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Research Article

Trending Themes on the Nature of Science in Science Education: A Bibliometric Analysis with VOSviewer

Serpil KARA[1]

[1] Necmettin Erbakan University, Ahmet Keleşoğlu Faculty of Education, Türkiye, serpilkara@erbakan.edu.tr, http://orcid.org/0000-0002-0482-7617

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Abstract – This study aimed to identify themes that indicate trends in the nature of science (NoS) in science education. The Web of Science (WoS) database was used for this purpose. A bibliometric approach was adopted, and the VOSviewer software was used to identify and systematically map research trends in the field of scientific innovation and to identify intellectual relationships in this network. In this context, the study covered the years 2013-2023. The categories "Education & Educational Research" and "Education Scientific Disciplines" were selected in the WoS database, and only article-type studies were included by excluding other publication categories obtained in the breakdown of the results. Finally, 263 articles were analyzed . According to the findings, the "Education Educational Research" WoS category is at the forefront. The publications made according to the years show alternating trends of increase and decrease. Lederman, N.G. is the author with the highest number of citations. Erduran, S. is the author with the highest number of studies and the highest total link strength. The majority of publications were in the journal "Research In Science Education." The words "scientific literacy" and "history of science" were used most frequently after "nature of science" and "science education" among the keywords. The most frequently repeated words in the abstracts of the articles were "questionnaire" and "interview". Finally, the countries ranked in the top three in terms of total link strength and the most cited countries were the USA, England, and Türkiye, respectively.

Keywords: Nature of science, science education, bibliometric analysis, VOSviewer, history of science and scientific literacy

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Corresponding author: Serpil KARA, serpilkara@erbakan.edu.tr

Introduction

The primary purpose of science is to explain natural phenomena in a logical and organized manner, develop theories, and discover basic principles and concepts. By integrating scientific methods into educational environments, the goal is for students to conduct research to understand the world and actively participate in the scientific process to understand how scientific knowledge and the nature of science (NoS) are formed (Ministry of National Education [MoNE], 2018).

The NoS is defined as a discipline that seeks answers to issues such as the working methods of scientists, the definition of science, the interaction between science and society, and the values and beliefs in scientific knowledge (Lederman 2007). The literature reveals that the NoS is handled on the basis of dimensions (Khishfe & Abd-El-Khalick, 2002; Lederman, 2007). These dimensions are considered the changeability, empiricism, theoretical basis, and imaginative and creative aspects of scientific knowledge, as well as the influence of the social and cultural environment, and the theoretical, observational, and inferential nature of scientific knowledge.

Khishfe and Abd-El-Khalick (2002) proposed three approaches for teaching NoS: historical, indirect, and direct reflective. On the other hand, the Family Resemblance Approach can be integrated into science curricula to enable students to learn and understand science holistically in its epistemic, cognitive, and social dimensions (Kaya & Erduran, 2016). Therefore, in the related literature, various approaches are used in the field of science education to teach the NoS (Gören & Kaya, 2023).

NoS in Science Education

An important research area in science education is the NoS (Gören & Kaya, 2023), and one of the main goals of this education is to enable students to understand the NoS (AAAS, 1993; NRC, 1996; McComas, 2004; NGSS, 2013; Voss et al., 2023). Therefore, it is argued that curricula should be organized and implemented to develop an understanding of science and NoS (Abd-El-Khalick, F., & Lederman, N. G.,2000). When evaluated globally, science education reform documents and curricula include outcomes related to the development of NoS understanding (NGSS Lead States, 2013; NRC, 1996). In the context of science education, NoS plays a critical role in teaching students the basic principles, methods, and processes of science. One of the main objectives of our country's Science Curriculum, which aims to raise all individuals to be science-literate, is to help them understand how scientific

knowledge is created by scientists, the processes through which this knowledge is created, and how it is used in new research (MoNE, 2018).

Effective teaching of the NoS is not only limited to the transfer of knowledge in science education (Çakıcı, 2009), but also aims to improve students' abilities to apply knowledge, generate new questions, and question existing knowledge (Ayvacı & Akdemir, 2017). In this context, teaching strategies and curricula must be designed to support students' scientific thinking and problem-solving skills. Such teaching helps students develop a deeper understanding of the NoS and gain perspectives on the social, ethical, and practical dimensions of science (Hwang et al., 2015). Indeed, understanding the NoS in science education not only increases the scientific knowledge of individuals, but it also develops social consciousness and responsibility (Crowther et al., 2005) and enables individuals to think critically by understanding the production of scientific knowledge (Jimenez-Aleixandre et al., 2000). Therefore, in the literature, both teachers (Adsiz & Kutluca, 2023; Kurt & Kaya, 2023) and students (Gülmez Güngörmez & Akgün, 2020; Ozan & Uluçınar Sağır, 2020; Stadermann & Goedhart, 2020; Yacoubian, 2021) identify or develop an understanding of the NoS in the context (Bugingo et al., 2024), or it is observed that various methods are used for effective teaching (Gören & Kaya, 2023).

The ESERA conference, organized by the European Science Education Research Association, encompasses worldwide research in the field of science education. When the studies on NoS in the ESERA-2009 conference were examined, it was found that the studies on NoS were directly related to science subjects: NoS and student-teacher views, conceptual understanding, the relationship between NoS and teaching methods, and even epistemological beliefs (Öztürk & Kaptan, 2014). Studies focusing on various components have been conducted to determine or develop NoS understanding in the global context. In this context, it is important to identify trends in the current literature on the Nature of Science (NoS) and teaching in the field of science education. One of the studies that has frequently been used recently to identify trends in terms of various components is bibliometric analysis.

Bibliometric Analysis and Study Importance

Bibliometric analysis is preferred to obtain information about the breadth and quantity of the topic (Comarú et al., 2021), as well as for a general understanding of its nature and to guide future studies (Pradana et al., 2023). While it allows us to reveal the evolutionary nuances of a particular field, it also sheds light on emerging areas in that field. Bibliometric

analysis involves the application of quantitative techniques to bibliometric data (Donthu et al., 2021).

When the related literature is examined, it is seen that there are studies on science education (Comarú et al., 2021; Effendi et al., 2021; Maryanti et al., 2023; Solehuddin et al., 2022; Sönmez & Hastürk, 2020; Tosun, 2024) and limited bibliometric studies on NoS (Kurtuluş & Bilen, 2021; Yanuarti & Suprapto, 2021). Kurtuluş and Bilen (2021) conducted a bibliometric analysis of studies on NoS in science education, published in science, physics, chemistry, and biology education journals indexed in the WoS database between 1986-2019. On the other hand, Yanuarti and Suprapto (2021) conducted a bibliometric analysis of studies on NoS in science education between 2011 and 2020 based on the Scopus database. However, studies on bibliometric analysis of NoS in science education remain limited. One of the important goals of science education is for students to understand the NoS (AAAS, 1993; NGSS Lead States, 2013; NRC, 1996), and goals related to the NoS are included in science education reform documents and curricula (AAAS, 1993; NGSS Lead States, 2013; NRC, 1996). On the other hand, since NoS teaching has critical importance in the dimension of raising scientifically literate individuals (Widowati et al., 2017), and since the understanding of NoS has long been among the goals of science education (Voss et al., 2023), it is important to know the trends of studies on NoS in science education.

It is thought that presenting the trends of the studies on the NoS in science teaching and the innovations at the current point through a bibliometric analysis will shed light on the researchers who will work in this field in terms of identifying the gaps, new scientific paths, and study topics, and will make a significant contribution to the establishment of scientific cooperation globally. This approach will assist in establishing scientific cooperation globally. The bibliometric analysis on science teaching aims to provide researchers with important information on existing literature and to help them determine which areas are more extensively studied and which topics are not sufficiently researched. This provides an opportunity to focus on previously unexplored topics and is expected to contribute to the identification of new research topics by addressing research gaps. The analysis of the existing findings will enable scientists to develop innovative research questions and new methods in the field. By examining collaborations between research conducted in different countries and institutions at the global level, bibliometric analysis provides a broader perspective on the research community and increases opportunities for international collaboration. As a result, this study is expected to serve as a guide for new and existing researchers and to make a

significant contribution to the development of the field, by providing a roadmap for science teaching and NoS.

In this context, this study was designed to answer the following questions.

1. Regarding research on NoS in science education;

a. What is the WoS category distribution?

b. How is the distribution based on years?

c. What is the ranking of the top 10 authors with the most studies?

d. What is the distribution of journals in which their articles were published?

e. What is the citation analysis network of the authors?

f. What is the co-author analysis network?

g. What is the keyword analysis network?

h. What is the analysis network for the most frequently used words in the article abstracts?

ı. What is country citation analysis network?

Method

The research design, data collection, and analysis processes are described below.

Research Design

In this research, a bibliometric approach was adopted to identify and systematically map research trends in the field of scientific innovation (Prahani et al., 2024) and intellectual relationships in this network (Li & Xu, 2022). The VOSviewer program, a visualization tool used in the bibliometric approach, was applied. VOSviewer uses elements such as scientific publications, journals, researchers, research institutions, organizations, countries, keywords, and terms to create and visualize networks of relationships through links such as coauthorship, collaboration, citation, and cocitation (Aria & Cuccurullo, 2017; Van Eck & Waltman, 2022).

Data Collection and Analysis

In this study, the widely used Web of Science (WoS) database (Sarkar et al., 2022), which hosts scientific documents in all disciplines, was used to obtain data. WoS, the first bibliometric database established by the Institute for Scientific Information (ISI) (Pranckute, 2021), was preferred because it is widely used for academic literature search and selection (Agrifoglio et al., 2021). It is a multidisciplinary and selective database consisting of various

specialized indexes grouped according to the type or theme of the indexed content. It is a core collection of six major citation indexes (Pranckute, 2021).

On 21.07.2024, access to the WoS was provided through the university database affiliated with the researcher, and the contents indexed there were used as criteria. In the WoS database, a search using the keywords “nature of science” and “science education” under the title "topic" yielded 722 results. The nature of science has gained an important place in educational curricula in recent years because of its foundational impact and comprehensive scope. Prior to 2013, scientific studies generally showed an increasing trend. Between 2013 and 2023, scientific studies showed fluctuating trends, and the importance given to science in the education system increased, which makes it important to analyze these periods. Moreover, the fact that data will continue to flow as of 2024 provides an important context for understanding the trends and developments over the last decade. Therefore, analyzing studies from this decade is of primary importance, to better understand the changes in the nature and practices of science. Given that the NoS is a very broad and long-established subject, has recently gained an important place in education curricula, and will continue to have active data flow in 2024, the aim was to analyze studies from 2013 to 2023 to determine the trend over the last ten years. In this context, 502 publications were identified. In the next stage, the categories of “Education & Educational Research” and “Education Scientific Disciplines” were selected in the WoS database, and only articles as document type were analyzed. A total of 263 publications were identified and analyzed. Papers, book chapters, article reviews, early access, editorial material, and book reviews were not included in the dataset or evaluated. The selection process of the articles to be included in the study with the PRISMA flow diagram (Moher et al., 2009) is shown in Figure 1.

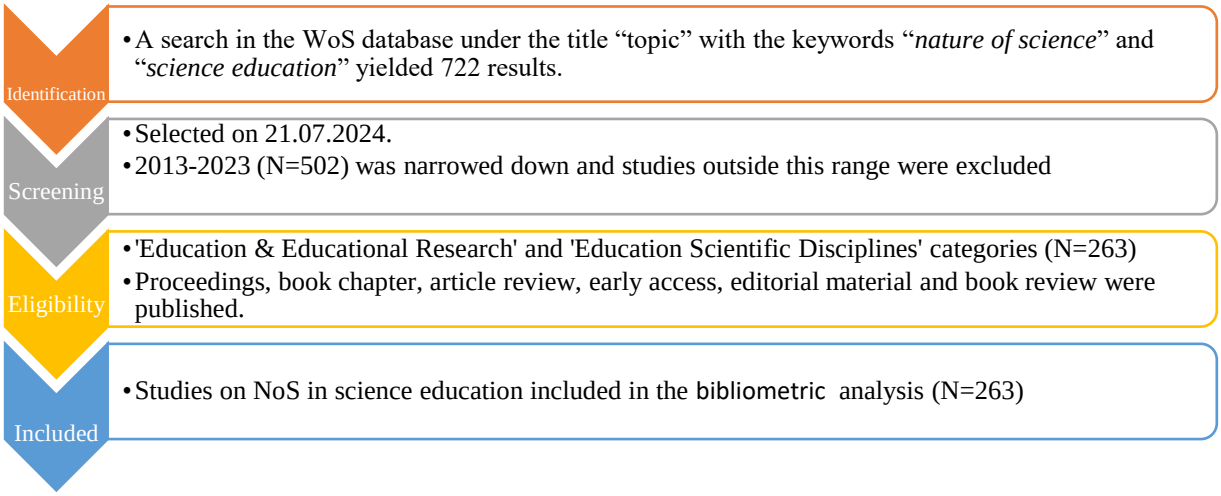


Figure 1 Selection Process of the Articles to be Included in the Study

Findings

WoS Category Breakdown

Firstly, the distribution of the first ten categories reached in the research conducted using the keywords “nature of science” and “science education” is given in Table 1. The distribution of the categories of ‘Education & Educational Research’ and ‘Education Scientific Disciplines’ are given in Table 2.

Table 1 WoS Category Distribution of Studies on Nos in Science Education

Category	Number of articles
Education & educational research	532
History philosophy of science	103
Education scientific disciplines	94
Cultural studies	21
Biology	15
Geosciences multidisciplinary	7
Psychology educational	6
Chemistry multidisciplinary	4
Physics multidisciplinary	4
Psychology multidisciplinary	4

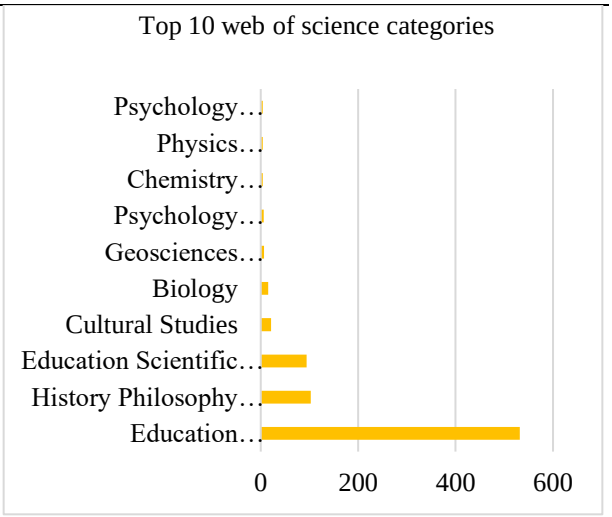
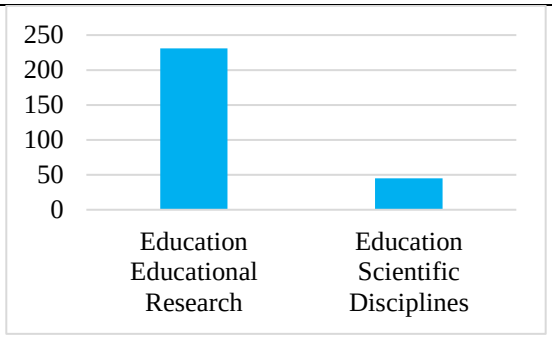


Table 2 WoS Category Breakdowns Selected within the Scope of the Research

Category	Number of articles
Education & educational research	231
Education scientific disciplines	45

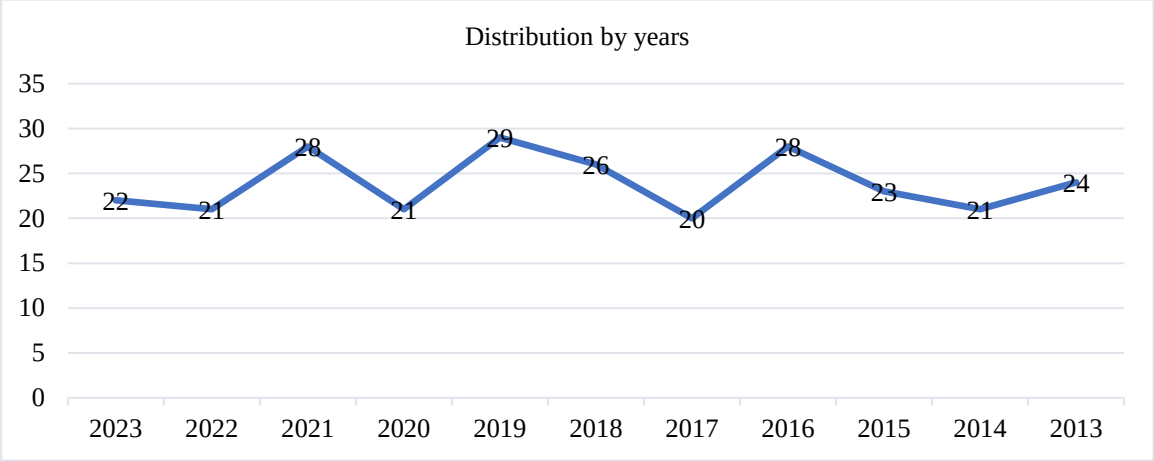


When Tables 1 and 2 are examined together, it can be seen that the “Education & Educational Research” category is at the forefront of the WoS category distribution of the studies on the NoS in science education.

Distribution of Research on NoS in Science Education by Year

Table 3 shows a distribution of research conducted between 2013 and 2023.

Table 3 Distribution of NoS Research in Science Education by Year



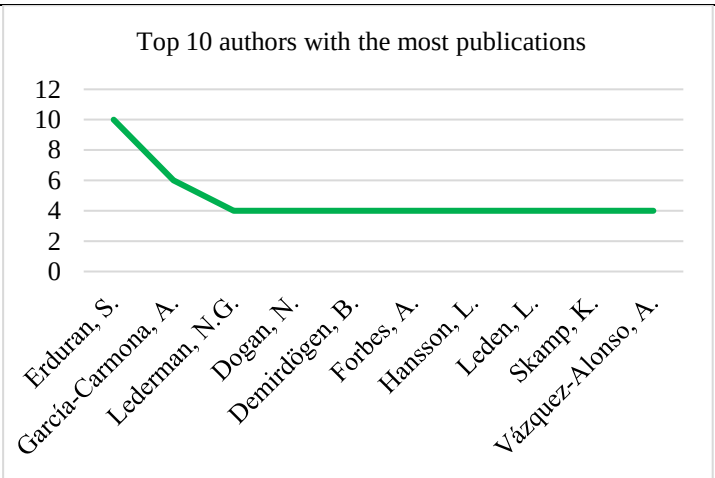
An analysis of the yearly distribution reveals that *f*=24 articles were published in 2013, *f*=21 in 2014, *f*=23 in 2015, *f*=28 in 2016, *f*=20 in 2017, *f*=26 in 2018, *f*=29 in 2019, *f*=21 in 2020, *f*=28 in 2021, *f*=21 in 2022 and *f*=22 in 2023. Considering the number of studies by years, it is seen that there was an increase in 2015, 2016, 2018, 2019 and 2021, and a decrease in 2017, 2020, and 2022. Starting from 2023, considering the increase in the number of studies, it can be said that studies on the NoS in science education will increase in the coming years 2024 and 2025.

Findings of the Top 10 Authors with the Most Number of Studies

Table 4 lists the top 10 authors who conducted the most studies on NoS in science education between 2013 and 2023, as revealed in the analysis.

Table 4 Top 10 Authors with the Most NoS Work in Science Education

Author name	Number of articles
Erduran, S.	10
García-Carmona, A.	6
Lederman, N.G.	4
Dogan, N.	4
Demirdögen, B.	4
Forbes, A.	4
Hansson, L.	4
Leden, L.	4
Skamp, K.	4
Vázquez-Alonso, A.	4



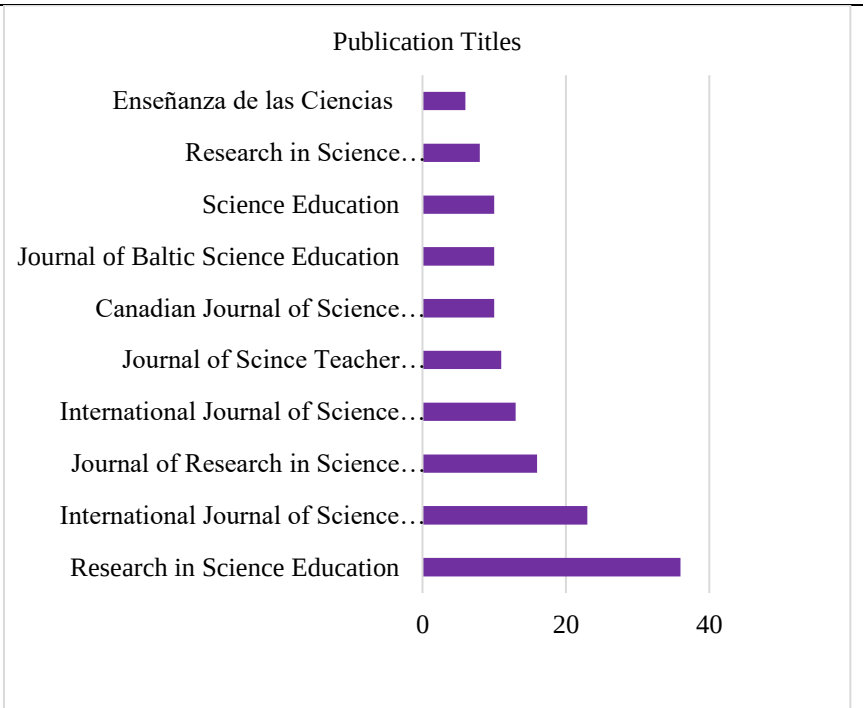
When Table 4 is examined, the author who conducted the most studies on the subject was Erduran, S.

Distribution of journals in which research on NoS in science education is published

The findings regarding the distribution of the journals in which the studies were published are presented in Table 5.

Table 5 Distribution of Journals in which Articles Related to the NoS in Science Education were Published

Journals	Number of articles
Research in science education	36
International journal of science education	23
Journal of research in science teaching	16
International journal of science and mathematics education	13
Journal of science teacher education	11
Canadian journal of science, mathematics, and technology education	10
Journal of baltic science education	10
Science education	10
Research in science and technological education	8
Enseñanza de las ciencias	6



According to Table 5, the studies on NoS in science education were mostly found in Research in Science Education and International Journal of Science Education.

Citation Analysis Network of Authors in Research on the NoS in Science Education (Citation of Authors)

At least 2 publications and at least 2 different citation criteria were used in the bibliometric analysis to identify author networks. The results that met the criteria are visualized in Figure 2.

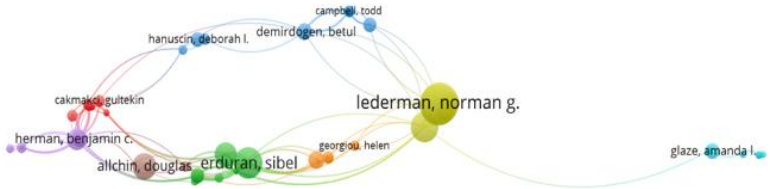


Figure 2 Citation Analysis of the Authors

In the author citation network map in Figure 2, the most cited authors are Lederman, N. G. (365 citations, 5 publications), Lederman, J. S. (352 citations, 3 publications), Erduran, S. (201 citations, 10 publications), Schwartz, R. S. (198 citations, 2 publications), and Allchin, D. (146 citations, 3 publications). A total of 8 clusters, 194 links, and 286 total link strengths were determined over 59 units with links between authors.

Analysis Network of Co-Authorship of Authors in Research on NoS in Science Education (Co-Authorship of Authors)

A bibliometric network was created based on the criteria; at least 1 publication and at least 1 citation, to identify the most contributing, connected, and collaborating authors. The bibliometric network of the data is presented in Figure 3.

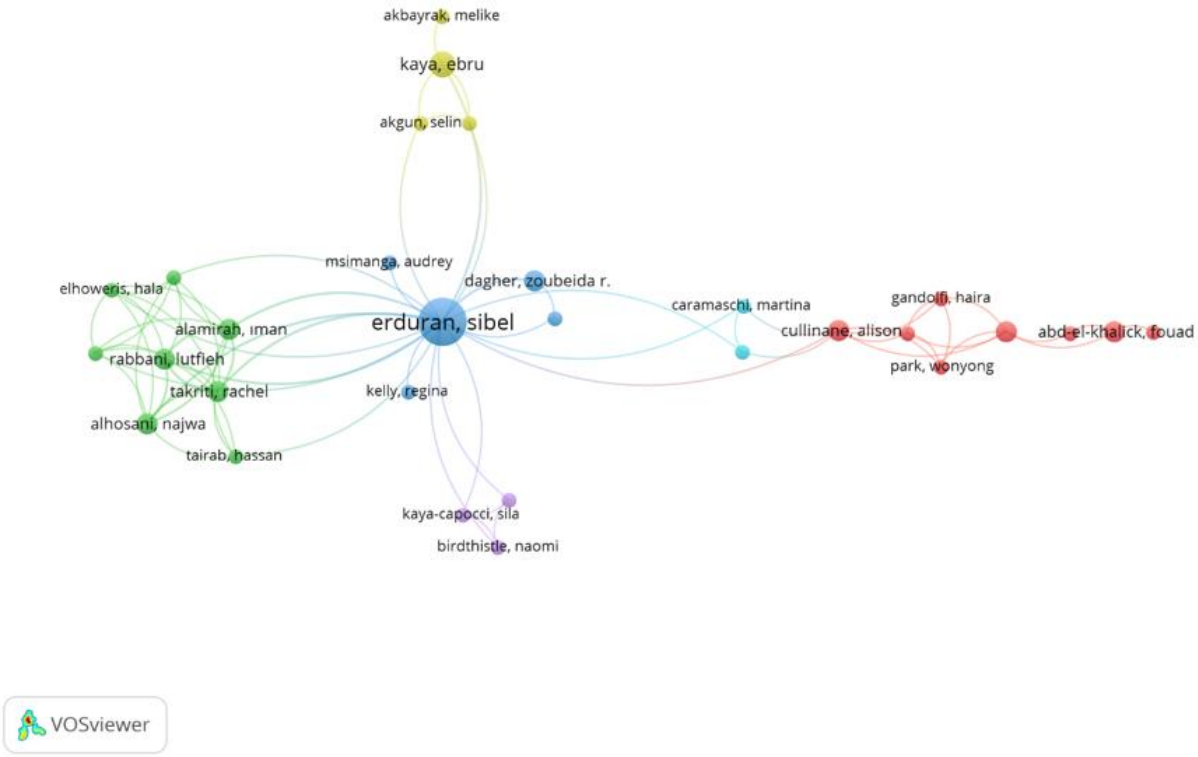


Figure 3 Co-authorship of the Authors Analysis

According to Figure 3, the bibliometric network formed consisted of 71 links merging into 6 clusters with a total of 83 link strengths obtained. The authors with the highest total link strength are Erduran, S. (10 publications, 201 links, total link strength 27), Doğan, N. (4 publications, 32 links, total link strength 18), Çakmakçı, G. (4 publications, 33 links, total link strength 17), Yalaki, Y., and Irez, S. (3 publications, 28 links, total link strength 15), and Furman, M. (2 publications, 29 links, total link strength 13).

Analysis Network of Keywords in Research on Nos in Science Education (Co-Occurrence of Author Keywords)

To determine the analysis network of keywords in the studies on NoS in science education, the analysis type was selected as "Co-occurrence," and the analysis unit was selected as "Author Keywords" in the VOSviewer program. The network obtained as a result of the analysis is shown in Figure 4.

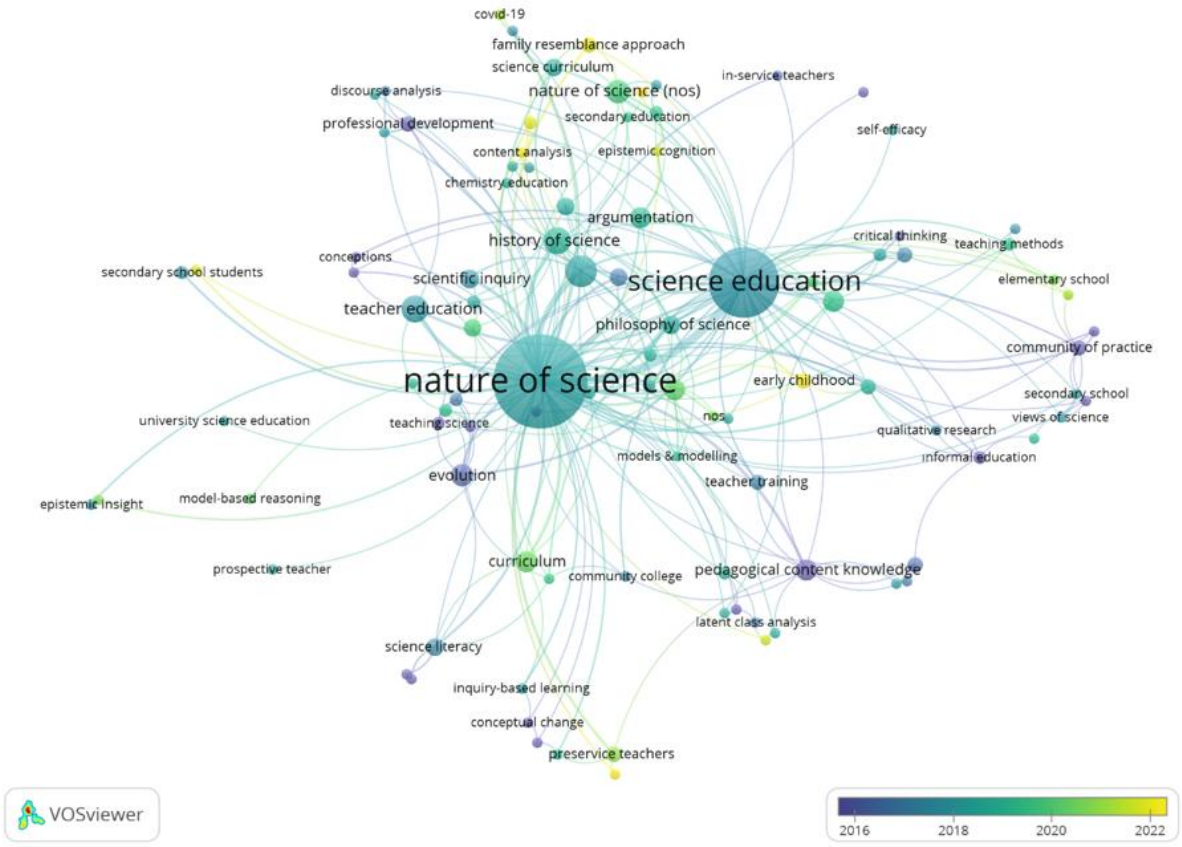


Figure 4 Co-occurrence Analysis of the Author Keywords

According to Figure 4, 99 out of 687 words were found in the keyword analysis to meet this threshold of occurring at least 2 times in frequency. Thus, 20 clusters, 288 links, and 475 total link strengths were identified. Among the keywords in the published articles,

"nature of science" was the most frequent (138), followed by "science education" (76), "scientific literacy" (16), "history of science" with 12 occurrences, and "teacher education" with 12 occurrences. As a result of the analysis of 209 related items, a total of 24 clusters, 790 links, and 1278 total link strengths were identified. Since the 2020s (Figure 4, yellow areas), keywords such as "family resemblance approach; early childhood; content analysis; special education" have begun to appear in the studies.

Analysis Network of the Most Frequently Used Words in the Abstracts of Articles in Research on the NoS in Science Education

"Abstract field" and "binary counting" methods were selected, and the total number of terms in the abstracts, of the publications was determined as 5889. The minimum number of repetitions was set to 10, and the analysis was performed on the 92 terms that met this criterion. The word network obtained as a result of the analysis is shown in Figure 5.

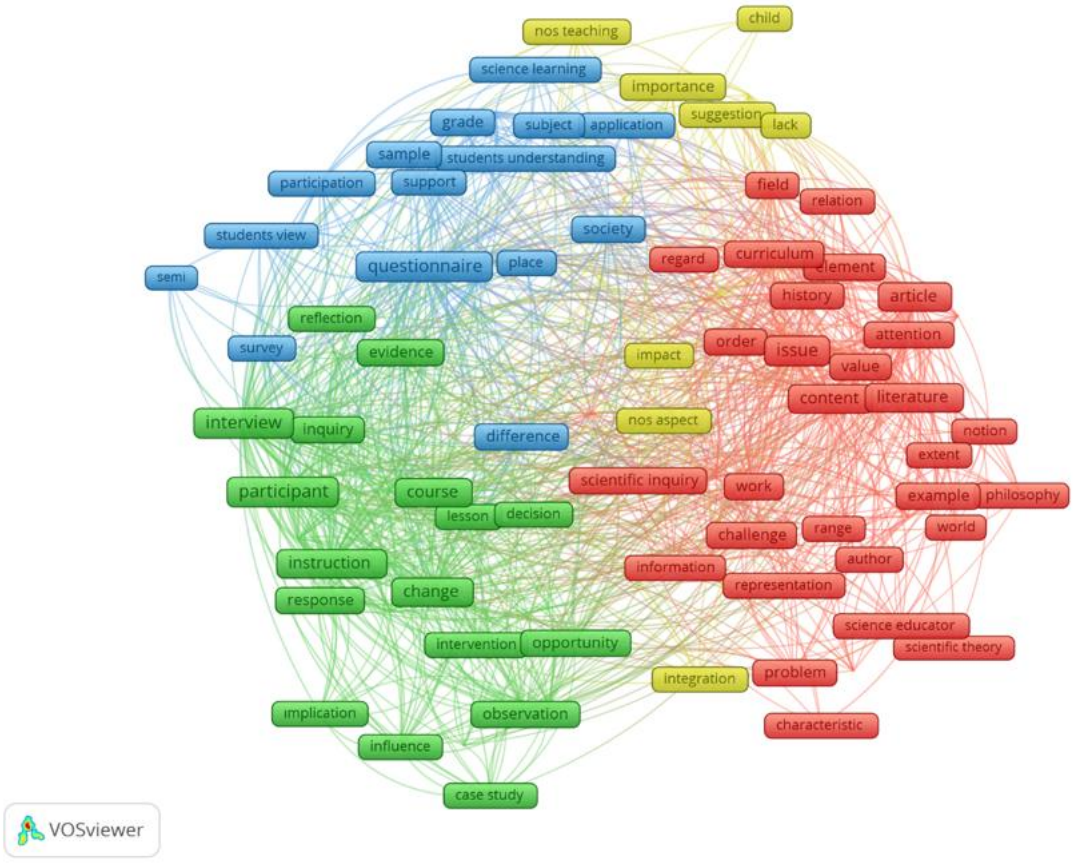


Figure 5 Most Frequently Used Words in the Abstracts

The map revealed 4 thematic clusters [Cluster 1 red (*f*=37), Cluster 2 green (*f*=26), Cluster 3 blue (*f*=18), and Cluster 4 yellow (*f*=11)]. The largest circle in each cluster represents the dominant keyword. When Figure 5 is analyzed, the most frequently repeated

words in the abstracts of the related articles are questionnaire (*f*=51, blue cluster,) interview (*f*=49, green cluster,) participant (*f*=49, green cluster,) issue (*f*=48, red cluster,) and course (*f*=40, green cluster).

Citation Analysis Network of Countries in Research on The Nos in Science Education (Citation of Countries)

To create a network map based on the citations received by the countries from which the publications originated, 31 observation units were analyzed in accordance with the condition that a specific country published at least two works and received at least two citations. The network map is shown in Figure 6.

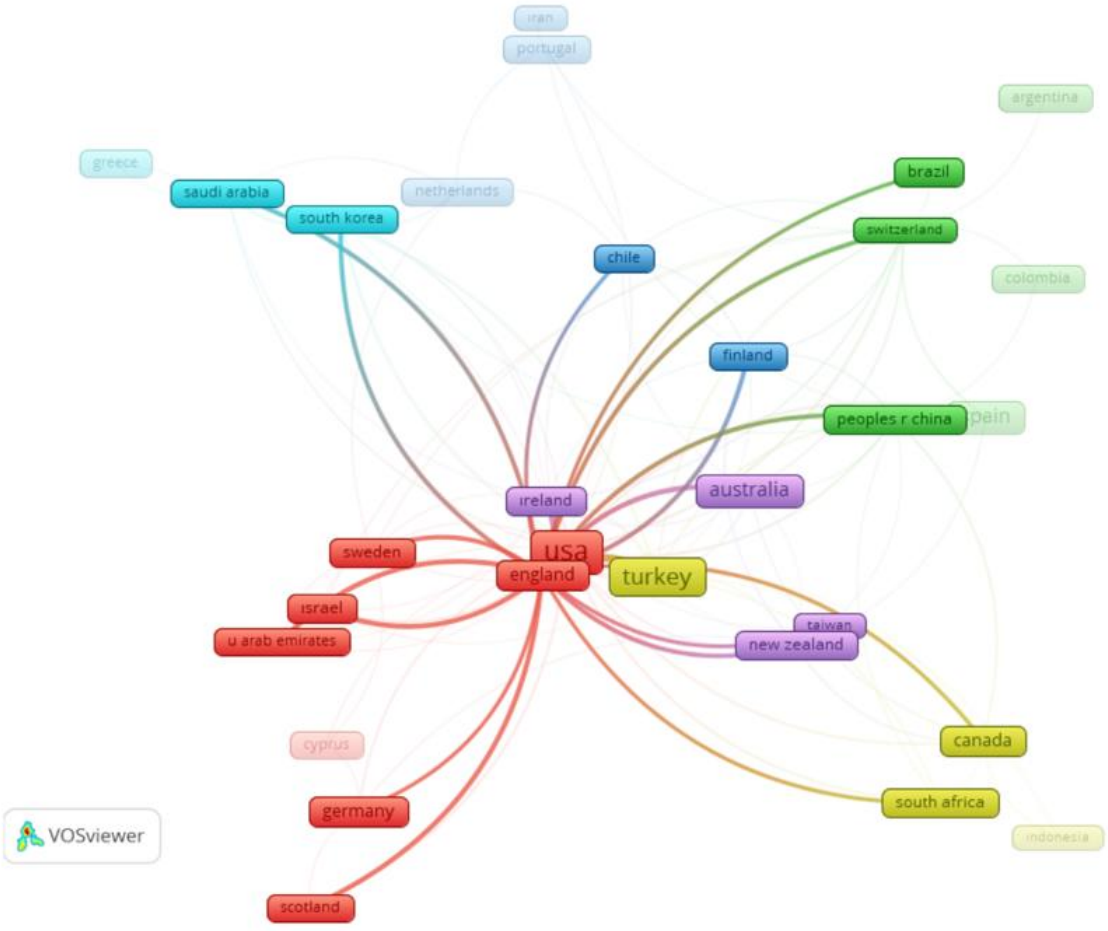


Figure 6 Analysis of Country Citations

In the citation analysis network of countries, the top three countries in terms of total link strength and the most cited countries were the USA (2135 citations, 78 publications), England (606 citations, 15 publications), and Türkiye (735 citations, 41 publications). The

level of relationships among the 31 units is explained by 7 clusters, 113 links, and 256 total link strengths.

Conclusions, Discussions, and Suggestions

In this study, a bibliometric analysis of articles related to NoS studies in science education in the categories of "Education & Educational Research" and "Education Scientific Disciplines" in the WoS database was presented. The studies included in this context cover the years 2013-2023. According to the findings, most articles in the Web of Science category distribution were in the "Education & Educational Research" category.

When the findings regarding the distribution of the studies by year were evaluated, the intensity of the studies increased in 2016 (*f*=28), 2019 (*f*=29), and 2021 (*f*=28). It then started to decline in 2023 (*f*=22). However, in general, studies on NoS in science education fluctuate over time. There are concrete suggestions on how to make changes in science curricula to transform various aspects of the NoS into a more holistic and inclusive form (Caramaschi et al., 2022). From a global perspective, considering the goals related to the NoS in science education reform documents and curricula (AAAS, 1993; NGSS Lead States, 2013; NRC, 1996) and similarly in our country in both the primary education curriculum (MoNE, 2018) and teacher training programs (CoHE, 2018), we expect that studies on the subject will gain intensity.

Erduran, S. and García-carmona, A. are the authors who conducted the most studies on the subject, with Research in Science Education being the journal where their work is most frequently published. On the other hand, the authors with the highest number of citations are Lederman, N. G., Lederman, Judith S., and Erduran, S. The authors with the highest total link strength are Erduran, S., Doğan, N., and Çakmakçı,. G. Tosun (2024) concluded that Lederman N.G. is one of the most cited authors in science education research, indicating that the subject of the NoS is intensively studied.

The most frequently repeated keywords in the published articles were "NoS," "science education," "scientific literacy," "history of science," and "teacher education." This can be interpreted as the studies mostly focused on teachers' scientific literacy, and the history of science conceptions. Tosun (2024) found that one of the frequently used keywords and core topics in the results of bibliometric analysis of science education research articles from the past 40 years was NoS and that NoS was among the most preferred topics between 2007 and 2021. In the current study, it was concluded that keywords such as familial approach, early

childhood, content analysis, and special education started to be included in studies in the 2020s. As a result of a systematic review of studies on the family resemblance approach to the NoS in science education, it was determined that the number of studies using FRA has increased in the last decade (Cheung & Erduran, 2023), which supports the findings of the current study.

On the other hand, although there has been limited interest in teaching NoS in early childhood in the past years (Bell & Clair, 2015), a study based on the NoS approach in early childhood found that conversations about the NoS are possible for the youngest children, and that focusing on science at an early age will contribute to the NoS literature (Hansson et al., 2020). In recent years, there has been a focus on the importance of understanding the NoS in early childhood. It will represent one of the important research topics in this field. In recent years, content analysis studies have been conducted analyzing the NoS under various components (Bett et al., 2023; Cheung & Erduran, 2023; Jaenudin et al., 2021; Okan & Kaya, 2023; Suryani et al., 2022). the NoS is an important subject that can be examined under a wide variety of variables; therefore, it can guide different study topics. Considering that content analyses, like bibliometric analyses, are conducted to determine trends and tendencies related to any subject, it is important to repeat them at certain time intervals. Similarly, studies on the NoS in the field of special education have been included in recent years (Librea-Carden & Mulvey, 2023; Librea-Carden et al., 2021), and this field offers potential for further study on the NoS.

According to the findings related to the most frequently used words in the abstracts of the articles, the research priorities of the NoS researchers in science education were identified as questionnaire, interview, participant, issue, and course. In this case, the studies focused on obtaining teachers' opinions on NoS, derived from course and subject/activity practices. Finally, it was concluded that the countries in the top three in terms of total link strength in the citation analysis network of countries and the countries with the highest number of citations were the USA, the UK, and Türkiye. The finding that the USA and the UK are the leading countries in science education research (Tosun, 2024) supports the findings of this study. On the other hand, just as teachers' views on the NoS play a key role in how they teach science (Takriti, et al., 2024), it is also important to obtain their students' perspectives on the NoS as a result of activities and practices to understand and succeed in science (Karataş Öztürk et al., 2023; Yacoubian, 2021). It can be concluded that there has been an increase in questionnaire and interview studies on the NoS. After the review of the studies on

FRA in the NoS in science education, it was found that interviews and questionnaires were the leading methods (Cheung & Erduran, 2023). Considering that views and students are among the most used keywords in a bibliometric study on the NoS (Kurtuluş & Bilen, 2021), in another content analysis study, students were the sample in a significant portion of the studies (Taşkın, 2021), and recent studies have progressed on determining student views (Gülmez Güngörmez & Akgün, 2020; Ozan & Uluçınar Sağır, 2020; Stadermann & Goedhart, 2020), it can be considered that what is meant as participant in the results of the current study constitutes the group of students. However, because one of the most frequently repeated words among the keywords of the articles of the current study was "teacher education," the group characterized as "participants" in this study consists of teachers.

In future research, it should be considered that teachers should receive quality training to effectively transfer knowledge. In this context, a model in which different practices are implemented and evaluated in undergraduate teacher training programs (e.g., see Wahbeh & Abd-El-Khalick, 2014) or a model based on science teachers' pedagogical content knowledge resources can be used for more effective teaching of NoS. In addition, it may be recommended to conduct similar studies using domestic databases such as ULAKBİM and Council of Higher Education (CoHE) Thesis Archive, and internationally using databases such as Scopus and PubMed.

Compliance with Ethical Standards

Disclosure of potential conflicts of interest

I have no conflict of interest to declare.

Funding

The study was not funded

CRediT author statement.

All stages of the study were provided by the author

Research involving humans and/or animals

No data were collected from human participants in the study. The research is a document review. All data were obtained by accessing the Web of Science-WoS database in the e-Library documentation unit of Necmettin Erbakan University

Fen Eğitiminde Bilimin Doğası Üzerine Eğilim Gösteren Temalar: VOSviewer ile Bibliyometrik Bir Analiz

Özet:

Bu araştırmada, fen eğitiminde bilimin doğası üzerine eğilim gösteren temaların belirlenmesi amaçlanmıştır. Bu amaç doğrultusunda Web of Science-WoS veri tabanı kullanılmıştır. Bilimsel inovatif alanındaki araştırma eğilimlerini tanımlamak ve sistematik bir şekilde haritalamak ve bu ağdaki entelektüel ilişkileri belirlemek amacıyla bibliyometrik yaklaşım benimsenmiş ve VOSviewer yazılım programı kullanılmıştır. Bu kapsamda çalışmaya 2013-2023 yılları baz alınmış, WoS veri tabanında Education & Educational Research' ve 'Education Scientific Disciplines' kategorileri seçilmiş ve sonuçların dökümünde elde edilen diğer yayın kategorileri çıkarılarak sadece makale türündeki çalışmalar veri setine dahil edilerek nihayetinde toplamda 263 makale incelenmiştir. Elde edilen bulgulara göre, 'Education & Educational Research' WoS kategorisinin ön planda olduğu, yıllara göre yapılan yayınların artıp azalan bir eğilim gösterdiği, en fazla çalışma yapan yazar Erduran S., en fazla atıf alan yazarın Lederman, N. G ve aralarında toplam bağlantı gücü en fazla yazarın ise Erduran, S olduğu, en fazla yayının 'Research in Scıence Educatıon' dergisinde yer aldığı, anahtar kelimelerden "nature of science", "science education" den sonra en sık "scientific literacy" ve "history of science" kelimelerinin; makalelerin özetlerinde yer alan en sık tekrar eden kelimelerin ise questionnaire ve interview kelimelerinin kullanıldığı ve son olarak ise toplam bağlantı gücü açısından ilk üçte yer alan ve aynı zamanda en fazla atıf alan ülkeler sırasıyla ABD, İngiltere ve Türkiye olarak tespit edilmiştir.

Anahtar kelimeler: Bilimin doğası, fen eğitimi, bibliyometrik analiz, VOSviewer, bilim tarihi ve bilimsel okuryazarlık.

References

Abd-El-Khalick, F., & Lederman, N. G. (2000). Improving science teachers' conceptions of nature of science: A critical review of the literature. *International Journal of Science Education, 22*(7), 665-701. https://doi.org/10.1080/09500690050044044

Adsiz, E., & Yiğit Kutluca, A. (2023). Teachers' views on the teaching of science process skills through integrated science and mathematics activities: Effect of the nature of science understandings. *Educational Academic Research, 48*(1), 27-41. https://doi.org/10.5152/AUJKKEF.2023.1023067

Agrifoglio, R., Metallo, C., & di Nauta, P. (2021). Understanding knowledge management in public organizations through the organizational knowing perspective: a systematic literature review and bibliometric Analysis. *Public Organization Review, 21*, 137–156. https://doi.org/10.1007/s11115-020-00480-7

American Association for the Advancement of Science (AAAS). (1993). Benchmarks for science literacy: A project 2061 report. Oxford University.

Aria, M., & Cuccurullo, C. (2017). Bibliometrix: an R-tool for comprehensive science mapping analysis. *Journal of Informetrics, 11*(4), 959-975. http://dx.doi.org/10.1016/j.joi.2017.08.007

Ayvacı, H. Ş., & Akdemir, E. (2017). An examination of theses in the field of nature of science published from 2013 in terms of different variables. *YYU Journal of Education Faculty, 14*(1), 1178-1218. http://dx.doi.org/10.23891/efdyyu.2017.43

Bell, R. L., & Clair, T. L. S. (2015). Too little, too late: Addressing the nature of science in early childhood education. In K. C. Trundle & M. Saçkes (Eds.). *Research in early childhood science education* (pp. 125–141). Springer. https://doi.org/10.1007/978-94-017-9505-0_6

Bett, N. N., Piccolo, C., Roberson, N. D., Charbonneau, A. J., & Addison, C. J. (2023). Students' views on the nature of science in an interdisciplinary first-year science program: Content analysis of a weekly reflection activity. *Teaching & Learning Inquiry, 11*. https://doi.org/10.20343/teachlearninqu.11.10

Bugingo, J. B., Yadav, L. L., Mugisha, I. S., & Mashood, K. K. (2024). Improving teachers' and students' views on nature of science through active instructional approaches: a review of the literature. *Science & Education, 33*, 29–71. https://doi.org/10.1007/s11191-022-00382-8

Caramaschi, M., Cullinane, A., Levrini, O., & Erduran, S. (2022). Mapping the nature of science in the Italian physics curriculum: From missing links to opportunities for reform. *International Journal of Science Education, 44*(1), 115–135. https://doi.org/10.1080/09500693.2021.2017061

Cheung, K. K. C., & Erduran, S. (2023). A systematic review of research on family resemblance approach to nature of science in science education. *Science & Education, 32*, 1637–1673. https://doi.org/10.1007/s11191-022-00379-3

Comarú, M. W., Lopes, R. M., Braga, L. A. M., Batista Mota, F., & Galvão, C. (2021). A bibliometric and descriptive analysis of inclusive education in science education. *Studies in Science Education, 57*(2), 241-263. https://doi.org/10.1080/03057267.2021.1897930

CoHE. (2018). Fen bilgisi öğretmenliği lisans programı. https://www.yok.gov.tr/Documents/Kurumsal/egitim_ogretim_dairesi/Yeni-Ogretmen-Yetistirme-Lisans-Programlari/Fen_Bilgisi_Ogretmenligi_Lisans_Programi.pdf

Crowther, D. T., Lederman N.G. & Lederman, J. S. (2005). Methods and strategies: understanding the true meaning of nature of science. *Science and Children, 43*(2), 50-52. https://my.nsta.org/resource/7842/methods-and-strategies-understanding-the-true-meaning-of-nature-of-science

Çakıcı, Y. (2009). A prerequisite in science education: Understanding nature of science. *M.Ü. Atatürk Eğitim Fakültesi Eğitim Bilimleri Dergisi, 29,* 57-74. https://dergipark.org.tr/tr/pub/maruaebd/issue/370/2114

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research, 133*, 285–296. https://doi.org/10.1016/j.jbusres.2021.04.070

Effendi, D. N., Irwandani, Anggraini, W., Jatmiko, A., Rahmayanti, H., Ichsan, I. Z., & Rahman, M. M. (2021). Bibliometric analysis of scientific literacy using VOS viewer: Analysis of science education. *Journal of Physics: Conference Series, 1796*, Article 012096. https://doi:10.1088/1742-6596/1796/1/012096

Gören, D. & Kaya, E. (2023). The relationship between students' understanding of nature of science and their metacognitive awareness. *Boğaziçi University Journal of Education. 40-2*(2). 315-336. https://doi.org/10.52597/buje.1123164

Gülmez Güngörmez, H. & Akgün, A. (2020). Student's opinions about nature of science activities embedded in process oriented guided inquiry learning method. *Electronic*

Journal of Education Sciences, 9(18), 128-148. https://dergipark.org.tr/en/pub/ejedus/issue/58123/718234

Hansson, L., & Leden, L. & Thulin, S. (2020). Book talks as an approach to nature of science teaching in early childhood education. *International Journal of Science Education, 42*(12), 2095-2111. https://doi.org/10.1080/09500693.2020.1812011

Hwang, G. J., Lai, C. L., & Wang, S. Y. (2015). Seamless flipped learning: A mobile technology-enhanced flipped classroom with effective learning strategies. *Journal of Computers in Education, 2*, 449-473. https://doi.org/10.1007/s40692-015-0043-0

Jaenudin, I., Aisyiah, P.N., Suryani, R., & Widodod, A. (2021). Content analysis of the nature of science on elementary thematic textbooks 2013 curriculum. *Premiere Educandum: Jurnal Pendidikan Dasar dan Pembelajaran, 11*(2), 227 – 242. https://doi.org/10.25273/pe.v11i2.9187

Jimenez-Aleixandre, M. P., Rodriguez, A. B., & Duschl, R. A. (2000). "Doing the lesson" or "doing science": Argument in high school genetics. *Science Education, 84*(6), 757–792. https://doi.org/10.1002/1098-237X(200011)84:6<757::AID-SCE5>3.0.CO;2-F

Karataş Öztürk, S., Işık, H. & Alpaslan, M. M. (2023). Examination of middle school students' views on the nature of scientific knowledge in the context of learning activities. *The Journal of Buca Faculty of Education, 57,*1555-1580. https://doi.org/10.53444/deubefd.1274069

Kaya, E. & Erduran, S. (2016). Yeniden kavramsallaştırılmış "Aile Benzerliği Yaklaşımı": Fen eğitiminde bilimin doğasına bütünsel bir bakış açısı. *Part B: Türk Fen Eğitimi Dergisi, 13*(2), 77-90.

Khishfe, R., & Abd-El-Khalick, F. (2002). Influence of explicit and reflective versus implicit inquiry-oriented instruction on sixth graders' views of nature of science. *Journal of Research in Science Teaching, 39*(7), 551–578. http://doi.org/10.1002/tea.10036

Kurt, G., & Kaya, E. (2023). Reconceptualized family resemblance to the nature of science in the science curriculum and teachers' views. *The Journal of Buca Faculty of Education, 57,* 1780-1807. https://doi.org/10.53444/deubefd.1289427

Kurtuluş, M. A., & Bilen, K. (2021). A bibliometric analysis on nature of science: a review of the research between 1986-2019. *Scientific Educational Studies, 5*(1), 47-65. https://doi.org/10.31798/ses.941238

Lederman, N. G. (2007). Pedagogy and the practice of science. *International Journal of Science Education, 29*(7), 931-934. https://doi.org/10.1080/14697680601043290

Li, B., & Xu, Z. (2022). A comprehensive bibliometric analysis of financial innovation. *Economic Research-Ekonomska Istraˇzivanja, 35*(1), 367–390. https://doi.org/10.1080/1331677X.2021.1893203

Librea-Carden, M. R., Mulvey, B. K., Borgerding, L. A., Wiley, A. L., & Ferdous, T. (2021). 'Science is accessible for everyone': Preservice special education teachers' nature of science perceptions and instructional practices. *International Journal of Science Education, 43*(6), 949–968. https://doi.org/10.1080/09500693.2021.1893857

Librea-Carden, M.R., & Mulvey, B.K. (2023). The potential of nature of science (NOS) in special education (SPED): Preservice teachers' conceptions, plans, and identified NOS implications for SPED. *Research in Science Education,* 53, 1097–1118. https://doi.org/10.1007/s11165-023-10125-6

Maryanti, R., Nandiyanto, A. B. D., Hufad, A., Sunardi, S. Husaeni, D. N. A., & Husaeni, D. F. A. (2023). A computational bibliometric analysis of science education research using vosviewer. *Journal of Engineering Science and Technology, 18*(1), 301- 309. https://jestec.taylors.edu.my/Vol%2018%20Issue%201%20February%20%202023/18_1_20.pdf

McComas, W. F. (2004). Keys to teaching the nature of science: Focusing on the nature of science in the science classroom. *The Science Teacher, 71*(9), 24-27. https://www.researchgate.net/publication/262450010

NGSS Lead States. (2013). *The next generation science standards*. National Academy Press.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & The Prisma Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *Annals of Internal Medicine, 151*(4), 264–269. https:// doi. org/10. 7326/ 0003- 4819-151-4- 20090 8180- 00135

MoNE. (2018). *Fen bilimleri dersi öğretim programı (ilkokul ve ortaokul 3, 4, 5, 6, 7 ve 8. sınıflar)*.

NRC (National Research Council). (1996). National science education standards. *National Academy of Sciences*. https://doi.org/10.17226/4962

Okan, B., & Kaya, E. (2023). A content analysis of the representation of the nature of science in a Turkish science textbook. In: Carvalho, G.S., Afonso, A.S., Anastácio, Z. (eds) *Fostering scientific Citizenship in an Uncertain World. Contributions from Science Education Research*, 13. Springer. https://doi.org/10.1007/978-3-031-32225-9_5

Ozan, F., & Uluçınar Sağır, Ş. (2020). The effect of stem activities to the secondary school students opinions on the nature of science. *Journal of STEAM Education, 3* (2), 32-43. https://dergipark.org.tr/en/download/article-file/1188146#764293]-1188146.pdf

Öztürk, E., & Kaptan, F. (2014 A view on "ESERA 2009" science education researches conferance and its content studies about nature of science, argumentation, history, philosophy and sociology of science. *Kastamonu Education Journal, 22*(2), 649-672. https://dergipark.org.tr/tr/pub/kefdergi/issue/22602/241502

Pradana, M., Elisa, H. P., & Syarifuddin, S. (2023). The growing trend of Islamic fashion: A bibliometric analysis. *Cogent Social Sciences, 9*(1), 2184557. https://doi.org/10.1080/23311886.2023.2184557

Prahani, B. K.**,** Rizki, I. A., Suprapto, N., Irwanto, I., & Kurtulus, M. A. (2024). Mapping research on scientific creativity: A bibliometric review of the literature in the last 20 years. *Thinking Skills and Creativity, 52*, 101-495. https://doi.org/10.1016/j.tsc.2024.101495

Pranckute, R. (2021). Web of Science (WoS) and scopus: The titans of bibliographic information in today's academic world. *Publications,* 9, 12. https://doi.org/10.3390/publications9010012

Sarkar, A., Wang, H., Rahman, A., Memon, W. H., & Qian, L. (2022). A bibliometric analysis of sustainable agriculture: based on the Web of Science (WOS) platform. *Environmental Science and Pollution Research, 29,* 38928–38949. https://doi.org/10.1007/s11356-022-19632-x

Solehuddin, M., Muktiarni, M., Rahayu, N. I., & Maryanti, R. (2022). Counseling guidance in science education: Definition, literature review, and bibliometric analysis. *Journal of Engineering Science and Technology, (Special Issue on ISCoE2022),* 1- 13. https://jestec.taylors.edu.my/Special%20Issue%20ISCoE%202022_1/ISCoE%201_01.pdf

Sönmez, H., & Hastürk, G. H. (2020). Bibliographic analysis of doctoral level thesis studies in science education domain in Turkey. *Journal of Human Science Researches , 9*(5), 3174-3194. https://dergipark.org.tr/tr/download/article-file/1099718

Stadermann, H. K. E., & Goedhart, M. J. (2020). Secondary school students' views of nature of science in quantum physics. *International Journal of Science Education, 42*(6), 997–1016. https://doi.org/10.1080/09500693.2020.1745926

Suryani, R., Widodo, A., & Sujana A. (2022). Content analysis of the nature of science in the thematic learning book for lower grade elementary school 2013 curriculum. *Proceeding The 4th International Conference on Elementary Education, 4*(1), 596-608.

Takriti, R. A., Erduran, S., Tairab, H., Kaya, E., Alhosani, N., Rabbani, L., & Alamirah, I. (2024). Translation and validation of a questionnaire for measuring teachers' views on nature of science. *Research in Science &Technological Education, 42*(3), 812–827. https://doi.org/10.1080/02635143.2022.2138846

Taşkın, T. (2021). An examination on nature of science studies in terms of different variables. *Bolu Abant İzzet Baysal University Journal of Faculty of Education, 21*(1), 1-20. https://dx.doi.org/10.17240/aibuefd.2021.21.60703-794024

Tosun, C. (2024). Analysis of the last 40 years of science education research via bibliometric methods. *Science & Education, 33*, 451–480. https://doi.org/10.1007/s11191-022-00400-9

Wahbeh, N., & Abd-El-Khalick, F. (2014). Revisiting the translation of nature of science understandings into instructional practice: Teachers' nature of science pedagogical content knowledge. *International Journal of Science Education*, *36*(3), 425–466. https://doi.org/10.1080/09500693.2013.786852

Widowati, A., Widodo, E., Anjarsari, P., & Setuju (2017). The development of scientific literacy through nature of science (NoS) within inquiry based learning approach. *Journal of Physics: Conference Series*, *909*, Article 012067. https://doi.org/10.1088/1742-6596/909/1/012067

Van Eck, N. J., & Waltman, L. (2022). VOSviewer manual (version 1.6.18. CWTS Meaningful Metrics. https://www.vosviewer.com/documentation/Manual_VOSviewer_1.6.8.pdf

Voss, S., Kent-Schneider, I., Kruse, J., & Daemicke, R. (2023). Investigating the development of preservice science teachers' nature of science instructional views across rings of the family resemblance approach wheel. *Science & Education 32*,1363–1399 https://doi.org/10.1007/s11191-023-00418-7

Yacoubian, H. A. (2021). Students' views of nature of science. *Science & Education, 30*, 381–408. https://doi.org/10.1007/s11191-020-00179-7

Yanuarti, E.A., & Suprapto, N. (2021). Ten years of research on history of science (physics): A bibliometric analysis. *Studies in Philosophy of Science and Education, 2*(1), 7-16. https://doi.org/10.46627/sipose.v2i1.66