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From taboo topics to socio-scientific issues: A bibliometric analysis on the trend and growth of knowledge about teaching controversial issues

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Highlights:

- Research on teaching controversial issues has increased significantly in the last 30 years.
- The teaching of controversial issues has not been limited to social studies; it has evolved into a multidisciplinary and values-based field of research.
- While international cooperation has strengthened, particularly centered in the US and the UK, Türkiye has achieved a remarkable position in terms of publication and citation numbers.

Abstract

Teaching controversial issues in the classroom has been praised for several educational reasons, including its contribution to critical thinking, the development of citizenship competencies, and the fostering of an understanding of science and technology. This paper presents a bibliometric analysis of works indexed in the Scopus database related to teaching controversial issues. We investigated the trends in publications and citations, keyword co-occurrence, country performance, and research collaborations on works completed between 1993 and 2023. Our findings indicate a significant increase in studies examining the teaching of controversial issues, particularly since 2006, with variation by subject. Research on teaching socio-scientific issues in science education has significantly increased, with 346 papers out of 743. Keyword co-occurrence analysis revealed nine clusters, predominantly focusing on teaching socio-scientific issues, addressing controversial issues, and integrating these issues into teacher training. Analyzed by total publication and citation counts, nine of the top ten journals and eight of the top ten articles have a scope and content related to science education issues. We found three research collaboration patterns: language proximity, geographic proximity, and an independent collaboration pattern. While the US and Great Britain were among the leading countries, scholars from other nations have also made substantial contributions to the growth of this research field.

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1. Introduction

Bibliometric analyses provide concise, comprehensible information on the progression, quantity, authorship, and geographical distribution of academic publications within a particular study area. By enabling and empowering academics to obtain a thorough overview in one setting, identifying knowledge gaps, generating new research ideas, and demonstrating the significance of their planned contributions to the subject, such studies have the potential to provide solid bases for expanding a discipline in innovative and significant ways (Donthu et al., 2021). Bibliometric research has gained increased attention due to its benefits and the availability of analytical tools such as VOSviewer, Gephi, and Leximancer. Such studies can be undertaken to analyze a research domain, including constructs, contexts, disciplines, fields, outlets, methods, or theories (Mukherjee et al., 2022). The proliferation of academic journals, universities, and colleges has led to a substantial surge in scholarly publications worldwide. Bibliometric studies have emerged as a roadmap for academics seeking to close the gaps and focus on the most promising areas for further research.

This study uses bibliometric techniques to analyze the trends and growth in knowledge about teaching controversial issues (TCI). Donthu et al. (2021) recommend using bibliometric analysis when the review's scope is broad and the dataset is too large to review manually. TCI as a research topic has received significant attention from various academic disciplines, including educational science, social studies, science education, citizenship education, sociology, psychology, political science, and philosophy of education. As of March 24, 2024, searching 'controversial issues' on Scopus and Web of Science without any search restrictions yielded 12,256 and 8500 results, respectively. Our literature review reveals that, despite significant work on the TCI, no bibliometric studies have been done on this topic. We aim to analyze research literature from the last thirty years (1993-2003) to identify trends in TCI publications, co-authorship, the most productive researchers, the geographical locations of articles, and the co-occurrence frequency of keywords. Thus, the following research questions were formulated based on our objectives and literature review:

(1) What has been the trend of knowledge expansion in the past thirty years regarding TCI?

(2) Which countries and authors have the highest number of publications and citations regarding TCI?

(3) Which journals are the most prolific in terms of citations and publications regarding TCI?

(4) Which TCI keywords are the most often studied?

(5) What patterns exist in terms of author and country collaborations?

1.1. Importance of teaching controversial issues

Controversial issues are defined as socio-scientific topics that concern the general society and public, on which people hold different opinions, thoughts, and perspectives based on their values, beliefs, interests, and the evidence available to them (Dearden, 1981; Stradling, 1984; Wellington, 1986). The controversy around a topic does not merely stem from its phenomenological or empirical description but rather from the varying values, perspectives, and relative importance of evidence held by individuals. Controversial issues exhibit behavioral, epistemological, and political characteristics (Yacek, 2018), including contested facts, polarized views, opposing values and beliefs, intense emotions, conflicts of interest, distrust, and a lack of trust, as well as denigration of the other (Kerr et al., 2021).

Students often speak of controversial issues outside of class or school and occasionally initiate class discussions on them (Cassar et al., 2023). Therefore, one goal of TCI in the classroom is to employ an instructional approach that systematically addresses and responds to students' questions and motivations. However, the educational objective of TCI stems from the more profound benefits it serves. Class discussion has often been accepted as the best practice for teaching controversial issues (Hand & Levinson, 2012), and much of TCI's value stems from the pedagogical character of controversial issues and the discussion method itself. Through class discussion, teachers are expected to demonstrate a high regard for students' autonomy and actively refrain from employing indoctrination methods. These features describe the minimum procedural requirements of a civic or political class. A political class helps sustain students' sense of political literacy, fairness, and engagement (Hess & McAvoy, 2015). As such, TCI has a conceptual and normative connection with democratic education and can be related to the Deweyan idea that schools should prepare pupils for life (Kauppi & Drerup, 2021). Developing individuals with the ability to debate controversial issues and an understanding of the procedural rules that support democratic discourse is essential for establishing a democratic society (Chikoko et al., 2011). Students who engage in class deliberation activities are more likely to have excellent perspective-taking skills than those who are not

engaged (Avery et al., 2013). By actively engaging in discussions on controversial issues, students can align themselves with various viewpoints, perspectives, and socio-cultural identities.

Discussing controversial issues can also improve civic competency. Civic talk is crucial to active citizenship, public reason, and justification (Arslan et al., 2023). Research indicates that discussing current national and global issues within families, in class, and in peer groups is statistically associated with both conventional and unconventional forms of citizenship participation (Klofstad, 2009; Ekström & Östman, 2013). Participating in discussions about controversial issues also has significant cognitive and social-emotional benefits (Kraatz et al., 2022). Engaging with controversial issues in class is crucial for fostering students' critical thinking skills, including perspective-taking, assessing evidence, establishing one's viewpoint, and overcoming biases.

1.2. Beyond social studies and civics curricula

TCI is traditionally seen as a distinct educational objective within social studies and civics. Although almost any topic may raise controversial issues, social studies classes are essential in helping students achieve this learning goal (Ersoy, 2010). Writing in 1941, Guilford argues that if discussion of controversial issues is 'omitted from the course, social studies become meaningless and insignificant' (p. 205). The NCSS (2007) has declared a position statement for the discussion of controversial issues in social studies: "In order to foster democratic processes and establish an informed citizenry, the ability to freely study, investigate, present, interpret, discuss, and debate relevant facts, issues, and ideas is deemed necessary" (p. 186). NCSS has also made important contributions to TCI by developing guidance and theoretical frameworks, publishing instructional materials, and releasing policy statements. Sharp (2006) researched the presentation of controversial issues in three journals (Social Education, Social Studies and the Young Learner, and Middle Level Learning) published by the National Council for the Social Studies (NCSS) between 1973 and 2003, and found 883 articles, based on expert identification. This close attention is also evident in educational practices. Research indicates that social studies and civics teachers are more inclined towards TCI and report more pertinent behaviors (Erlich & Gindi, 2018).

In recent years, TCI has extended beyond the scope of social studies and civics curricula, encompassing a significant portion of the overall curriculum. The vocabulary of this educational practice and its studies shifted from taboo topics to controversial issues to socio-scientific issues. The term 'socio-scientific issues' in the teaching context appeared around the end of the 1990s (Patronis et al., 1999). Global concerns about socio-scientific issues that receive public interest have grown in educational settings. Given the broad coverage of controversial issues today, many academic disciplines deal with TCI or hot topics that interest both experts and the general public: nuclear energy (Borgerding & Dagistan, 2018), genetics, genetically modified food, and cloning (Khishfe et al., 2017; Aivelo &Uitto, 2019) environmental issues (Gayford, 2002; Cotton, 2006), climate change (Ho & Seow, 2015), terrorism (Jerome & Elwick, 2019), prejudice (Tribukait, 2021), racism (Wahl, et al., 2000), corruption (Cotton, 2006). As such, TCI covers many curricula, including science education (Gardner & Jones, 2010; Borgerding & Dagistan, 2018), religious education (Flensner, 2020), and geography (Ho & Seow, 2015).

Scholars in science education are showing a growing interest in the topic, extending the scope of controversial issues under the new phrase 'controversial socio-scientific issues' (Day & Bryce, 2010; Cebesoy & Chang Rundgren, 2021; Chen & Xiao, 2021). It is now evident that controversial socio-scientific issues are global concerns. Scholars and educators have recognized that incorporating controversial socio-scientific topics into formal education substantially improves public understanding of science and technology.

2. Method

2.1. Data Collection and Extraction

Scholars retrieve publications for bibliometric analyses mainly from the Web of Science (WOS) and Scopus databases. Although these databases may introduce biases in comparative analysis due to unequal distributions across countries and languages, given their quality and quantity, they provide the best documents currently available compared to other databases (Mongeon & Paul-Hus, 2015). In this study, we used Scopus because of its more comprehensive coverage of publications and countries than the Web of Science (Echchakoui, 2020). The searched topic is determined ('controversial issues' OR 'controversial public issues' OR 'controversial topics' OR 'controversial subjects' OR 'controversial and sensitive issues' OR 'taboo topics" OR 'socio-scientific issues' OR 'socio-scientific issues'). Because we aimed to analyze the topic in an educational setting, we further restricted the topic to 'teaching.' The database yielded 1290 results

with no year restriction. By restricting the publication year to 1993-2023, the number of research studies conducted in the past 30 years was reduced to 1,196. As a next step, the document type was restricted to "article and review" and the language to 'English.' The search string retained 818 publications. Two researchers independently checked the titles and abstracts of these studies. During the assessment process, studies deemed irrelevant to the teaching of controversial issues or duplicates were excluded from the sample. As a result, the final sample of 743 studies was obtained. Following the guidance developed by Donthu et al. (2021), we outlined the study procedure, as shown in Figure 1.

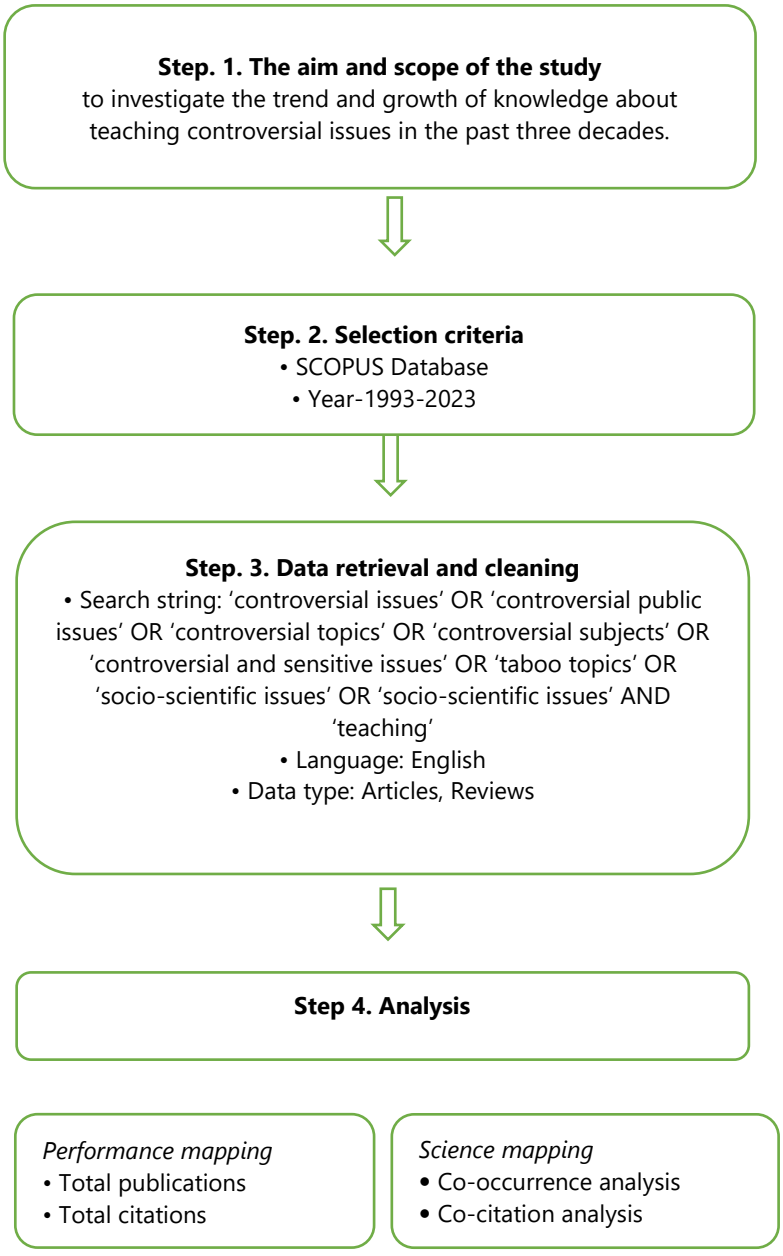

Figure 1. The research procedure

2.2. Analysis

In bibliometric studies, performance analysis examines how effectively scholars and organizations conduct research and publish their findings. This research examines the number of publications, the number of authors, the top authors, their institutions, and the countries associated with the specified area. Science mapping aims to reveal the trends, dynamics, and structure of specific scientific subjects (Zupic &

Čater, 2014). Co-word analysis aims to establish a conceptual framework for a topic by examining the relationships between words within documents. Words that often appear together in documents indicate a close connection between the topics they represent (Koseoglu et al., 2016). Analysing the occurrence of keywords helps to reveal popular topics in the investigated research area (Wang & Lu, 2020). We used VOSviewer for data analysis. VOSviewer is unique among computer programs for bibliometric mapping in that it provides a user-friendly graphical depiction of bibliometric maps.

3. Results

3.1. Performance Analysis Results

The distribution of TCI publications during the past 30 years was first analyzed by year. Figure 2 illustrates that the number of studies remained constant between 1993 and 2005. Sixty-seven studies were published during this period, averaging 5.15 publications per year. On the other hand, there has been a noticeable increase in publications since 2006, with the annual total reaching 79 by 2023.

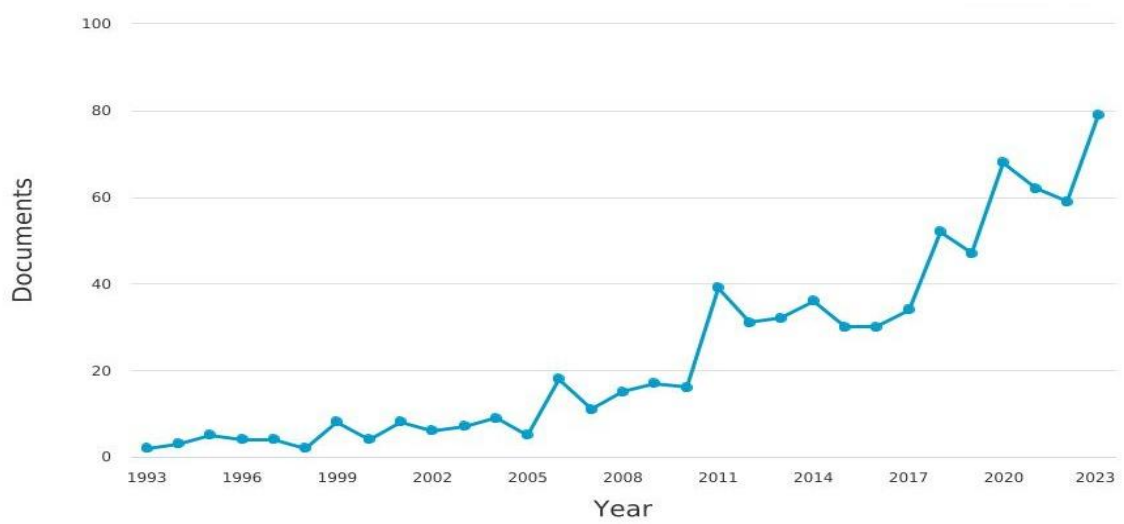

Figure 2. The Total Publications Increased Throughout the Course of Thirty Years (1993–2023)

Regarding the number of documents and citations over the past 30 years, the findings indicate that the United States had the largest count, with 245 articles, followed by the United Kingdom with 70 articles and Turkey with 51. Upon examining the citations given to these papers, it is evident that the United States holds the top position, with the United Kingdom and Germany following closely behind. The United Kingdom is the first in terms of average citations, followed by the United States and Germany. It is noticeable that the following ten countries have contributed approximately 77 % of the literature, with a total of 573 papers. Table 1 presents the top ten countries' performance in terms of the number of articles, citing articles, and average citations.

Table 1. The Top 10 Countries by Citation Count

Rank	Countries	Number of articles	Citing articles	Average citations
1	United States	245	6997	28,6
2	United Kingdom	70	2552	36,5
3	Turkey	51	711	13,9
4	Germany	48	1073	22,3
5	Sweden	38	534	14
6	Spain	32	363	11,3
7	Australia	29	531	18,3
8	Israel	24	415	17,3
9	China	18	138	7,6
10	Netherlands	18	222	12,3
	All	573	13536	18,2

Our second performance analysis variable concerned the leading journals that published articles on TCI. Table 2 shows that the International Journal of Science Education had the most papers, with 45, followed by the Journal of Research in Science Teaching (30) and Science and Education (21). As shown in Table 2, the average citation performance of these journals varies significantly depending on the citing articles. Another notable finding is that eight of the top ten journals exclusively publish works on science education. The scopes of the two journals, Theory and Research in Social Education and Sustainability, differ significantly from those of the others.

Table 2. The top 10 journals by citation count

Rank	Journals	Number of articles	Citing articles	Average citations
1	*International Journal of Science Education*	45	2764	61,4
2	*Journal of Research in Science Teaching*	30	1663	55,4
3	*Science and Education*	21	432	20,6
4	*Research in Science Education*	20	990	49,5
5	*Theory and Research in Social Education*	14	578	41,3
6	*Cultural Studies of Science Education*	13	199	15,3
7	*International Journal of Science and Mathematics Education*	11	356	32,4
8	*Sustainability*	11	125	11,4
9	*Eurasia Journal of Mathematics Science and Technology Education*	10	145	14,5
10	*Journal of Biological Education*	9	153	17
	All	184	7405	31,9

The total and average number of citations for each author and publication were analyzed. With 453 citations, Kolstø's (2001) paper 'Scientific literacy for citizenship: Tools for dealing with the science dimension of controversial socio-scientific issues' is the most cited work on TCI. In this paper, Kolstø presents a comprehensive framework for examining the scientific dimension of controversial socio-scientific topics, with a specific emphasis on advancing science education to foster the acquisition of civic skills in the foreseeable future.

The paper by Monroe et al. (2019), titled 'Identifying effective climate change education strategies: a systematic review of the research, ' ranks second among the most cited documents. Although it ranks second in total citations, this study far outpaces others, averaging 84 citations annually. Monroe et al. (2019) conducted a systematic review of 49 documents to deepen our understanding of successful climate change education. They identified four key factors likely to influence the effectiveness: (1) engaging in deliberative discussions, (2) interacting with scientists, (3) correcting misconceptions, and (4) implementing school or community projects. The paper by Sadler et al. (2007) entitled 'What do students gain by engaging in socio-scientific inquiry?' is third in the ranking of most cited papers. It argues that although the aims of citizenship education were promoted through socio-scientific issues, the specific methods remain unclear. The authors recommend developing socio-scientific thinking as a valuable educational framework. Table 3 shows the top 10 most cited articles, authors, and journals, along with their total and average citation counts.

Upon examining the content of these publications, we find that eight are closely related to science education. The study by Oulton et al. (2004) addresses the general issues in TCI without distinguishing between science and social science. The paper by Davies (2006) titled 'Global Citizenship: Abstraction or Framework for Action?' primarily focuses on controversial issues about social education, encompassing social justice, rights, cultural dynamics, and conflicts.

3.2. Science mapping results

Keywords co-occurrence analysis

Before conducting the keyword co-occurrence analysis, two spellings of socio-scientific issues (socio-scientific issues and socio-scientific issues) were consolidated for simplicity and readability in the study. Similarly, the terms 'controversial public issues,' 'controversial topics,' 'controversial subjects,' 'controversial and sensitive issues,' and 'taboo topics,' all of which convey nearly the same meaning, were merged under the umbrella term 'controversial issues.' Sixty-five keywords formed 9 clusters, each having at least five occurrences.

Table 3. The Top 10 Articles by Citation Count

Rank	Title	Authors	Journal	Publish Year	Total citations	Average per year
1	*Scientific literacy for citizenship: Tools for dealing with the science dimension of controversial socioscientific issues*	Kolstø, S.D.	Science Education	2001	453	19,7
2	*Identifying effective climate change education strategies: a systematic review of the research*	Monroe, M.C., Plate, R.R., Oxarart, A., Bowers, A., Chaves, W.A.	Environmental Education Research	2019	420	84
3	*What do students gain by engaging in socioscientific inquiry?*	Sadler, T.D., Barab, S.A., Scott, B.	Research in Science Education	2007	387	22,8
4	*Tangled Up in Views: Beliefs in the Nature of Science and Responses to Socioscientific Dilemmas*	Zeidler, D.L., Walker, K.A., Ackett, W.A., Simmons, M.L.	Science Education	2002	295	17,9
5	*Student conceptualizations of the nature of science in response to a socioscientific issue*	Sadler, T.D., Chambers, F.W., Zeidler, D.L.	International Journal of Science Education	2004	287	14,3
6	*Argument to Foster Scientific Literacy: A Review of Argument Interventions in K-12 Science Contexts*	Cavagnetto, A.R.	Review of Educational Research	2010	263	18,8
7	*Global citizenship: Abstraction or framework for action?*	Davies, L.	Educational Review	2006	249	13,8
8	*Reconceptualizing the teaching of controversial issues*	Oulton, C., Dillon, J., Grace, M.M.	International Journal of Science Education	2004	230	11,5
9	*Controversial issues - Teachers' attitudes and practices in the context of citizenship education*	Oulton, C., Day, V., Dillon, J., Grace, M.	Oxford Review of Education	2004	199	9,9
10	*Learning Science, Learning about Science, Doing Science: Different goals demand different learning methods*	Hodson, D.	International Journal of Science Education	2014	198	19,8

The most often appearing co-occurring keywords were 'socioscientific issues' (189), 'controversial issues' (86), 'science education' (38), 'argumentation' (33), 'scientific literacy' (31), and 'critical thinking' (21). Similarly, the keyword 'socioscientific issues' (212) has the highest total link strength, followed by the keywords 'controversial issues' (108), 'science education' (61), 'science literacy' (56), and 'argumentation' (51). Figure 3 shows the names of the most co-occurrence keywords with their link.

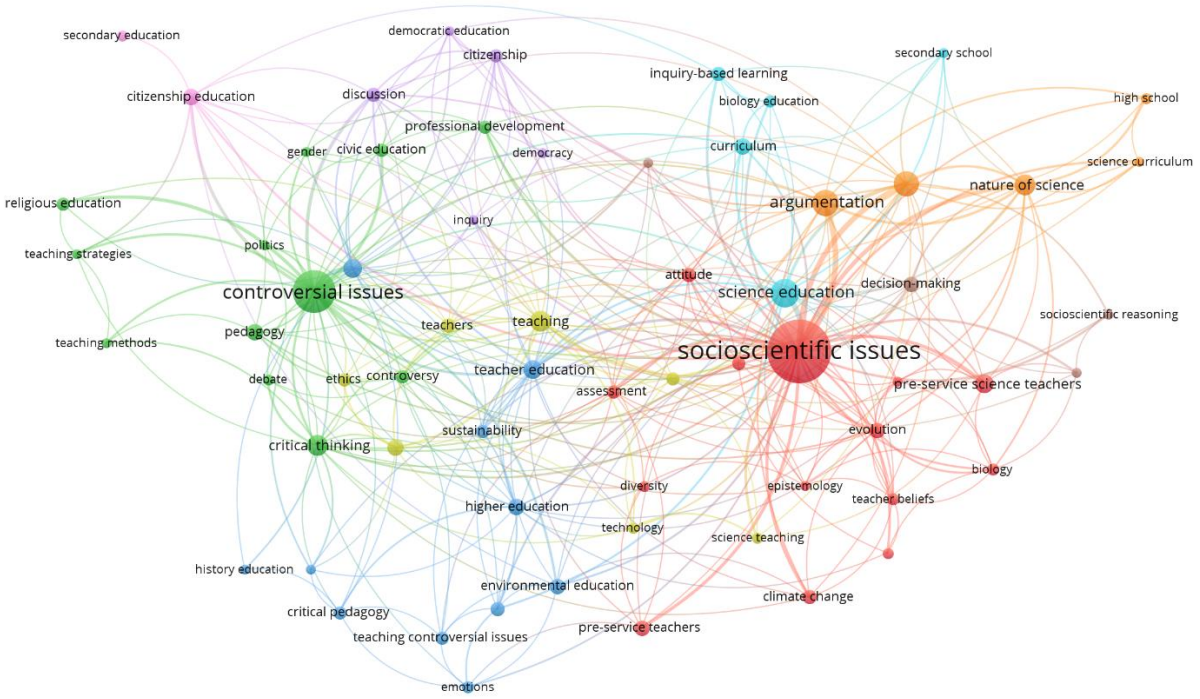

Figure 3. The 65 Most Indicative Keywords' Co-Occurrence

Upon closer examination of the nine clusters depicted in Figure 3, we find that three of them stand out as particularly noteworthy: teaching socioscientific issues (Cluster 1, Red), teaching controversial issues (Cluster 2, Green), and teaching controversial issues as part of teacher training (Cluster 3, Dark Blue). The first one, which focuses mainly on TCI, has the following essential keywords: socioscientific issues (189), pre-service science teachers (16), evolution (12), pre-service teachers (11), climate change (10), attitude (10) teaching practices (9), assessment (9), teachers' beliefs (7), biology (7), teacher professional development (6), diversity (6), epistemology (5), acceptance (5). The conceptual connections within this cluster reveal that studies on the TCI primarily focus on teachers' or teacher candidates' attitudes towards socioscientific issues, such as evolution, climate change, diversity, and epistemology, as well as teachers' experiences in teaching these issues. The second cluster shown in green includes the following key terms: controversial issues (86), critical thinking (21), pedagogy (13), civic education (9), religious education (9), professional development (8), controversy (8), debate (6), gender (5), politics (5), teaching methods (5), and teaching strategies (5). This cluster pattern shows a significant relationship between controversial issues and critical thinking. The third cluster, colored in dark blue, includes the following key terms: teacher education (17), social studies (16), higher education (14), environmental education (11), education for sustainability (10), critical pedagogy (9), teaching controversial issues (8), sustainability (8), emotions (7), history education (5), social justice (5). Within this particular cluster, there is a notable amount of research on social studies education as part of teacher education.

Figure 4 illustrates the trends of keywords, accompanied by an overlay visualization that shows the distribution of author keywords based on their co-occurrence across different years. Different colors illustrated prevailing concepts of the network map in a given average period. Brighter yellow keywords indicate later appearances, whereas deeper purple keywords imply earlier appearances. The analysis indicates that the articles published in the last three years have primarily focused on specific themes, with an average publication year and occurrence frequency: 'teacher professional development' (2020.83/6), 'religious education' (2020.67/9), 'STEM education' (2020.40/5), 'pre-service teachers' (2019.91/11), 'democratic education' (2019.80/5), 'social justice' (2019.80/5), 'inquiry-based learning' (2019.30/10), and 'education for sustainable development' (2019.20/10).

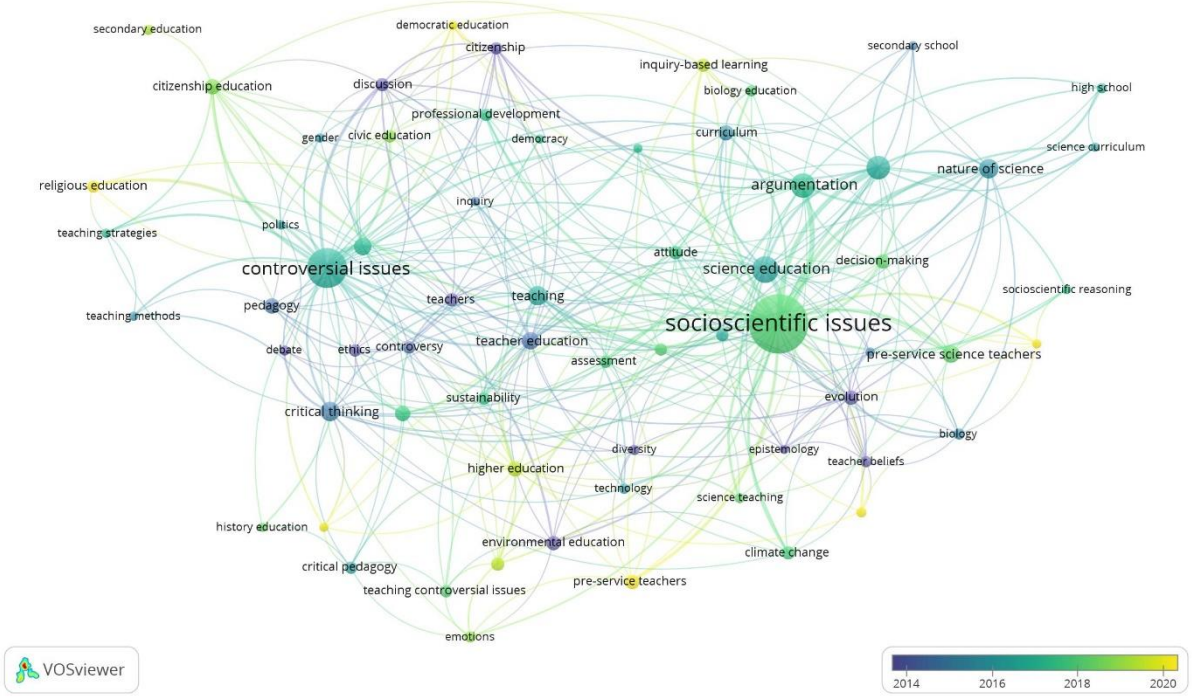

Figure 4. Distribution of Author Keywords by Year

Co-authorship analysis

For co-authorship analysis, we set the minimum number of documents per author to two. A total of 158 authors satisfied the established criteria. The network map comprises 24 nodes with 42 linkages, each representing an independent author. These nodes were divided into 6 clusters. Additionally, distinct cluster colors correspond to distinct author groupings. Among these clusters, the writers Troy D. Sadler (13 links), Loura Zangori (7 links), and Patricia J. Friedrichsen (6 links) represent the most prolific collaboration network in the figure, with the rest following. These authors, all affiliated with universities in the United States, have established a very productive network to create instructional frameworks focused on TCI, including topics such as climate change, carbon cycle, and scientific literacy (Ke et al, 2021; Zangori et al., 2017), as well as the professional development of teachers in the same context (Friedrichsen et al., 2021). They have also conducted rigorous tests to evaluate the effectiveness of these models.

The second cluster, which is more heterogeneous in terms of the countries in which they work (United States, Sweden, and South Korea), includes authors such as Dana L. Zeidler (link=5), Nina Christenson (3), Shu-Nu Chang Rundgren (1), and Hyunju Lee (1). The second cluster, comprising authors from the United States, Sweden, and South Korea, is more diverse and includes authors such as Dana L. Zeidler (with five links), Nina Christenson (with three links), Shu-Nu Chang Rundgren (with one link), and Hyunju Lee (with one link). These writers primarily focused on the use of argumentation in TCI (Christenson & Chang Rundgren, 2015; Christenson et al., 2014, 2017).

Country Collaboration Network

Our final analysis focuses on the country's collaboration network. The United States, the United Kingdom, and other European countries are represented as three significant cluster networks. The United States has the highest level of collaboration among the 69 countries that publish papers on TCI, with 24 linkages. The United States is followed by the United Kingdom (20), Germany (17), Spain (16), Sweden (15), and the Netherlands (15). The results illustrated in Figure 6 also suggest specific collaboration patterns. Our analysis reveals that geographical proximity (Austria, Belgium, France, Italy, Poland, Sweden, and Switzerland in the red cluster) and linguistic proximity (Colombia, Costa Rica, Panama, and Spain in the light blue cluster) have a significant influence on country collaboration. There are also some collaborations among geographically distant and linguistically different countries, as shown in the green cluster (Iran, Thailand, Turkey, and the United States). In the Dark Blue Cluster, collaborations are observed among Argentina, Bulgaria, Egypt, Lebanon, Saudi Arabia, and the United Kingdom.

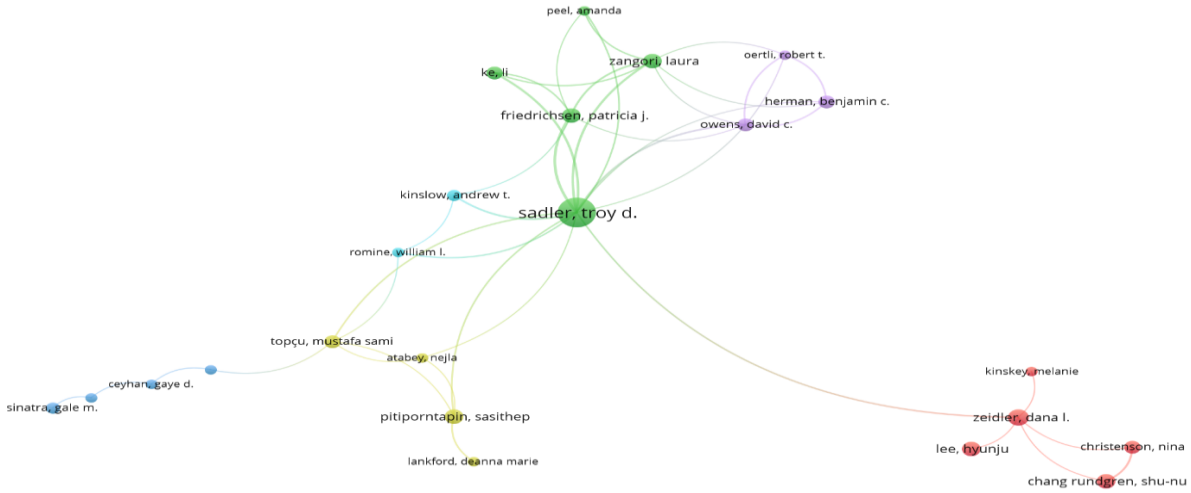

Figure 5. The Co-Authorship Network of Authors

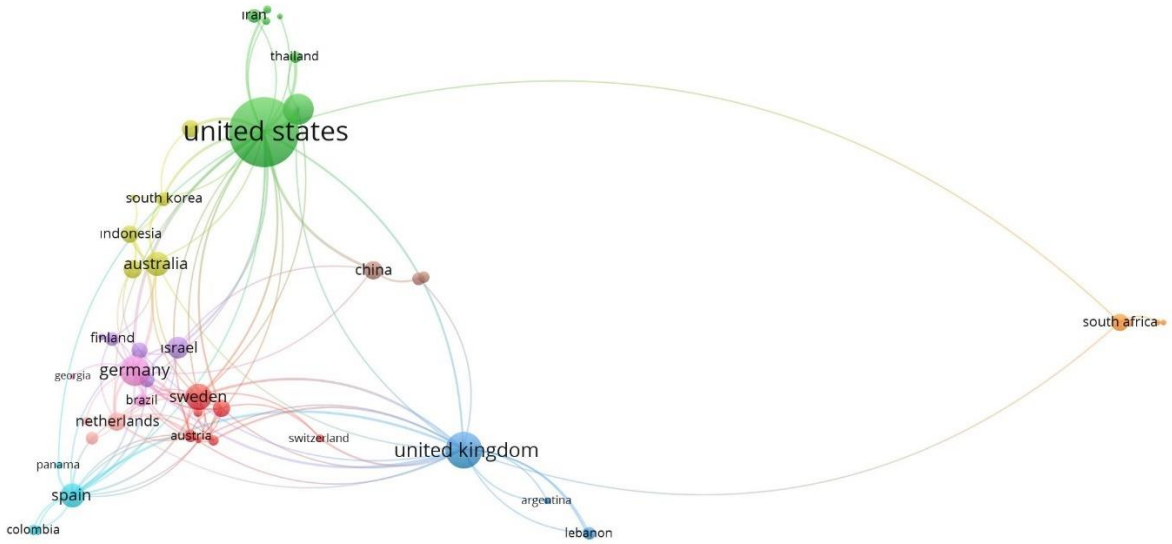

Figure 6. The Authorship Co-Occurrences between the Countries

4. Discussion and Conclusion

This study is the first bibliometric analysis of trends and research on TCI over the past three decades. In schools, controversial issues were sometimes called 'taboo topics,' likely because teachers found them challenging and costly to discuss in the classroom (Evans et al., 2000). However, the educational value of TCI has gained increasing recognition over time. Since the 2000s, the vocabulary and scope of TCI in schools have grown significantly to include social, political, and ethnic issues, as well as concerns related to new technologies and scientific topics. Our overall finding is that extensive research across various disciplines has led to a substantial rise in publications, citations, and keyword diversity, especially since 2006. Since then, there has been a notable surge in science education-related publications, with nine of the top ten leading journals and eight of the top ten articles on TCI. This increase in science education publications does not mean that social studies and civic-related topics have been overlooked. Instead, it emphasizes the diversity and broad range of research topics increasingly integrated into the research agenda.

Our study shows that research on TCI over the past thirty years has evolved in two main ways: it has reflected a better understanding of what makes a controversy. It has included more science- and technology-based controversies. As scientific and technological progress create more complex societal challenges, public debates, and shared interests, adding these topics to school curricula is a natural and essential step in social education. Teaching socio-scientific issues helps students develop key conceptual tools, critical thinking skills, and moral awareness needed to engage thoughtfully with the fast-changing world around them. In this way, schools become crucial places for teaching individuals to understand scientific advancements within their broader social, political, and ethical contexts, encouraging informed participation in democratic decision-making. Despite the growing number of information sources about science and technology, teachers remain among the most trusted sources of information on scientific and technological issues (Massarani et al., 2021). Therefore, it is important to understand the knowledge and perspectives of both science teachers and students on science as a social enterprise and its social contexts when developing teaching approaches that promote scientific literacy for citizenship (Kolstø, 2001).

Our keyword analysis indicates that, despite the increasing number of science-related publications, a significant amount of work in social studies and civic studies has also been published over the past thirty years. For example, the terms 'critical thinking,' 'civic education,' 'religious education,' 'controversy,' 'gender,' 'politics,' and 'social justice' each appeared five to twenty-one times within a cluster of keywords. Our analysis, which reflects current trends in published research, further demonstrates this diversity and plurality. As shown in Figure 4, the most frequently researched current topics related to TCI include pre-service teachers, inquiry-based learning, education for sustainable development, religious education, teacher professional development, STEM education, and democratic education. Keyword analysis reveals that the research mainly focuses on teaching specific topics connected to controversial issues across various areas. No keywords related to perceived 'barriers' in the administrative, educational, political, or cultural contexts were identified. We believe this is an important topic that deserves further investigation.

The collaboration network illustrates the scientific relationships among researchers from different countries. According to the National Science Board (2008), the percentage of co-authored publications worldwide increased from 8.3% in 1988 to 20% in 2005. To gain a more comprehensive understanding of the international landscape and collaboration dynamics in TCI, we analyzed the publication output of various authors and their cooperative relationships. Over the last three decades, there has been a substantial rise in international research collaboration, as shown by the increase in co-authored articles. Although there is no data explaining the motives behind international collaboration, our findings reveal a clear trend toward such cooperation. Researchers affiliated with universities in the US and the UK are among the most collaborative scholars in TCI, a pattern observed across most academic fields globally (National Science Board, 2021). In this context, our results align with evidence that cultural, linguistic, and geographical proximity significantly influence the patterns and frequency of international scientific collaboration (Hou et al., 2021). The strongest co-authorship link in this study was between the United States and Great Britain, while European countries also demonstrated notable co-authorship connections. International collaboration among authors has played a crucial role in disseminating scientific findings related to controversial issues. Analyzing the publications of the leading scholars shown in Figure 5 reveals that all collaborative authors publish work on science education, most of which originates from universities in the United States.

Regarding the country analysis findings, it is not surprising that the United States and Great Britain lead in total publications, citation counts, and research collaboration, given that TCI initially emerged as an educational goal in both countries. However, our results from all types of analyses suggest that Chinese scholars have not yet given adequate attention to TCI as an academic subject, despite China's leading position in recent country rankings in total publications (Scimago, 2024). Relatively limited interest in TCI within the Chinese context may be understood as a consequence of the broader political nature of the educational system. It also indicates political sensitivities related not only to the classroom practice of TCI but also to researching this topic. Among the top ten countries in our results, Turkey's performance, ranking third in total publications and fourth in total citations, is notable. Contrary to Turkey's position in other academic disciplines, one possible explanation for this achievement could be the considerable recruitment of professors in education colleges. Social studies and science education programs are separate departments in the Turkish education system. A substantial number of theses and articles focus on social studies education in Turkey, mainly on citizenship, values, and teaching methods, with increasing attention to controversial issues, digital media, and global ethics (Ersoy, 2010; Öntaş et al., 20121). TCI has a deeply value-laden purpose. It promotes the democratic ideal by cultivating informed, responsible, and critically minded individuals who understand the implications of socioscientific issues both locally and globally, and

who respect others. As such, it functions as an integrative element across the entire school curriculum. Our review of existing literature supports this multifaceted role of TCI. Currently, most academic disciplines and school programs consider TCI a key educational goal at various levels, from primary schools to higher education. Previous studies frequently highlight the conceptual and pedagogical connection between TCI and critical thinking (Payne & Gainey, 2003; Greene & Yu, 2015). Evidence of this relationship is also reflected in our findings regarding the co-occurrence of keyword clusters, with critical thinking having the highest number of connections (21) to the controversial issues cluster. Lastly, to ensure an accurate interpretation of our findings, we should note a limitation related to the scope of our dataset. Since our bibliometric data were limited to Scopus, including data from other sources might influence the results and require further investigation. For example, the Social Studies journal, a prominent publication dedicated to understanding and addressing educational goals and challenges related to TCI since its first issue in 1909, is not indexed in Scopus and thus excluded from our analysis. This journal primarily publishes on social, political, cultural, religious, and educational aspects of controversial issues. A keyword search of controversial issues from 1934 to 2024 yielded 1,108 articles in this journal. Despite these limitations, this study provides strong evidence for the growing body of knowledge in TCI, a field likely to continue expanding in the future.

Statement of Researchers

Researchers' contribution rate statement: First Author: Conceptualization, methodology, investigation, validation, writing-original draft preparation, writing - review & editing. **Second Author:** Data collection, software, writing-original draft preparation, investigation, validation, formal analysis.
Conflict statement: There is no conflict of interest.
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