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Bibliometric Analysis of Global Research on Scientific Writing

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ABSTRACT

Scientific knowledge has been growing continuously and rapidly in recent years. Scientific writing plays an important role in the process of scientific knowledge. In recent years, there has been an increasing research effort on scientific writing. This research aims to reveal the growth trend of global research on scientific writing, the contributions to the field, the trending topics of the field, the main themes of the field, and the social interaction of the countries contributing to the field. For this purpose, 968 publications covering the period between 1959-2023 obtained from the Web of Science database were analysed by bibliometric analysis. According to the results of the study, scientific writing literature has shown a significant growth trend since 2010. The most productive journals in the field come from science journals such as chemistry and biology. The most productive countries are USA and UK has the highest publication impact. The countries with the highest collaboration are USA and UK respectively. The trending topic of the SW area is on the use of Chat GPT in scientific writing. The SW area is divided into four themes: scientific literacy and communication, scientific writing in medical research, scientific writing in higher education, and ethics of scientific writing. This research provided a comprehensive review of the accumulated knowledge in the field of SW and provided a holistic perspective on the field. Furthermore, some possible directions for future research are shown. This research has shown that in addition to traditional studies that provide scientific writing guidelines, SW will be shaped more by artificial intelligence developments in the coming years.

Keywords: Scientific writing; Higher education; Research; Bibliometric analysis; Academic writing

1. INTRODUCTION

According to World Bank data, the number of scientific and technical journals nearly doubled from 2000 to 2010, reaching two million. In 2018, this number increased to two and a half million[1]. Between 2015 and 2019, scientific output increased by 21 per cent, with growth rates of up to 46 % in some fields such as environmental sciences[2]. A study analysing the period 1907-2007 revealed that the number of scientific publications did not decline, but on the contrary, showed a continuous growth trend[3]. Another recent study confirmed this development trend of increasing scientific outputs[4].

Scientific writing (SW) plays an important role in this development of scientific knowledge. In the process of exponential growth and development of science from the beginning of science to the present day, the systematic and consistent dissemination of research results by researchers has played an important role. The most important contribution to the dissemination of research results by researchers comes from the nature of the SW process itself. How to report research results, reporting principles, basic principles of SW, ethical issues in SW and their learning among researchers have evolved over time. The basic principles of SW are nowadays almost standardised thanks to publishers, editors and reviewers involved in scientific publishing. However, scientific writing has a dynamic structure that changes and develops according to global conditions. For this reason, guiding studies on SW have been published from past to present. Gopen and Swan[5] explained how scientific writing should be and the mistakes made with examples. Ghasemi[6], *et al*. presented the principles of scientific writing in biomedical research. Thomas[7] presented a comprehensive study on scientific writing and research process.

When the literature is examined, it is seen that SW is handled from different perspectives. Moskovitz[8] examined Text Recycling in scientific writing from an ethical perspective. Yang[9], *et al.* designed an intervention to reduce students' plagiarism in scientific writing, to raise awareness about this issue and to avoid this problem. Hasanuddin[10], *et al.* revealed that collaborative learning has an important role in the development of students' scientific writing skills. Deng[11], *et al.* revealed how students' scientific writing skills can be developed in the field of science. Inzunza[12] examined the advantages and disadvantages of using a passive and active voice in writing academic texts, focusing on the linguistic elements of scientific writing. Wortman-Wunder and Wefes[13] found that organising effective and instructive workshops in scientific writing

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is effective on scientific writing. Similarly, Goyal[14], *et al.* found that educational workshops on scientific writing given to graduate students increased students' awareness and knowledge. More recent studies have addressed the inevitable relationship between artificial intelligence (AI) and scientific writing. Kim and Kim[15] examined teachers' perceptions of the use of artificial intelligence tools for scientific writing. Salvagno[16], *et al.* discussed the use of AI chatbots in scientific writing. Altma[17], *et al*. put forward a discussion on the use of Chat GPT in scientific writing process. As a result, studies on SW reflect different perspectives and the literature is getting richer.

Although there are various studies on SW research in the literature, there is no study that deals with the knowledge accumulated over many years. This research will fill this gap in the literature by addressing the SW field comprehensively. As a result, this research aims to reveal the growth trend of global research on SW that has been formed and continues to grow over many years, the journal, institution, country contributions to the field, the intellectual structure and social interactions of the field. For this purpose, answers to five main research questions will be sought:

(1) What is the growth trend of SW research?
(2) Which are the most influential sources, institutions and countries that have contributed the most to the SW field?
(3) What are the trending topics of the SW field?
(4) What are the main themes of the SW field?
(5) What is the social interaction of the countries contributing to the SW field?

2. METHODOLOGY

In this research, bibliometric analysis method was used to examine the SW field. Bibliometric analysis is a quantitative method that can handle the increasing volume of scientific research and data richness and reveal the underlying structure of a field[18]. Bibliometric analyses are often conducted with data obtained from databases that provide bibliometric data. In this research, Web of Science (WOS) database was used to capture research in the field of SW. This is because WOS is a large database that can provide sufficient data required for a field. The data of the study were obtained by searching for the concept of "scientific writing" in titles, abstracts and keywords (on 19 September 2023). Based on the views that books, book chapters, and conference proceedings lack robust peer review, only articles and review articles were included in the data set, following previous research in the literature. No filtering was made for publication language and time period. As a result, 968 articles were included in the data set. Before analysing the bibliometric data, the data were cleaned. The country names Ireland, Scotland, England and Waley were combined under United Kingdom. Words with the same meaning and plural words were identified and combined under a single word (e.g. publications/ puclication/scientific publication). The Biblioshiny tool offered by the R software package[19] and the Vosviewer tool[20], which is frequently used in data visualisation, were used to analyse the data.

In the analysis of the data, number of publications (NP), number of citations per publication (CPP), total citations (TC) indicators were used to show the growth trend of the field. The total number of citations per year (TCY) is one of the methods used to reveal the trend topics of the analysed field. TCY calculation was made to determine the trend topics of the field. Contributions to the field were measured in terms of productivity and impact. NP indicator was used as an indicator of productivity and CPP indicator was used as the impact of publications. Co-occurrence keywords analysis was performed to reveal the main themes of the field and co-authorship analysis of countries was performed to determine the social interaction between countries.

3. FINDINGS

3.1 Overview of SW Publications

The SW domain consists of a total of 968 publications contributed by 89 countries from 645 sources covering the period 1959-2023. The annual growth rate of the SW field is 5.49 % and the average age of the publications is about 9 years. The average CPP for the SW field is about 8.8, while the international co-authorship rate is 16 %. Table 1 shows basic information about SW publications.

3.2 Growth Trend of SW Field

Figure 1 shows the growth trend of the SW field according to years. According to the results, while the SW field did not show a significant progress for the first 40 years, an increase in the number of publications has been observed since the beginning of the 2000s. Although this increasing trend showed a significant development until 2010, the real increase was observed after 2010. CPP values, on the other hand, show a fluctuating trend over the years.

3.3 Most Productive and Impactful Journals

Table 2 shows the ten most productive and impactful journals in the field of SW. The highest contribution to the field has been made by "Journal of Chemical Education" which has been indexed in WOS since 1977. The same journal has the highest h and g index. "Written Communication" has the highest publication impact. It is seen that the highest contribution to the field generally comes from journals in the sciences such as biology and chemistry.

3.4 Most Productive and Impactful Institutions

Table 3 shows the highest contributing and most impactful institutions in the SW field. While the most productive institution is the University of A Coruña, the institution with the highest publication impact is the University of Birmingham. According to Table 3, it

Table 1. Main information about SW research

Timespan	1959:2023
Article	879
Article; early access	17
Review	71
Review; early access	1
Sources	645
Publications	968
Annual growth rate %	5,69
Publication Average Age	8,93
Countries	89
Average citations per publication	8,768
References	27006
Authors	2461
Authors of single-authored publication (number of publications)	341
Single-authored docs (number of authors)	361
Co-authors per publication	2,79
International co-authorships %	16,01

can be said that especially the institutions in the USA contribute more to the SW field.

3.5 Most Productive and Impactful Countries

Table 4 shows the most contributing and impactful countries in the field of SW. While the most productive country is USA, the country with the highest publication impact is UK. According to Table 4, it can be said that especially USA's contribution to the SW field is quite high compared to other countries. USA's productivity in SW is about five times higher than that of the second ranked UK. However, the UK has the highest publication impact among the most productive countries. Australia has the second highest publication impact. However, Australia ranks eighth in terms of productivity. Among the most productive countries, China has the lowest number of publications. The country with the lowest publication impact is Germany.

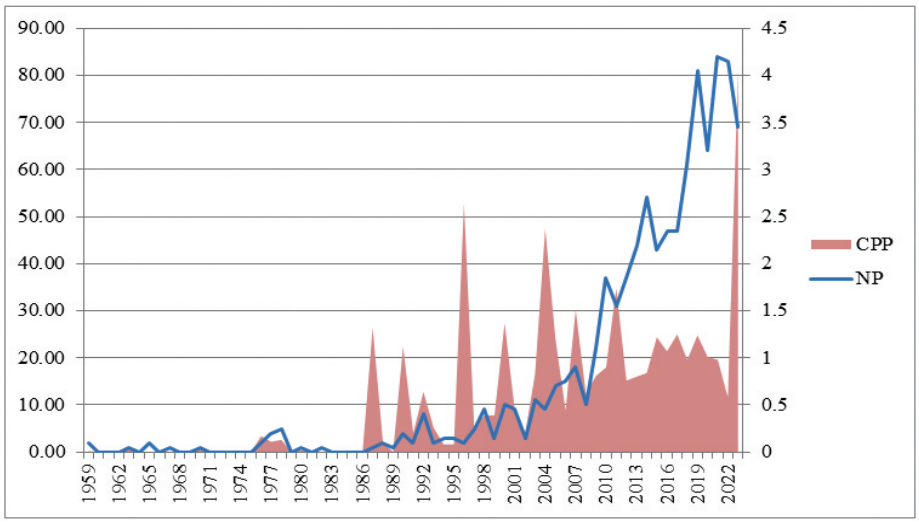
3.6 Trending Topics of SW Field

In order to reveal the trending topics of the SW field, TCY values were calculated and the top ten

Table 2. The 10 most productive and impactful journals

No.	Sources	NP	TC	CPP	h	g	PSY
1	Journal of Chemical Education	21	186	8,86	9	13	1977
2	Journal of Microbiology & Biology Education	15	56	2,67	4	6	2015
3	American Biology Teacher	13	44	2,10	4	6	1991
4	Written Communication	11	283	13,48	8	11	1988
5	English For Specific Purposes	10	189	9,00	6	10	2003
6	International Journal of Endocrinology and Metabolism	9	77	3,67	6	8	2018
7	Advances in Physiology Education	9	50	2,38	5	6	1997
8	International Journal of Science Education	9	138	6,57	5	9	2001
9	Biochemistry and Molecular Biology Education	9	39	1,86	4	6	2007
10	Lfe-Revista De Lenguas Para Fines Especificos	9	15	0,71	2	3	2005

NP: number of publications, TC: Total citations, CPP: citations per publication, h: h index, g: g index, PSY: publication start year



(NP: number of publication, CPP: citations per publication)

Figure 1. Publication growth trends of SW research by year.

Table 3. The 10 most productive and impactful institutions

No.	Institution	Publicatons	Citations	CPP
1	University of A Coruña, Spain	13	50	3,8
2	Duke University, USA	11	200	18,2
3	Shahid Beheshti University of Medical Sciences, Iran	10	79	7,9
4	University of British Columbia, Canada	9	58	6,4
5	Pennsylvania State University, USA	8	187	23,4
6	University of North Carolina, USA	8	122	15,3
7	Vanderbilt University, USA	8	80	10,0
8	University of Queensland, Australia	7	92	13,1
9	University of Colorado, USA	7	55	7,9
10	University of Birmingham, UK	6	394	65,7

Table 4. The 10 most productive and impactful countries

No.	Country	Publications	Citations	CPP
1	USA	310	3422	11,0
2	UK	72	1137	15,8
3	Spain	65	324	5,0
4	Canada	50	619	12,4
5	Brazil	41	276	6,7
6	Germany	41	173	4,2
7	France	38	215	5,7
8	Australia	35	473	13,5
9	India	35	180	5,1
10	China	30	327	10,9

publications with the highest TCY values are given in Table 5. According to the results, especially the first three publications are remarkable. Sallam[21] presented the benefits and potential risks of Chat GPT in healthcare education, research and practice. Alkaissi and McFarlane's[22] study includes discussions on the use of Chat GPT in scientific writing. Salvagno[16], *et al.* on the other hand, discusses the use of artificial intelligence tools and Chat GPT in particular in scientific writing. While half of the ten studies in the list are related to Chat GPT, two studies are related to review writing, one study is related to article writing, one study is related to title writing and one study is related to linguistic features in SW. To summarise, the trending topics in SW are related to Chat GPT and principles for article writing.

3.7 Basic Themes of the SW Field

Figure 2 shows the map of the co-occurrence keywords analysis conducted to reveal the thematic themes of the SW domain. The SW domain is divided into four basic themes. The red theme covers topics that form the foundations of scientific writing such as scientific literacy, peer review, scientific communication. Among the studies in this theme, peer review and receiving feedback were focussed on scientific literacy and writing skills and revealed that they had positive effects on students' scientific writing[23]. Parkinson and Adendorff[24] focused on the effects of popular science articles on scientific literacy. Deng[11], *et al.* examined the effects of peer assessment and collaborative discussion on students' scientific writing competences and found that they had positive contributions. Alluqmani and Shamir[25] examined the differences between scientific writing styles in different disciplines and found that different writing styles are applied even in disciplines that are close to each other.

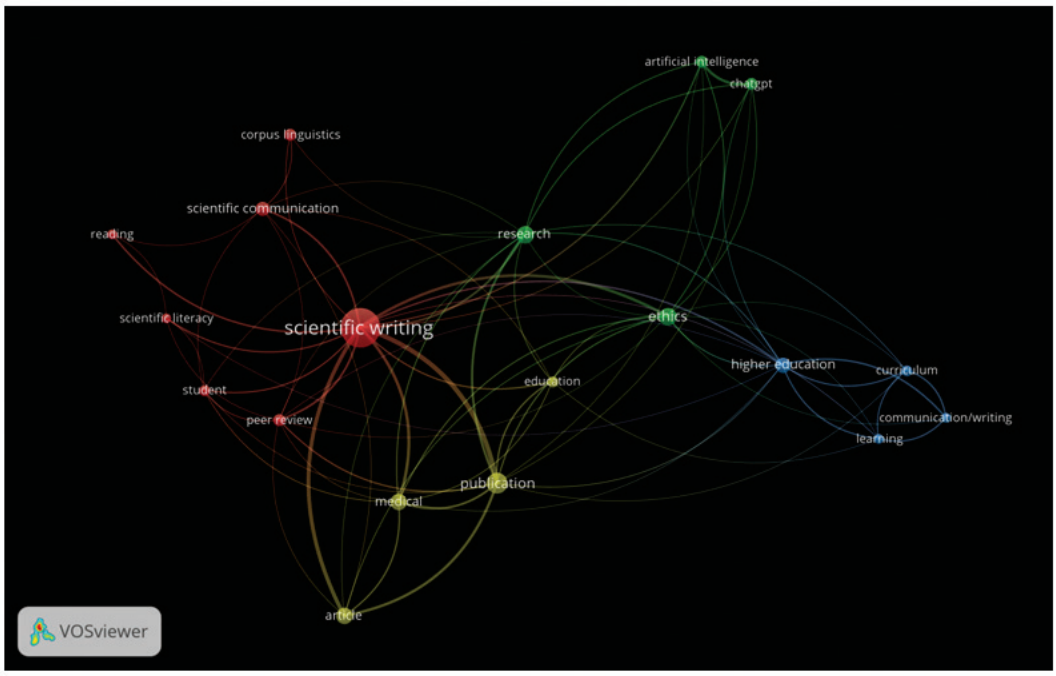
The yellow theme is related to scientific writing on medical education, medical research and publications. The effect of workshops on scientific writing in medical research has been examined[26-27]. It was aimed to develop strategies to facilitate scientific writing and how publications can be written in health sciences[28]. Some studies have examined the scientific writing competence of training courses and the satisfaction level of participants with them[29]. Within this theme, competency models have been proposed for health researchers to improve scientific writing[30]. The most common mistakes in writing articles in the medical field have been revealed[31]. Similarly, the misuse of medical language in academic writing has been revealed[32]. In this theme, the difficulties and conveniences that medical doctors face when writing their first scientific articles have also been addressed[33]. In addition, there are studies that provide guidelines on how to review[34]. Similarly, the views of authors and editors who have published in journals in the field of health on reviewer evaluations have been examined[35]. As a result, in this theme, studies on how to improve scientific writing in the field of health, increasing the competence of researchers, guidelines and opinions on reviewing in the scientific publication process, and mistakes made in article writing, such as improving academic writing and preventing mistakes, were revealed.

The blue theme is related to the learning and curriculum of scientific writing, which is related to scientific writing in higher education. Within this theme,

Table 5. Trending research topics

No.	TCY	Author(s)	Publication title	Focus point
1	86,0	Sallam (2023)	ChatGPT utility in healthcare education, research, and practice: systematic review on the promising perspectives and valid concerns	Chat GPT
2	61,0	Alkaissi , H., and McFarlane, S. I. (2023)	Artificial hallucinations in ChatGPT: implications in scientific writing	Chat GPT
3	54,0	Salvagno , M., Taccone, Salvagno, M., Taccone, F. S., and Gerli, A. G. (2023)	Can artificial intelligence help for scientific writing?	Chat GPT
4	29,6	Gasparyan, A. Y., Ayvazyan, L., Blackmore, H., and Kitas, G. D. (2011)	Writing a narrative biomedical review: considerations for authors, peer reviewers, and editors	Writing review
5	21,0	Gao, C. A., Howard, F. M., Markov, N. S., Dyer, E. C., Ramesh, S., Luo, Y., and Pearson, A. T. (2023)	Comparing scientific abstracts generated by ChatGPT to real abstracts with detectors and blinded human reviewers	Chat GPT
6	15,0	Vaishya, R., Misra, A., and Vaish, A. (2023)	ChatGPT: Is this version good for healthcare and research?	Chat GPT
7	12,7	Behzadi, P., and Gajdács, M. (2021)	Writing a strong scientific paper in medicine and the biomedical sciences: a checklist and recommendations for early career researchers	Writing article
8	10,8	Donato, H., and Donato, M. (2019)	Stages for undertaking a systematic review	Writing review
9	10,4	Fang, Z. (2005)	Scientific literacy: A systemic functional linguistics perspective	Linguistic features in SW
10	10,3	Letchford, A., Moat, H. S., and Preis, T. (2015)	The advantage of short paper titles	Writing title

TCY: total citation per year



(The threshold is 10 times existence, Total words: 19)

Figure 2. Co-occurrance keywords analysis map.

there are studies on how academic literacy is formed in higher education students[36]. There is a focus on developing graduate students' scientific writing and basic research skills[37]. Another study addressed the challenges and experiences of scientific communication in the context of scientific writing in doctoral education[38]. Whether previous recommendations about the structure of theses have been implemented in existing theses is the subject of another study[39]. Similarly, the effect of peer reviews on postgraduate theses was examined[40]. Another study revealed the effects of formative peer feedback on higher education students' writing skills[41]. There are studies focusing on students' academic writing skills and addressing the issue of doctoral students' ability to publish in English[42]. Practices regarding students' academic writing skills at universities have been addressed from the perspective of academics[43]. More generally, there are studies that provide a conceptual discussion and recommendations for academic writing in universities[44]. As a result, this theme has addressed scientific writing in the context of higher education. In particular, the current practices in university students' scientific writing, how they can be improved, the obstacles encountered were analysed and solutions were discussed.

The green theme covers studies that emphasise the ethical aspects of the scientific writing process and discussions on artificial intelligence writing applications. Since the first day ChatGPT was introduced, how it is used in scientific writing has been a subject of discussion and studies on this subject have grown. In scientific literature, the advantages and disadvantages of ChatGPT have been discussed and discussions on its limitations have been put forward[22,45]. In academic literature, studies have been conducted on the potential threats of ChatGPT[46]. It has been proven that ChatGPT can write existing scientific publications, which are quite close to existing works, but commit ethical violations such as fabricating references[47]. Furthermore, the problematic aspects of the use of ChatGPT in scientific writing have been discussed from an ethical point of view and it has been stated that it may increase inequality for disadvantaged countries and researchers[16]. Ethical issues that may arise with the development of such large language models have been addressed in terms of researchers, academics and scientific publishing[48]. Along with the identification of these problem areas, solutions have also been developed. The current state of plagiarism detection tools has been discussed in the context of artificial intelligence in academic writing[49]. However, artificial intelligence models are not limited to Chat GPT. There are many other artificial intelligence tools and their number is increasing day by day. Although there are criticisms about the use of Chat GPT and other tools and models in scientific writing, it can be said that it is not correct to exclude them completely. Artificial intelligence models can also be used in academic writing in a useful and ethical way. There are also opinions that these models should be used in a useful way in important issues for scientific writing such as correcting grammatical and spelling errors of articles, literature reviews, increasing readability and fluency, and increasing syntax complexity[50]. In conclusion, this theme of the scientific writing literature has examined the possible threats, limitations, potential threats and advantages of artificial intelligence models and especially Chat GPT in academic writing. These studies also addressed the ethical aspects of scientific writing.

3.8 Social Interaction of Countries in SW Field

Figure 3 shows the co-authorship map of the countries contributing to the SW field. According to the results of the analysis, it is seen that countries that are geographically close to each other have more collaboration. For example, Colombia, Argentina, Chile are in the American continent and geographically close countries. Similarly, Italy, the Netherlands, Switzerland, Türkiye and Sweden are countries on the European continent and have more co-authorship. Since USA and UK are located in the centre of the map, they

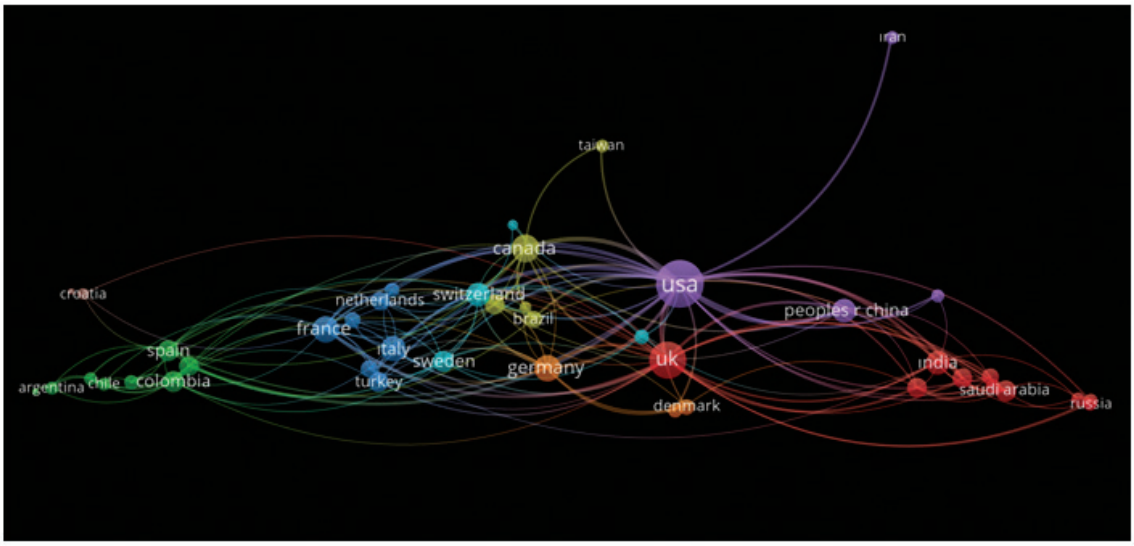


Figure 3. Co-authorship analysis of countries map.

are in the position of a bridge connecting the country groups contributing to the SW field. It is seen that the most collaboration is made by the USA and the UK, respectively. This situation has also supported the contribution of these two countries to the field as revealed in the previous analysis. Because it is known that countries that collaborate more are more productive.

4. DISCUSSION AND CONCLUSIONS

This research has revealed the intellectual structure of the SW field, which has shown a significant growth trend in recent years, the contributions to the field, the trending topics of the field, the main themes of the field and the social interaction of countries. According to the results of the study, the SW field has shown a growing trend especially since the beginning of the 2000s and the growth of the literature has accelerated since 2010. The highest contribution to the field came from science journals such as biology and chemistry. The highest contribution to the field was generally made by institutions in the USA. However, the University of Birmingham has the highest publication impact. USA has a significant dominance among 89 countries contributing to the SW field. USA has more than four times more publications than the second ranked UK. The most influential publications in the SW field come from the UK. Analysing the trending topics of the field, it is seen that the topics related to Chat GPT have been addressed in the SW field in recent years. Introduced in 2022, Chat GPT is one of the artificial intelligence tools that has shown its impact in many fields in a short time, and the use, advantages and potential risks of this tool in the scientific writing process are discussed. This research also revealed the main themes of the SW field. Scientific literacy and scientific communication, scientific writing in medical research, scientific writing in higher education, ethical aspects of scientific writing were the main themes of the SW field.

This research revealed that scientific writing literature has increased significantly in recent years. The thematic analysis revealed that the scientific writing literature is related to scientific literacy in medical research, scientific writing skills of students and academics, their learning and the creation of curriculum. In addition, an important theme of scientific writing literature is related to the ethical aspect of academic writing. Scientific writing refers to the reporting of scientific processes in an academic language and following a certain structure. It is important that the results of science are reported appropriately. This clearly ensures the development of certain standards in the world of science and enables readers and researchers to carry out scientific processes by following a certain system. For this reason, especially higher education institutions endeavour to improve students' scientific writing skills. By examining the cognitive readiness of students in the scientific writing process, scientific writing competences are developed by applying various teaching methods within the framework of a specific curriculum. Previous studies have revealed that such activities for students improve students' scientific writing skills[10,13,14].

Efforts to improve scientific writing in students and academics have also focussed on the ethical aspect of this process. Because, an important part of the scientific writing process involves the reporting of research in an ethical framework. Ethical violations such as referencing, citation, permission procedures required in scientific writing, copyright, and plagiarism have been the subject of scientific writing literature. As this study reveals, there has been an increasing debate on the use of Chat GPT in scientific writing, especially in the last few years[8,15,17]. This obviously includes whether and how an AI model can be used in scientific writing. In addition, the advantages and disadvantages of such tools are mentioned. This discussion is a natural consequence of the widespread use of AI models in recent years. The conclusion to be drawn from this is that the awareness of students and academics about the use of artificial intelligence models in the scientific writing process should be increased. This can be achieved by planning and implementing various programmes for students and academics. In this century where technology is developing rapidly, today's models will develop over time. Today's AI models may be replaced by new products in the future. For this reason, it is clear that especially university administrators should follow the latest developments in scientific writing and develop students and academicians in this direction.

In addition to such new developments in the recent years, scientific writing has been proceeding in a traditional system. The basic structure of a scientific article, reporting processes, ethical issues have had the same system for many years. Therefore, especially graduate students are expected to be competent in this field. Consequently, the practical teaching of scientific writing in higher education institutions within the framework of a comprehensive curriculum can contribute to students' research competence. Obviously, this can also contribute to students' scientific literacy levels. It is obvious that for a critical academic reading, the researcher should attain a certain level of competence. For this reason, it should be aimed to increase the competences of graduate students, who are the researchers of the future, in the scientific writing process.

This research has revealed the contribution of research on scientific writing at the level of journals, institutions and countries, identified the main themes of the field, and identified trending topics. This research has provided an overview of the long-term knowledge of scientific writing. In future research, a more in-depth analysis can be conducted by focusing on student scientific writing studies. For this purpose, content analysis method can be used to analyse the studies more closely. Secondly, in the light of recent developments, ethical violations in scientific writing can be analysed and how they can be prevented. In addition, studies can be carried out on curriculum development, implementation and their results for the prevention of ethical violations.

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