
Education Educational Research	39	Meteorology Atmospheric Sciences	2
Environmental Sciences Ecology	25	Neurosciences Neurology	2
Science Technology	25	Oceanography	2
Social Sciences	16	Public Environmental Occupational Health	2
Engineering	8	Sociology	2
Psychology	8	Agriculture	1
Philosophy	7	Anatomy Morphology	1
Business Economics	5	Anthropology	1
Information Science Library Science	5	Development Studies	1
Life Sciences Biomedicine	5	Entomology	1
Linguistics	5	Ethnic Studies	1
Astronomy Astrophysics	4	Evolutionary Biology	1
Computer Science	4	Food Science Technology	1
Geology	4	Geography	1
Area Studies	3	Government Law	1
Biodiversity Conservation	3	Health Care Sciences Services	1
Cultural Studies	3	Literature	1
General Internal Medicine	3	Marine Freshwater Biology	1
Plant Sciences	3	Pharmacology Pharmacy	1
Social Issues	3	Public Administration	1
Arts Humanities	2	Toxicology	1
Asian Studies	2	Water Resources	1
Biochemistry Molecular Biology	2	Zoology	1

When examined in terms of the most preferred topics in the field of science communication, with 177 research areas, "communication" took the first place. This number was followed by the subject of "history philosophy of sci-

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ence" with 62. It has been determined that 39 articles are related to the subject of "education research". 25 articles were related to "environmental sciences ecology". Agriculture, Anatomy Morphology, Anthropology, Development Studies, Entomology, Ethnic Studies, Evolutionary Biology, Food Science Technology, Geography, Government Law, Health Care Science Services, Literature, Marine Freshwater Biology, Pharmacology Pharmacy, Public Administration, Toxicology, Water Resources, Zoology it was determined that the subjects were the least studied subjects.

Table 6
Distribution of Funds Supporting the Studies

Funding Agencies	Number of Article	Funding Agencies	Number of Article
National Science Foundation (NSF) (USA)	5	European Commission Horizon 2020 Research and Innovation Funding Programme (EC)	2
European Commission (EC)	5	Fundacao De Amparo A Pesquisa Do Estado De Sao Paulo Fapesp (FAPESP) (Brazil)	2
UK Research and Innovation (UKRI) (UK)	5	Grants-in-Aid for Scientific Research (KAKENHI) (Japan)	2
Economic and Social Research Council (ESRC) (UK)	4	Japan Society for the Promotion of Science (Japan)	2
German Research Foundation (DFG) (Germany)	4	The Kavli Foundation (USA)	2
Ministry of Education Culture Sports (Science And Technology Japan (MEXT) (Japan)	3	Natural Sciences and Engineering Research Council of Canada (NSERC) (Canada)	2
National Research Foundation (NRF) (South Africa)	3	National Science Foundation (NSF) (USA)	2
Spanish Government (Spain)	3	Portuguese Foundation for Science and Technology (FCT) (Portugal)	2
Australian Government (Australia)	2	Rita Allen Foundation (USA)	2
CNPq-Conselho Nacional de Desenvolvimento Cientifico e Tecnologico-(Brazil)	2	Stiftung Mercator Schweiz (Switzerland)	2
Danish Council for Independent Research- Humanities (FKK) (Denmark)	2	U.S. Department of Agriculture (USDA) (USA)	2
Department of Tourism University of Otago New Zealand-(New Zealand)	2	University of Otago Doctoral Scholarship (New Zealand)	2
Diane Campbell-Hunt Memorial Award-University of Otago (New Zealand)	2	The University of Seville (Spain)	2
European Commission Joint Research Centre (JRC) (EC)	2		

In the study, the institutions that funded the articles were searched and as a result of the research, it was determined that a total of 70 articles received support. In the study, when the agencies providing funding support in terms of countries were examined, the USA funding agencies that supported 13 articles were in the first place.

It was determined that EU funding agencies supported 9 articles. UK funding agencies supported 9 articles. While it was determined that the Japanese funding agencies supported 7 articles, it was determined that the New Zealand funding agencies supported 6 articles. While Spanish funding agencies supported 5 articles, German funding agencies supported 4 articles.

Brazil's funding agencies supported 4 articles. South African funding agencies supported 3 articles. Denmark funding agencies supported 2 articles. Australian funding agencies appear to support 2 articles.

Canadian funding agencies supported 2 articles. Portugal's funding agencies supported 2 articles, while Switzerland's funding agencies supported 2 articles. As a result, it is seen that only 70 of the 322 articles examined in the study received support. When the funding agencies that support the articles are examined in terms of countries, USA, EU, UK, Japan and New Zealand countries are at the forefront.

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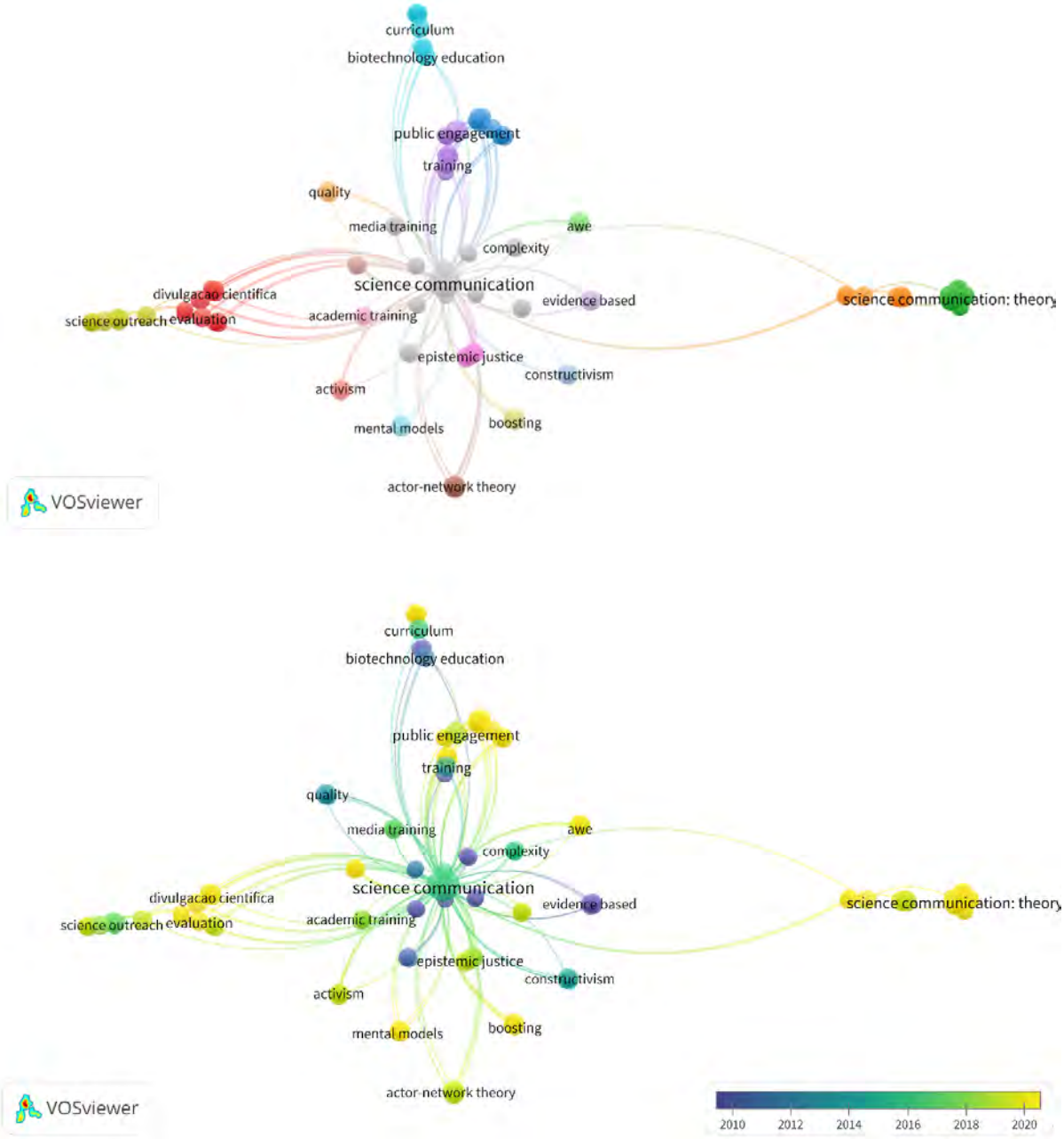
Figure 3
Keyword Cloud



In the study, the prominent keywords in the field of science communication were examined. A word cloud of keywords was created and the link between the keywords was examined. When the word cloud is examined, after 2010, it is seen that the study subjects have become more prominent and intensified.

It turns out that in the period from 2010 to 2020, the blue-colored subjects first switched to green and then yellow-colored subjects. In the focus of science communication, "taxonomy", "methodology", "quality", "biotechnology education" blue-colored subjects have been forming decencies between 2010 and 2014.

Green-colored topics are determined as "biotechnology", "complexity", "academic training", "media training", "training", "science engagement", "actor-network theory", "curriculum". The subjects in yellow are intensified in the

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2020s. These issues come to the fore in the form of "public engagement", "misformation", "public communication of science", "evaluation", "mental models", "boosting". In recent years, it has emerged that studies on science communication and public, public and misinformation have increased.

Discussion

Societal needs for science and information are increasing day by day. Burakgazi (2017) defines science communication as the use of reliable information among scientists, policy, society, decision-makers, industry, and other stakeholders. While scientists share science and knowledge with the society, it is important that they are trained in communication. Science have fulfilled its purpose to the extent that it is shared with and delivered to the society. Gedrovics (2007), who stated that science is for people first of all, stated that interest in science is a driving force for the human mind. Science communication, above all, is seen as a personal, national, cultural, and political need (Lewenstein, 2014). Undoubtedly, science communication has become more visible to the society with the development of communication technologies. Considering that scientists and society receive scientific developments from the mass media (Hayes & Grossman, 2010), the importance of the media in terms of science communication becomes more evident. Using a wide variety of communication tools, scientists can quickly and directly convey their messages to different groups. However, it is important for scientists to receive training in science communication in order to present themselves and their scientific studies in a clearer and more understandable way. As a matter of fact, Abersek and Abersek (2010) state that engineers need communication skills and they should be trained in this regard. Edmondston et al., (2010) found that science communication was not given enough value in their study on students studying in the biotechnology department. In order to close the gap between science and society (Utma, 2017), more studies should be carried out in the field of science communication and the society should be exposed to scientific information (Kohen & Dori, 2019). In this context, articles on science communication scanned in the Web of Science database were examined in this study. English articles were found by typing "topic", "title", "keywords". 322 articles were analyzed by bibliometric analysis method. Within the scope of the study, the articles published between 2000-2022 were examined according to years, countries, funds, research area, publishers, country scores and citations, and keywords. According to the results of the research, most articles were published in 2022 ($N = 58$). Among the countries, the USA stands out with the highest number of articles ($N = 86$). Then the UK, Australia, Germany took the first place with the number of articles. These results reveal that the USA is the first country to create science policies and the UK sends scientists to media organizations with journalism scholarships every year (Elmacı, 2015), and that they attach importance to the field of science communication and come to the fore in this field. It is also possible to evaluate this result in terms of publishers. In the study, it was revealed that the highest number of articles were published in the USA with 14 publishers. A total of 103 articles were published in USA publishers. The USA reveals that it has the most publishers in the field of science communication with this number. 66 articles have been published from Italy publishers and 51 articles have been published from UK publishers. 29 articles were published in Switzerland, 20 articles in Germany, 14 articles in the Netherlands, 9 articles in India. Brazil, Korea, Canada, Portugal, Japan, Spain, South Africa, Croatia, Poland and Azerbaijan country publishers have published 5 or less than 5 articles. The USA, Italy and the UK are at the top of the publishers where the articles are published. In the last 7 years (between 2016 and 2022), the USA ranked first with 72.6 points in country score distributions. The USA has generally increased its score each year. These results reveal that the USA has come to the forefront with its studies in the field of science communication. The UK is in second place with 31.81 points, Australia is in the third place with 30.4 points and Germany is in the fourth place with 25.99 points. Germany has surpassed other countries in the last 3 years (between 2020-2022). Germany scored 6.82 points in 2020, 5.16 points in 2021, and 7.53 points in 2022. Germany increased its score in 2022. Australia has increased its score over the last 4 years (2019-2022). The countries with the lowest scores are; Greece (0.53), Wales (0.6), Thailand (0.6), Pakistan (0.6), Taiwan (0.6), Argentina (0.13), Ireland (0.43), Indonesia (0.58), Kazakhstan (0.33). In line with these numeric data, the USA, Australia, the UK and Germany stand out as the countries that take place in the first place.

The USA in terms of citation, received the most citations from Germany, Switzerland, and Italy. Germany; Cited from Switzerland. Australia; People's Republic of China has the most citations from China. UK; cited from both sides, namely Ireland, Italy, USA and Netherlands, Australia. When the country-author analysis was examined, the USA country writer worked with Canadian authors, while the Australian countries authors worked with Canadian and New Zealand country writers. New Zealand country writers worked with the UK and Italy country writers. The UK country authors worked with Italy, New Zealand, Australia and Canada country authors. Among country authors,

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the USA, Australia and New Zealand show that country authors stand out and work solo. After the 2020s, country writers from the USA, the UK, Italy, Canada, Brazil, New Zealand and Australia come to the fore. In terms of the number of articles, the USA and Australia come to the fore. These numerical data reveal that the results are consistent.

When the study is evaluated in terms of research areas; The issue of "communication" is more prominent. 177 research areas have been related to the subject of "communication". This number was followed by the subject of history philosophy of science with 62. 39 articles are about education research. 25 articles are related to environmental sciences ecology. For example, studies in the field of climate change science communication are increasing. 1175 articles were obtained and analyzed in the WoS database on this subject (Chen et al., 2022). In the research conducted in the Scopus database with the keywords environment and communication, it was determined that there was an increase in environmental communication studies (Akerlof et al., 2022). A bibliometric analysis of the articles published on the Green Economy was conducted (Albayrak, 2023). A study was also carried out on green jobs (Durmaz et al., 2023). In the bibliometric analysis of publications obtained from SCI and SSCI databases between 1998 and 2019, it has been determined that industrial wastewater is among the most studied topics in recent years (Mao et al., 2021). Agriculture, Anatomy Morphology, Anthropology, Development Studies, Entomology, Ethnic Studies, Evolutionary Biology, Food Science Technology, Geography, Government Law, Health Care Science Services, Literature, Marine Freshwater Biology, Pharmacology Pharmacy, Public Administration, Toxicology, Water Resources, Zoology were the least studied subjects. It is predicted that the increase in the articles published on these subjects will also ensure the spread of science communication. With the continuous development of communication technology, studies in the field of communication have started to come to the fore. For example, 1,157 articles on science-based virtual brand communities between 2000 and 2020 were revealed by bibliometric analysis (Zheng et al., 2023). In the field of sports crisis communication, 1,283 scientific publications were examined by bibliometric analysis (Harker & Saffer, 2018). Ozcinar (2021) conducted a bibliometric analysis of communication education between 1990-2020. Between 1975 and 2016, when many articles on human resources education were published, 900 articles were reached and analyzed with bibliometric analysis management (Danvila-del-Valle et al., 2019). In another study conducted with data obtained from the Web of Science database between 2013 and 2022, it was found that social sciences are interdisciplinary, public administration, environmental studies, urban studies, psychology are multidisciplinary, followed by educational research, communication, management, political science and law (Catone, 2023).

In the study, the institutions that funded the articles were searched and as a result of the research, it was determined that a total of 70 articles received support. In the study, when the institutions providing funding support in terms of countries were examined, the USA funding agencies that supported 13 articles were in the first place. It was determined that EU funders supported 9 articles and UK funders supported 9 articles. It was determined that Japanese funding agencies supported 7 articles. It was determined that New Zealand funders supported 6 articles. Spanish funding organizations supported 5 articles. Germany funders supported 4 articles and Brazil funders supported 4 articles. South African funders supported 3 articles. Denmark, Australia, Canada, Portugal and Switzerland funding agencies supported 2 articles, a total of 5 countries supported 10 articles. As a result, it is seen that only 70 of the 322 articles examined in the study received support. When the funding organizations that support the articles are examined in terms of countries, USA, EU, UK, Japan and New Zealand countries are at the forefront.

Within the scope of the study, keywords were determined in the field of science communication. A word cloud of keywords has been created. When the word cloud is examined, it is seen that the study topics have become more specific and intensified after 2010. It turns out that from 2010 to 2020, the blue-colored subjects first shifted to green, then yellow-colored subjects (Figure 3). In the focus of science communication, blue-colored topics such as "taxonomy", "methodology", "quality", "biotechnology education" are intensified between 2010-2014. Green-colored topics are determined as "biotechnology", "complexity", "academic training", "media training", "training", "science engagement", "actor-network theory", "curriculum". The subjects in yellow are intensified in the 2020s. These issues come to the fore in the form of "public engagement", "misformation", "public communication of science", "evaluation", "mental models", "boosting". In recent years, it has emerged that studies on science communication and public, public and misinformation have increased. In the research conducted by creating the "communication" category in the journals indexed in the Web of Science Journal Citation Report, the topics of internet, public relations, advertising, health, relationship, discourse, news, telecommunications, public opinion, activism came to the fore between 1980-2013 (Montero Diaz et al., 2018). De las Heras-Pedrosa et al., (2022), who revealed the mapping analysis of the COVID-19 pandemic process, found that the concepts of vaccination, infodemi, risk perception, social distance and telemedicine were more involved in academic studies in 2021. In the global bibliometric analysis of the COVID-19 pandemic, the USA and China came to the fore in the academic field (Wang & Tian, 2021). Kuipers et

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al., (2022), who examined the articles in crisis and disaster journals between January 1, 2020, and June 30, 2022, with bibliometric analysis, it was determined that the concepts of risk, crisis communication, governance, mental health, resilience, and vulnerability came to the fore. In the bibliometric analysis on 21 st century skills in the field of education, it was determined that the concepts of technology, higher education, cooperation, critical thinking, creativity, pedagogy, education, teacher education, and evaluation were more prominent between the years 2000-2022 (Akcan et al., 2023). In the research conducted from the WoS database between 2015 and 2020, 12,272 publications on e-learning were reached. In the study, it was determined that the USA, Spain and China came to the fore (Djeki et al., 2022). In the field of digitalization and tourism (Ozogul Balyalı & Akgis Ilhan, 2023), political communication and social media issues come to the fore (Saf, 2023).

In line with the results of the study, it is revealed that most studies in the field of communication sciences were carried out by the USA. Considering the number of articles published by the countries, their country scores, publishers and institutions providing funding, it can be stated that the countries with the lowest scores in the ranking and the countries that are not included in the ranking should also pay attention to the issue of science communication and work on this issue. In the study conducted by Kohen and Dori (2019), articles published in 3 science communication journals and 3 science education journals published between 2000 and 2017 were examined, and it was determined that the importance of dialogue was emphasized in the articles in the examined journals as a result of the research. In this regard, Baram-Tsabari and Osborne (2015) emphasize that the common point of science educators and science communicators is to increase the importance of science in society and to involve various stakeholders in productive dialogues about science.

Conclusions and Implications

This study examines articles in the Web of Science database within the international literature on science communication from 2000 to 2022, using specific parameters. The study reveals the evolution of studies in the field, presenting the distribution of articles across years, countries, funding organizations, research areas, publication companies, country scores, and citations. The study provides important results and contributions for researchers in science communication by offering insights into paradigms in the field and a global perspective. Furthermore, it proposes a vision for future research.

The findings indicate that science communication is a developing field in science education and serves as a strong evaluation tool for science education policymakers and researchers, in addition to providing bibliometric indications. Consequently, science communication should be acknowledged as a study topic and receive sufficient financial support for extensive research, along with inclusion in organizational work programs. Benchmarking and ongoing monitoring of science communication levels are necessary to assess the success of projects and programs for all societal actors, not limited to students.

In conclusion, this study provides a comprehensive view of science communication research as a whole. By analyzing data from scientific papers, it demonstrates the changes in the field from 2000 to 2022. Based on these findings, the need for fostering coordinated and interdisciplinary collaboration between the scientific community and society is emphasized, leading to stronger and more reliable partnerships. The study anticipates that its results will assist experts and decision-makers in understanding the current state of science communication research and provide guidance for future endeavors.

Declaration of Interest

The authors declare no competing interest.

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