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Fen Eğitiminde Bilimsel Süreç Becerileri Üzerine Yapılan Çalışmaların Bibliyometrik Ve İçerik Analizi Yoluyla İncelenmesi

Examination of Studies on Scientific Process Skills in Science Education Through Bibliometric and Content Analysis

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ÖZ

Bu çalışma, Web of Science (WoS) veritabanından titizlikle çıkarılan verileri kullanarak, fen eğitimi alanındaki bilimsel süreç becerileri (BSB) ile ilgili akademik araştırmaların kapsamlı bir analizini sunmaktadır. Araştırmada, literatürdeki genel eğilimleri ve tematik yapıları ortaya çıkarmak için bibliyometrik analiz ve içerik analizini entegre ederek bütünsel bir yaklaşım kullanılmıştır. BSB konusunda yazarlar arası işbirlikleri, anahtar kelime eğilimleri ve en çok atıf alan çalışmaları incelemek için bibliyometrik analizden yararlanılmıştır. İçerik analizi ile en çok atıf alan makalelerin ele alınıp BSB'nin fen eğitimindeki durumunun detaylandırılması çalışmamıza özgün bir katkı sağlamıştır. Ayrıca, önceki çalışmalardan farklı olarak daha geniş bir veri seti ve daha uzun bir zaman dilimi kullanılmış, bu da BSB üzerine yapılan araştırmaların zaman içindeki değişimine dair daha kapsamlı bir çerçeve ortaya koymuştur. Analiz, 1992'deki ilk, ilgili çalışmadan Ağustos 2024'e kadar yayınlanan tüm çalışmaları kapsamaktadır. Bulgular, yayınlarda önemli bir artış olduğunu göstermektedir ve 2020, en yüksek yayın sayısına ulaşılan yıldır. Beş yıllık dönemler oluşturularak yürütülen incelemede ortalama yayın sayısı yılda sekiz yayın ile sınırlır. Yayınların çoğu "Eğitim, Eğitim Araştırması" konu başlığı altında sınıflandırılırken, "Biyoloji" alanında yayın sayısı daha azdır. Bu, BSB'nin öncelikle eğitim bağlamında incelendiğini göstermektedir. Dahası, çalışma SSCI ve ESCI endekslerindeki yayınların daha yaygın olduğunu, SCI-E endeksinde ise daha az sayıda çalışma bulunduğunu ortaya koymuştur. Bu alandaki en önde gelen araştırmacılar arasında Kamisah Osman, Hatice Zeynep İnan, Susan A. Kirch yer almaktadır. Özellikle, Türkiye'nin ülke dağılımında üst sıralarda yer aldığı görülmüştür ve bu durum araştırmacıların fen eğitiminde BSB'ye yoğun olarak odaklandığını göstermektedir. İncelenen çalışmalarda en sık görülen anahtar kelimeler "BSB", "fen eğitimi", "sorgulama" ve "değerlendirme"dir. Zamanla, "sorgulamaya dayalı öğrenme", "öğretmen eğitimi" ve "ilköğretim eğitimi" terimleri giderek daha yaygın hale gelmiştir. Ayrıca, bu alanda yayınlanan en önemli dergiler Journal of Research in Science Teaching ve International Journal of Science Education'dır. Yukarıda belirtilen ilerlemeye rağmen, çalışma Türk araştırmacıların görünürlüklerini artırmaları ve uluslararası standartlara ulaşmak için ulusal dergileri geliştirmeleri gerektiğini göstermektedir.

Anahtar Kelimeler: Bilimsel süreç becerileri, bibliyometrik analiz, fen eğitimi, içerik analizi.

ABSTRACT

This study presents a comprehensive analysis of academic research on scientific process skills (SPS) in science education using meticulously extracted data from the Web of Science (WoS) database. A holistic approach was employed in the research, integrating bibliometric analysis and content analysis to reveal general trends and thematic structures in the literature. Specifically, bibliometric analysis was employed to examine the most frequently cited studies on inter-author collaborations and keyword trends on SPS. Content analysis provides a unique contribution to our study by detailing the analysis of these publications.

A distinguishing feature of this study is the use of a more extensive data set and a more extended period than previous studies, providing a more comprehensive picture of the evolution of research on SPS over time. The VosViwer bibliometric analysis software employs an array of analytical methods, including citation analysis, co-author analysis, keyword matching, and collaboration network analysis, to identify trends within the field. The analysis encompasses studies published from the inaugural study in 1992 through August 2024. The findings reveal a substantial increase in publications, with 2020 demonstrating the highest number of publications. In contrast, the average number of publications during the preceding five-year period was restricted to eight per year. Most of these publications are classified under "Education, Educational Research," with a smaller number falling under "Biology." This observation suggests that the primary focus of SPS research is within the educational context. Furthermore, the study revealed that publications in the SSCI and ESCI indexes are more prevalent, while there are fewer studies in the SCI-E index. The prominent researchers in this field include Kamisah Osman, Hatice Zeynep Inan, and Susan A. Kirch. A notable observation was Turkey's high ranking in terms of country distribution. This observation indicates that researchers have dedicated significant attention to the SPS in the context of science education. The most prevalent keywords in the analyzed studies were "SPS," "science education," "inquiry," and "assessment." Over time, there has been an upward trend in the use of terms such as "inquiry-based learning," "teacher education," and "elementary education." The most prominent academic journals in this field include the Journal of Research in Science Teaching and the International Journal of Science Education. Notwithstanding the strides made, the study underscores Turkish researchers' need to enhance their visibility and cultivate national journals to attain international standards.

Keywords: Science education, scientific process skills, bibliometric analysis, content analysis.

INTRODUCTION

The 21st century is a period of unparalleled advancement in information and technology. In this context, the capacity of individuals to achieve scientific and technological literacy is becoming increasingly crucial for maintaining social and economic well-being. In light of this, science education emerges as a pivotal domain of educational inquiry, enabling learners to access scientific knowledge and comprehend and apply it meaningfully (Bybee, 2010). As a fundamental element of the educational curriculum, science education equips students with the cognitive tools essential for comprehending the natural world and the diverse phenomena that occur within it. At the primary education level, the overarching objective of science education is to foster in students the abilities for scientific reasoning, problem-solving, and well-informed decision-making while concurrently cultivating an enhanced awareness of environmental challenges and sustainability (Shouse et al., 2007).

In this educational process, students' acquisition of scientific process skills (SPS) represents a crucial element of science education, as these skills are indispensable for their engagement with scientific knowledge. Developing the capacity to process scientific information and critically evaluate the results obtained from such inquiry represents a central outcome of fostering SPS (Lederman & Lederman, 2012). Therefore, science education's fundamental purpose is to equip students with the cognitive tools required for scientific thinking and to ensure they can apply them effectively in diverse contexts (National Research Council [NRC], 2012). It is, therefore, imperative to emphasize the development of SPS, as this encompasses a wide range of fundamental scientific methodologies, including the ability to make observations, formulate hypotheses, design experiments, collect and analyze data, and derive evidence-based conclusions. Mastering these skills provides the foundation for how individuals approach, question, and interpret scientific knowledge, thereby establishing a robust foundation for lifelong learning and inquiry into scientific phenomena (Demirci-Güler, 2017; Lederman et al., 2014; Padilla et al., 1983).

A substantial corpus of academic research underscores the pivotal role of SPS in science education. The cultivation of these skills not only deepens students' understanding of scientific principles but encourages active and critical engagement in the learning process (Hofstein &

Rosenfeld, 1996). Cultivating SPS encourages students to acquire and apply scientific knowledge in practical contexts, thereby enabling them to devise solutions to real-world problems (Banchi & Bell, 2008). This is particularly significant at the primary school level, where developing these skills ignites students' innate scientific curiosity and fosters a persistent drive to explore, which helps maintain their sustained interest in science over time (Fensham, 2009).

Furthermore, the methods by which SPS are taught and evaluated are equally crucial in shaping science education beyond acquiring these skills. In this regard, research focused on instructional strategies and methodologies for enhancing SPS plays a pivotal role in determining the efficacy of educational practices (Linn & Eylon, 2011). In particular, approaches such as inquiry-based learning and experimental pedagogy have been repeatedly identified as highly effective in fostering the growth of students' SPS (Bybee et al., 2006). Such methods prompt students to engage directly with scientific inquiry, enabling them to actively construct knowledge and apply scientific reasoning in meaningful and practical ways.

1.1. Scientific process skills

The term "SPS" encompasses a set of abilities that include the capacity to obtain knowledge, resolve issues, and assess outcomes by applying scientific methods and techniques. These skills facilitate the development of scientific thinking and encourage a critical approach to scientific knowledge (NRC, 1996). The SPS are typically classified into principal categories (Ayas et al., 2012; Demirci-Güler, 2017).

1.1.1. Basic scientific process skills

Observation. The act of closely examining the occurrences within one's immediate environment through the senses to acquire information from these observations.

Measurement. The process of evaluating occurrences quantitatively or qualitatively according to established standards to collect data. The measurement process determines physical properties like length, volume, and mass.

Classification. The process of grouping and organizing objects or events according to specific characteristics. This permits the organization of data systematically and coherently.

Data recording. The process of recording information obtained from research or experiments clearly and understandably and organizing it for sharing with others.

Establishing a Number Space Relationship. It is the capacity to express the outcomes of the application in numerical form and present them as three-dimensional visualizations.

1.1.2. Causal scientific process skills

Prediction and anticipation: The capacity to articulate hypotheses regarding potential scenarios, informed by prior knowledge and observations.

Determination of variables: The process of identifying the factors that influence the outcomes of experiments. This is crucial for making precise comparisons between experimental and control groups.

Data interpretation: Representing observations and measurements as meaningful outputs based on the results obtained.

Concluding: It is the skill expressed as the process of reaching a judgment by generalizing the results in line with the comments based on the observations obtained from the experiment.

1.1.3. Experimental scientific process skills

Hypothesis formulation: Creating testable explanations or assumptions based on observations and available information.

Using data and modeling: The ability to create visuals to represent how unseen situations occur with the help of data obtained in experiments or research.

Changing and controlling variables: It is the correct execution of the processes of controlling and keeping constant by recognizing all the variables that will affect the result of the experiment.

Designing and conducting experiments: Creating systematic and controlled experiments to test hypotheses. This includes determining the independent and dependent variables and establishing the control group.

Decision making: This is the process of selecting the most accurate and appropriate solution to the problem situation due to research and experimentation.

1.1.4. Making operational definition skills

In contrast to the aforementioned classification, this skill is included in the 12-category classification system proposed by Barman (1992). While other skills resemble the aforementioned categories, this particular skill is highlighted due to its distinct nature. The formulation of operational definitions is undertaken to facilitate communication concerning the phenomena under investigation. In formulating these definitions, it is imperative to include the minimum amount of information necessary to differentiate the defined phenomenon from similar ones. Operational definitions can be derived from observable characteristics of phenomena and the operations to be performed. Operational definitions are characterized by precision and, in some cases, are based on mathematical relationships.

1.2. The significance of scientific process skills in science education

In science education, SPS facilitates students' engagement in active learning processes, enabling them to learn science hands-on. Such abilities permit students to critically evaluate scientific information and apply this understanding to their own experiences (Osborne et al., 2003). Moreover, developing SPS facilitates the growth of students' scientific thinking abilities and enhances their problem-solving capabilities (Julien & Barker, 2009). Such abilities facilitate the acquisition of comprehensive knowledge regarding scientific subjects and the subsequent application of this understanding to everyday contexts (Hofstein & Rosenfeld, 1996).

Furthermore, developing SPS has fostered students' curiosity and willingness to explore. The acquisition of these skills has been demonstrated to increase students' interest and motivation in scientific subjects and positively affect their attitudes towards scientific knowledge (Fensham, 2009). Developing these skills facilitates establishing a more robust connection to scientific knowledge, which fosters long-term scientific interest and achievement (Bybee et al., 2006). The advancement and evaluation of SPS are essential for enhancing the caliber of science instruction (Tan & Temiz, 2003).

1.3. Literature review

A literature review reveals numerous studies have demonstrated a positive correlation between developing SPS and enhancing students' creative abilities. This allows them to adopt scientific thinking processes (Özdemir & Dikici, 2017; Setiani et al., 2020). The capacity of students to engage in scientific thinking also enhances their creative thinking abilities. The capacity of students to generate novel ideas by adopting a multifaceted approach to events is further enhanced by the development of SPS. These studies aim to ascertain how creativity develops with acquiring SPS. Furthermore, some studies emphasize the importance of effectively utilizing SPS in acquiring and advancing scientific literacy (Colvill & Pattie, 2002; Handayani et al., 2018).

Scientific literacy is a requisite competency for individuals to comprehend, evaluate, and utilize scientific knowledge. Cultivating SPS enhances students' scientific literacy, facilitating their capacity to access and assimilate scientific knowledge. Such abilities facilitate not only the acquisition of knowledge but also its critical evaluation. SPS must be effectively taught in schools, as this will enable individuals to make decisions based on scientific knowledge. Conversely, some studies have demonstrated that SPS's active and effective utilization within the classroom environment can positively influence students' attitudes (Bilgin, 2006; Juhji & Nuangchalerm, 2020). These studies demonstrate that pedagogical approaches grounded in SPS positively impact students' interest in the subject matter and their attitudes toward scientific learning. Cultivating students' attitudes towards the course motivates them to learn more effectively and develop more efficient learning processes. Moreover, a substantial body of research indicates that developing SPS enhances students' capacity for reasoning, analytical thinking, and critical thinking (Markawi, 2013; Settlage & Southerland, 2007).

The SPS students facilitate a more profound examination of the causal relationships between events and problems, enhancing their capacity for sound reasoning. The capacity for critical thinking enables individuals to reflect on and evaluate existing knowledge, propose alternative solutions, and address problems in innovative ways (Darmaji et al., 2020; Tanti et al., 2020). Moreover, it has been demonstrated that various pedagogical approaches and techniques employed in the classroom effectively promote the growth of students' SPS (Mulyeni et al., 2019; Setiawan et al., 2021). Implementing diverse pedagogical strategies in the classroom has been demonstrated to facilitate students' more efficacious learning of these skills. For example, implementing problem-solving, inquiry-based, or experimental methodologies has been demonstrated to be more efficacious in teaching SPS. Educators' implementation of these methodologies in their pedagogical practices will prove beneficial in fostering the growth of students' scientific abilities.

Moreover, incorporating SPS into the instructional process and examining educators' understanding of these skills represent a prominent area of research (Gultepe, 2016; Turkmen & Kandemir, 2018). Teachers' proficiency in these skills affects their capacity to facilitate classroom learning and transfer these skills to their students. Increasing teacher knowledge regarding SPS and integration into classroom practices will facilitate student development.

In conclusion, Irwanto et al. (2019) posit that developing SPS enhances students' capacity to comprehend and integrate scientific knowledge while fostering critical thinking, decision-making, and problem-solving abilities. The acquisition of these skills enables students not only to learn scientific knowledge but also to gain the ability to apply that knowledge in real-world contexts. Applying critical thinking and problem-solving skills allows individuals to identify solutions to the challenges they encounter from a scientific perspective.

A literature review has demonstrated that SPS is a significant component of science education in developed and developing countries. A meta-analysis revealed that student-centered practices positively impact the improvement of SPS compared to teacher-centered approaches (Kol & Yaman, 2022). Furthermore, a notable correlation exists between SPS and science achievement, with an average effect size of 0.56 (Dolapcıoglu & Subası, 2022). However, research on SPS is more prevalent in developed countries, and there is an uneven coverage of SPS in science curricula globally (Mushani, 2021). Significant cognitive skills in science education include specific SPS (e.g., inference, measurement, identifying variables), critical thinking skills (e.g., interpreting and evaluating data), and reasoning skills (Hasanah & Shimizu, 2020). In their study, Yıldırım et al. (2016) systematically evaluated the literature on SPS in Turkey between

2000 and 2015. The inquiry-based learning approach was critical in advancing SPS (Yıldırım et al., 2016). Idris et al. (2022) examined 22 articles from the WoS and Scopus databases in their literature analysis. The authors identified seven subject-based subthemes within the domain of SPS. These are the seven subject-based sub-themes in SPS: The seven subject-based sub-themes in SPS are as follows: practical and mental application, inquiry-based approach, learning through discovery, strategic, manipulative skills, discussion skills, use of ınformation and communication Technologies, implementation of engineering-oriented science, technology, engineering, and mathematics (STEM) integration activities. A literature review reveals that SPS is significant in science education (Tan & Temiz, 2003). A substantial number of review studies have been conducted in this area, including those by Dolapcıoglu & Subası (2022), Hasanah & Shimizu (2020), İdris et al. (2022), Kol & Yaman (2022), and Yıldırım et al. (2016). These studies employ a range of methodologies, with meta-analysis and meta-synthesis being particularly prevalent. In the studies included in the literature review, various indices were examined. While the WoS database was similarly examined in the study conducted by Idris et al. (2022), in this study, 20 articles were examined through meta-analysis, and studies on SPS were classified according to the subjects. In conclusion, the studies in the literature differ from our study in terms of time, method, variables examined, and research questions, and our study will contribute to the existing literature. These findings underscore the significance of SPS in science education and the necessity of its balanced integration into curricula and teacher training programs.

The extant literature demonstrates that the effective teaching and assessment of SPS is associated with increased student achievement and motivation in science (Linn & Eylon, 2004). Literature reviews and bibliometric analyses on SPS in science education are crucial for elucidating the current knowledge and research trends in this field. Bibliometric analysis can assist in identifying research trends and knowledge gaps by examining publications, authors, and key terms within a specific field (Ellegaard & Wallin, 2015). Such analyses of SPS in science education can facilitate a more comprehensive understanding of teaching strategies and methods while offering future research directions. In recent years, there has been a notable surge in the number of studies examining SPS in science education. This increase is associated with the mounting evidence of the beneficial impact of SPS on students' academic performance and scientific thinking abilities (Bybee, 2010). This study diverges from previous reviews, meta-analyses, and meta-synthesis studies on SPS in two significant ways. First, it employs a holistic approach by integrating bibliometric and content analysis to reveal general trends and thematic structures in the literature. Second, it utilizes bibliometric analysis to examine the most cited studies on SPS, inter-author collaborations, keyword trends, and research methodologies. Content analysis uniquely contributes to our study by detailing the main themes addressed by these publications and how SPS is addressed in science education. In addition, unlike previous studies, a more extensive data set and a more extended period were used, which provides a more comprehensive picture of the changes in research on SPS over time. As a result, the study will significantly contribute to the literature regarding both method and scope. In this context, it is essential to examine the studies on SPS in science education literature to gain insight into the developments in this field and to identify trends that will inform future research. A bibliometric analysis method may be employed to conduct such a review. This study examines the literature on SPS in science education from a bibliometric perspective. In alignment with this objective, the present study seeks to quantitatively evaluate the research in this field to identify key trends and gaps. Such a study will constitute a significant step forward in understanding the developments in science education research on SPS. Moreover, the findings will furnish invaluable insight to inform future research endeavors and facilitate the advancement of pedagogical approaches. The following research questions were posed in the study conducted for this purpose:

1. What are the publication trends of studies on SPS in science education over time?
2. What is the distribution of studies on SPS according to the Web of Science categories?

3. What are the trends in the indexes where studies on SPS in science education are published?

4. What is the geographical distribution of studies on SPS in science education?

5. What is the distribution of studies on SPS in science education according to the institutions responsible for their publication?

6. What are the most frequently utilized keywords and terms in abstracts of studies on SPS in science education?

7. Which researchers have been most frequently cited in studies on SPS in science education?

8. What is the distribution of citations and co-citations in the journals where studies on SPS in science education are published?

9. What are the trends in the ten most cited articles on SPS in science education?

METHOD

Bibliometric analysis is used to quantitatively assess and analyze literature within a specific research area (Aria & Cuccurullo, 2017). This method identifies trends, research gaps, and scientific influences within a given area by analyzing bibliographic data, including articles published over a specified period, authors, citations, and keywords (Arıcı, 2024). A bibliometric analysis allows for investigating the evolution of research on SPS in science education over time. It enables the identification of research topics that have gained prominence and the examination of the research methods that are most frequently employed (Zupic & Čater, 2015). Accordingly, a bibliometric analysis was undertaken in the present study. The VOSviewer program was employed for analysis. VOSviewer is a software frequently utilized in bibliometric analyses to visualize the relationships between scientific publications (Van Eck & Waltman, 2010). The program utilizes various analytical methods, including citation analysis, co-author analysis, keyword matching, and collaboration network analysis, to identify trends within the field. The analysis process is based on citation links between articles, co-use of specific keywords, and collaborations between authors (Donthu et al., 2021). The present study selected VOSviewer due to its advanced visualization capabilities, its effectiveness in mapping scientific networks, and its capacity for rapid large-scale bibliometric analysis (Van Eck & Waltman, 2014). The selection of VOSviewer as a suitable tool for identifying research trends, analyzing influential authors, key topics, and scientific collaborations was particularly relevant in the field of SPS.

2.1. Article selection process

In order to gain insight into the current state of research on SPS in science education, an advanced search was conducted using the WoS database. In order to conduct an advanced search, the following terms were entered: TS=("science education" or "science teaching" or "science learning"). Furthermore, the following search terms were entered into the WoS search shortcut: TS=("science process skills" or "Skills in the scientific process" or "Science Process Knowledge"). After this search, 137 studies were identified (last accessed on 08/09/2024). No temporal, indexing, or other constraints were imposed to facilitate access to more detailed data within the study. The research encompasses all studies on SPS in science education published in the WoS database between 1992 and 2024.

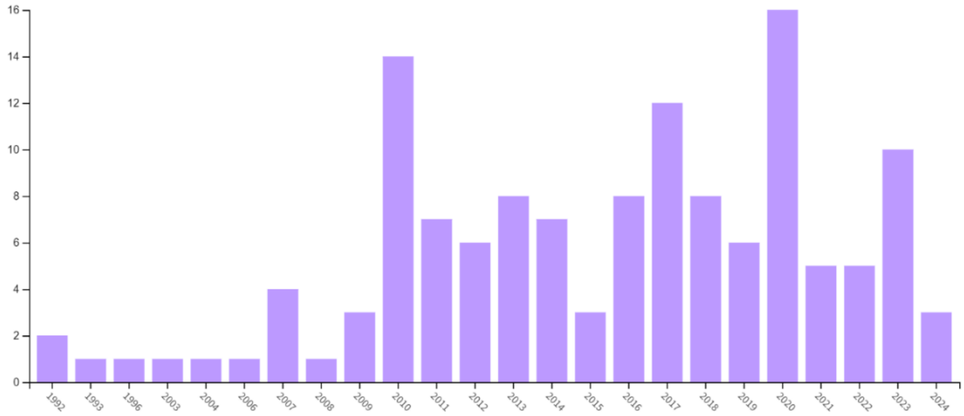
FINDINGS

3.1. Frequency of publication of studies on scientific process skills over the years

In the context of the research, the findings of the studies on the WoS were examined to ascertain the publication patterns related to SPS in science education over time. It was determined that these studies were first published in 1992. After that, the number of publications increased, with the most significant occurring in 2020 (f=16). It was observed that there were continuous fluctuations in the number of publications, with an average of eight publications in the last five years. The situation is illustrated in the graph presented in Figure 1 below.

Figure 1

Frequency of publication of studies on SPS over the years

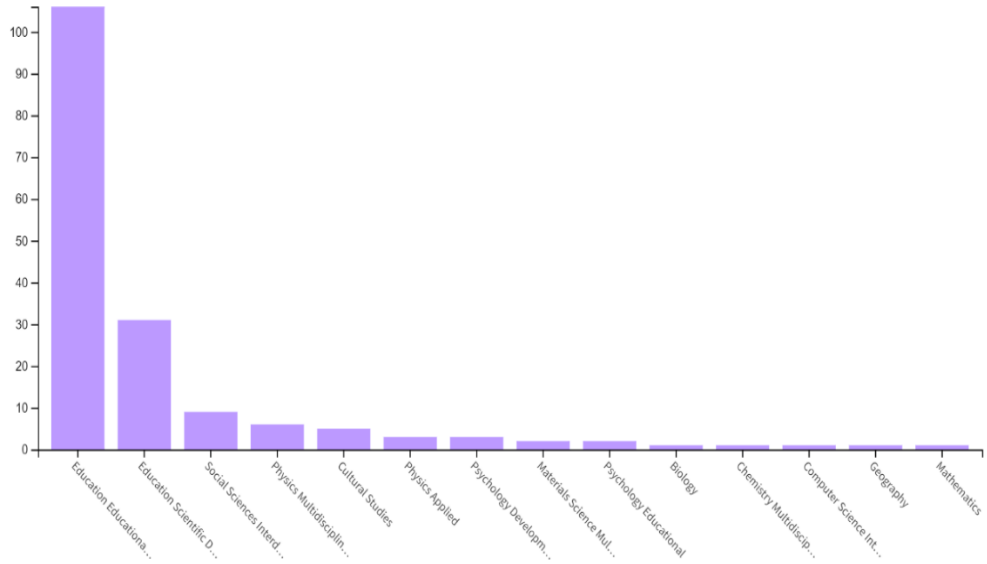


3.2. Distribution of studies on scientific process skills according to their classification by categories

Within the framework of this research, a comprehensive analysis was conducted on the studies indexed in the WoS database to examine the distribution of publications related to SPS within science education. These studies were categorized according to their respective WoS classifications. The analysis revealed that the highest concentration of studies fell within the categories of Education, Educational Research (f=106), followed by Education, Scientific Disciplines (f=31), Social Sciences, Interdisciplinary (f=9), and Physics, Multidisciplinary (f=6). On the other hand, the category with the most miniature representation was Biology, with only a single study identified (f=1). This suggests a notable disparity in research focus across different scientific disciplines, indicating areas for further research. The graphical representation of this categorical distribution is provided below in Figure 2, which offers a visual summary of the data.

Figure 2

Classification of studies on SPS according to categories



A comprehensive analysis was conducted to ascertain the frequency and percentage values of the categories of SPS. A tabular representation was devised to illustrate the frequency and percentage values of the categories, and the resulting table is presented in Table 1 below.

Table 1

Frequency and percentage values of the categories

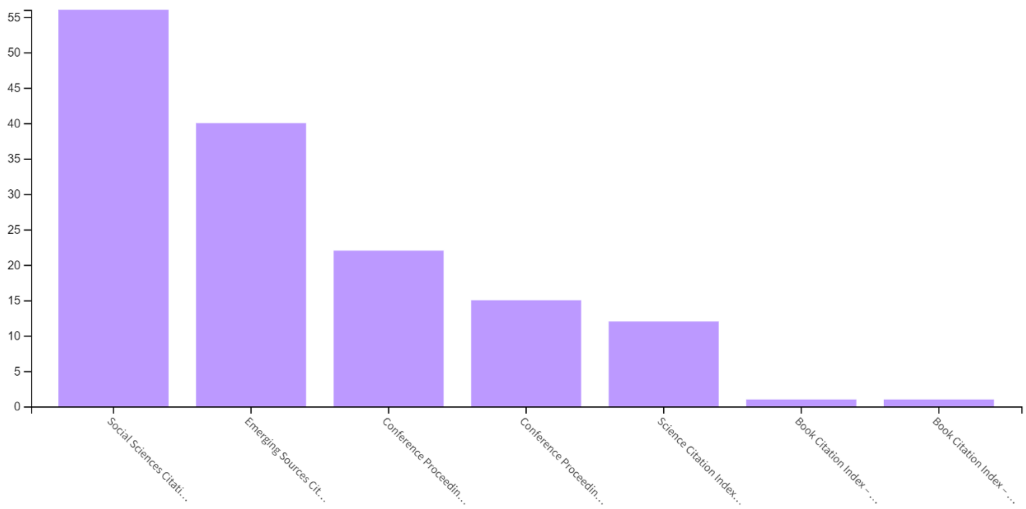
Categories	***f***	***%***
Education Educational Research	106	77.37
Education Scientific Disciplines	31	22.62
Social sciences Interdisciplinary	9	6.56
Physics Multidisciplinary	6	4.38
Cultural Studies	5	3.65
Physics Applied	3	2.19
Psychology Developmental	3	2.19
Materials Science Multidisciplinary	2	1.46
Psychology Educational	2	1.46
Biology	1	0.73
Chemistry Multidisciplinary	1	0.73
Computer Science Interdisciplinary Applications	1	0.73
Geography	1	0.73
Mathematics	1	0.73

3.3. Distribution of studies on scientific process skills in science education according to indices

In the context of this research, the results of studies indexed in WoS were analyzed to ascertain the distribution of publications about SPS in science education, classified according to WoS indexes. The results indicate that the Social Sciences Citation Index (SSCI) (f=56), the Emerging Sources Citation Index (ESCI) (f=40), and the Conference Proceedings Citation Index-Social Science & Humanities (CPCI-SSH) (f=22) are the most frequently cited. The Conference Proceedings Citation Index-Science (CPCI-S) (f=15), the Science Citation Index Expanded (SCI-EXPANDED) (f=12), the Book Citation Index-Science (BKCI-S) (f=1), and the Book Citation Index-Science (BKCI-S) (f=1) were also included in the analysis. Figure 3 below provides a summary of the situation.

Figure 3

Distribution of studies on SPS according to the specified indices



3.4. Distribution of studies on scientific process skills in science education according to countries

As part of this research, the studies indexed in the WoS database were analyzed to determine the geographical distribution of publications focusing on SPS within science education. The findings revealed that certain countries contribute more significantly to the body of research in this area. Specifically, Turkey emerged as the leading country in terms of publication frequency, with 46 studies, followed by the United States of America with 30 studies, Indonesia with 22, Malaysia with 9, and Spain with 6. These results suggest a concentrated interest in developing SPS in certain regions, particularly within Turkey and the USA, while other countries have comparatively fewer publications on this subject. Figure 4, presented below, visually represents this distribution, offering further insights into the geographical trends observed in the research landscape.

Figure 4

Distribution of studies on SPS in science education by country

3.5. Distribution of studies on science process skills in science education according to institutions

In order to gain a deeper understanding of the institutional contributions to publications related to SPS in science education, an analysis was conducted of the studies indexed in the WoS database. This analysis aimed to identify which academic institutions have been the most active in producing research on this topic. The results revealed that Hacettepe University (f=8) ranked as the leading institution in terms of publication output, followed by Universiti Kebangsaan Malaysia (f=5), Gazi University (f=4), and the State University System of Florida (f=4). These findings highlight the significant role played by institutions from Turkey and Malaysia and contributions from institutions in the United States. The data, which provide a clearer view of institutional research efforts in this domain, are visually represented in Figure 5 below.

Figure 5

Distribution of studies on SPS in science education by institutions

3.6. The most frequently used words in the abstracts of studies on scientific process skills in science education

The bibliographic data from the WoS database were imported into the analysis software to generate a visual map based on text data, specifically focusing on the most frequently occurring terms within the abstract sections of the articles. For this analysis, the abstract section was chosen as the primary field of study, and a binary counting method was employed to track the frequency of terms. The threshold for the minimum number of occurrences of a term was set at 15, resulting in a total of 2,830 terms being grouped into 35 distinct clusters. Of these, 21 terms were identified as meeting the criteria for display on the final map, illustrated in Figure 6.

The analysis revealed that the most frequently occurring term in the abstracts was "process skill," with a total frequency of 123. In addition to this, several other terms appeared frequently across the articles, including "science" (f=62), "test" (f=46), "science education" (f=40), "learning" (f=39), and "development" (f=36). These terms reflect critical focus areas within the research literature on SPS. Moreover, an examination of the temporal distribution of these terms across the years of publication indicates an increasing emphasis on concepts related to science inquiry, the effectiveness of science education, and science learning in recent years. The temporal trends in the frequency of the most commonly used terms within the abstracts are depicted in Figure 7, offering further insights into the evolving research focus in this area.

Figure 6

The most frequently occurring words in the abstract sections of the studies

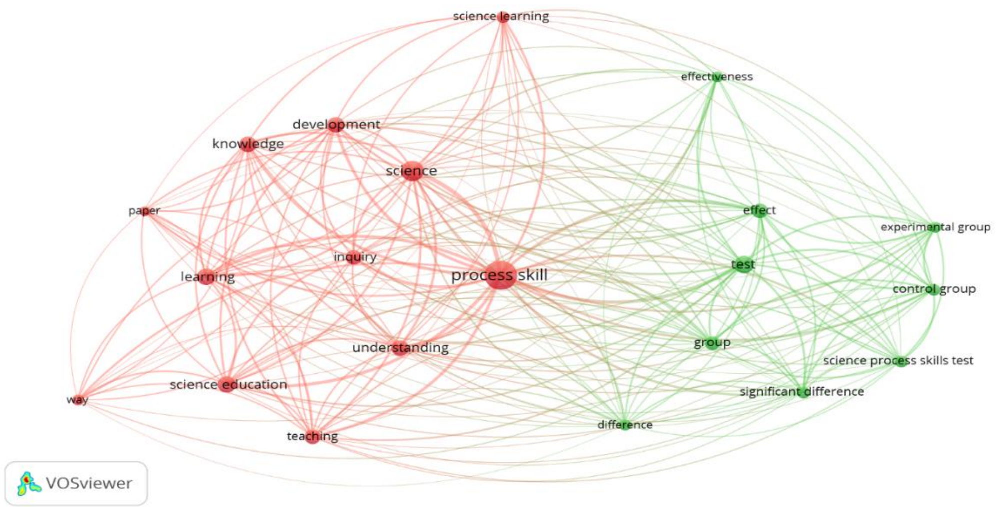
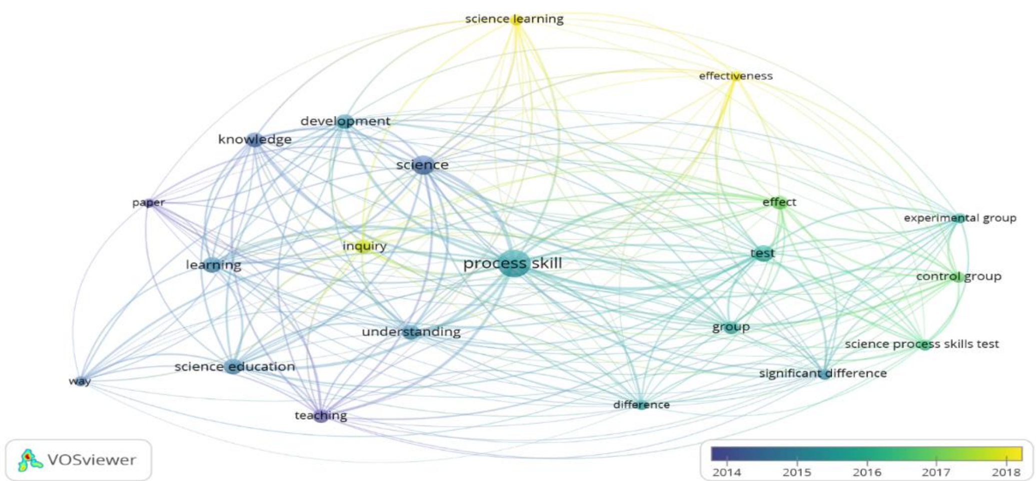


Figure 7

Distribution of the most commonly used words in the abstract sections of articles according to years



A combination of co-occurrence analysis and author keywords was applied to generate a text-based map highlighting the most frequently used keywords. The threshold for the minimum number of keyword occurrences was set to three, and the software automatically selected 15 keywords for inclusion in the analysis. The resulting map is presented in Figure 8. The analysis revealed that 338 keywords were organized into seven distinct clusters, indicating significant thematic groupings within the research literature. Among these, the most frequently used keyword was identified as "SPS" (f=62). Other prominent keywords in the analyzed articles included "science education" (f=36), "evaluation" (f=5), "conceptual understanding" (f=4), and "inquiry" (f=4).

The findings also emphasize critical educational concepts such as inquiry, primary school education, teacher education, evaluation, and preschool learning. Notably, teacher education, inquiry, and evaluation topics were predominantly examined within primary education. In contrast, the evaluation and science education variables were more emphasized in preschool education discussions. These results suggest evolving trends in the literature, with specific concepts gaining prominence in recent years. The temporal distribution of the number of articles by year is provided in Figure 9, offering further insight into how research interest in these areas has fluctuated over time.

Figure 8

The most commonly used keywords in research on SPS in science education

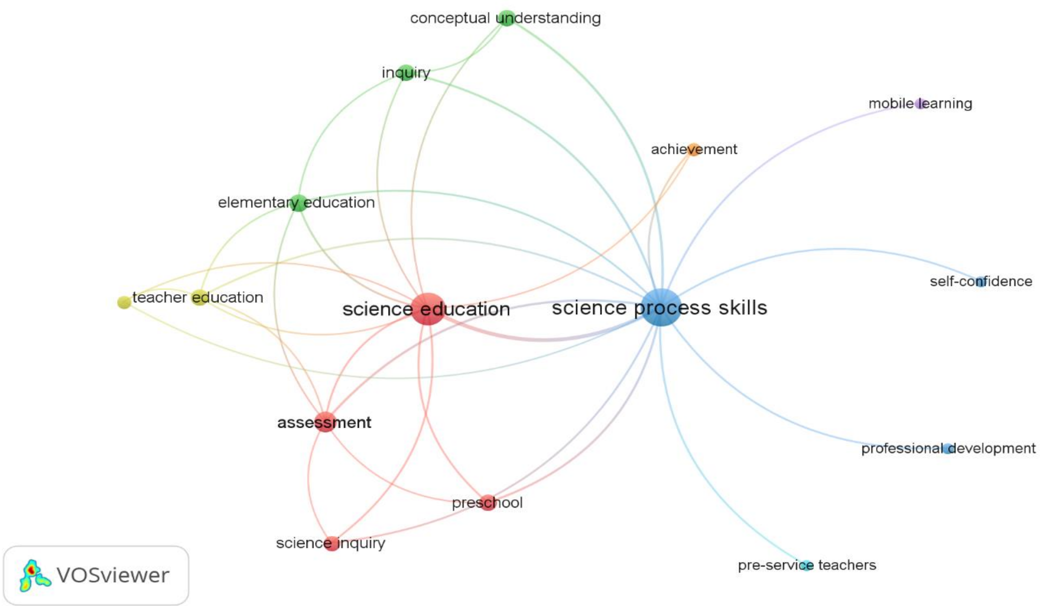
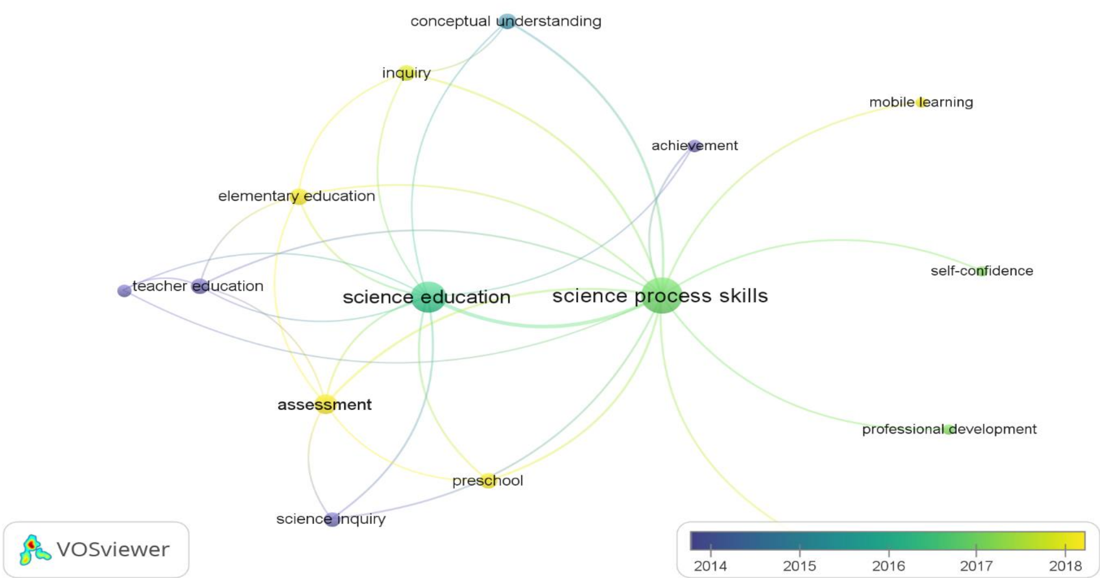


Figure 9

Distribution of keywords used in research on SPS in science education by years



3.7. The most prominent authors in scientific process skills in science education

A map was generated utilizing citation analysis and authorship selection techniques to identify the most frequently cited authors in the field of SPS within science education. The criteria for inclusion in the analysis were set such that authors needed to have at least two documents and two citations each. The analysis automatically determined that 28 authors met these criteria for selection. The resulting map in Figure 10 visually represents the most frequently cited scholars in this domain. Among the most prominent authors identified are Kamısah Osman, with a total of 131 citations; Hatice Zeynep İnan, who has garnered 83 citations; Susan A. Kirch, with 41 citations; and V. M. Chabalengula, who has received 39 citations. These results highlight the leading figures in the research on SPS, reflecting their significant influence and contribution to the academic discourse in this field.

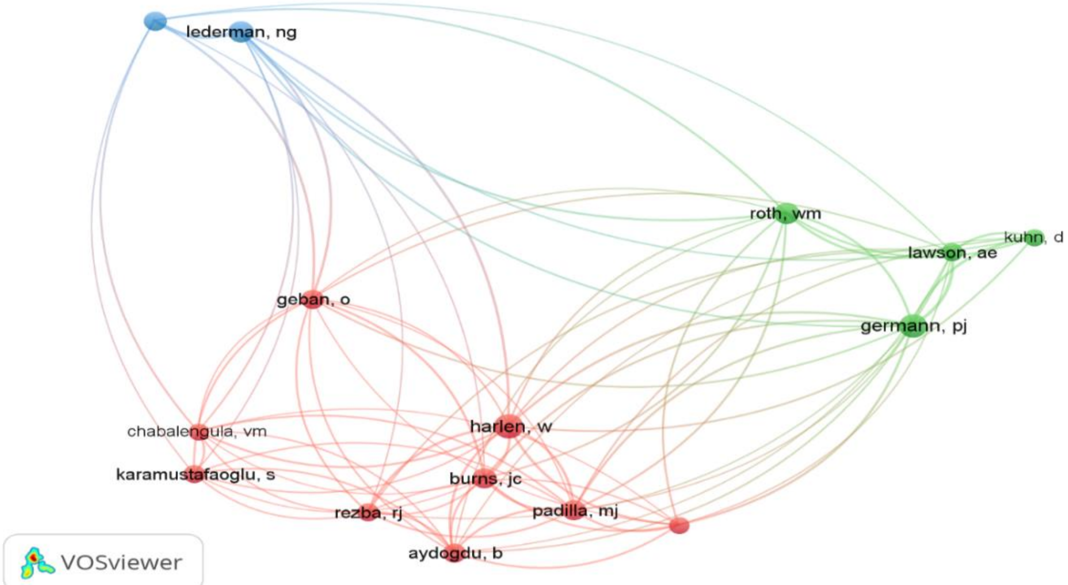
Figure 10

The authors who have been most frequently cited in the literature on this topic

In order to conduct a comprehensive co-citation analysis and identify the most frequently cited authors in the research on SPS within science education, a set of terms was selected for use in the analysis program. The criteria for inclusion required that an author have a minimum of 10 citations. Based on this criterion, the analysis automatically selected 16 authors for evaluation. The resulting map, illustrated in Figure 11, highlights the prominent figures in this field based on citation frequency. Among the most frequently cited authors are Harlen W., with 29 citations; P.J. German, who has accumulated 25 citations; WM Roth, with 20 citations; and NG Laderman, who has received 18 citations. These findings underscore the significant contributions of these scholars to the literature on SPS in science education.

Figure 11

The majority of the most frequently cited authors in this field



3.8. Journals with high impact value that include studies on scientific process skills in science education

This analysis aimed to generate a map through citation analysis and source identification to determine the most frequently cited journals in research related to SPS within science education. In order to be included in the study, journals were required to have a minimum of three documents and five citations. Based on these criteria, the analysis automatically selected ten journals for evaluation. The resulting map, presented in Figure 12, visually represents this field's most frequently cited journals. The journals identified are: *Journal of Research in Science Teaching* (284 citations, 4 documents), *Energy Education Science and Technology Part-B: Social and Educational Studies* (137 citations, 4 documents), *International Journal of Science Education* (99 citations, 6 documents), *Eurasia Journal of Mathematics, Science, and Technology Education* (44 citations, 3 documents) and *Research in Science & Technological Education* (43 citations, 3 documents). These journals represent critical sources of influential research in SPS, reflecting their substantial impact on the academic literature.

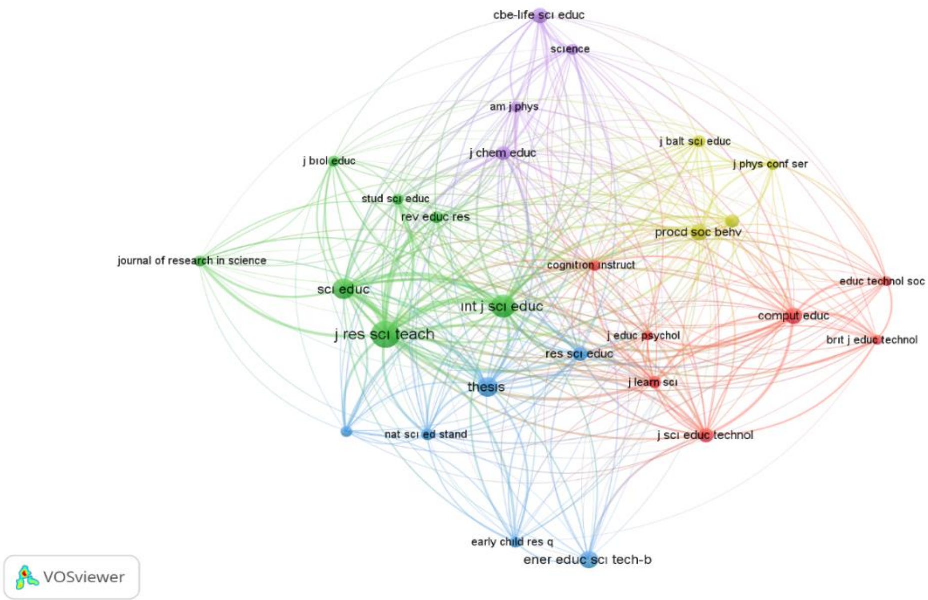
Figure 12

The journals that have been most frequently cited in the literature (citation analysis)

In order to identify the most prominent journals that publish research on SPS within the field of science education, a co-citation analysis was conducted utilizing the analysis program, with a particular focus on cited sources. For the analysis to be robust, the minimum citation threshold for a source was set at 20, and the program automatically selected 28 sources based on this criterion. The resulting map, shown in Figure 13, illustrates the journals with the most citations. The journals identified as having the most significant impact in this field are *The Journal of Research in Science Teaching*, with 250 co-citations*; the International Journal of Science Education*, with 154 co-citations; *Science Education Journal*, with 116 co-citations; and *Thesis*, with 114 co-citations. These findings highlight the prominent journals frequently cited in the literature on SPS, underscoring their influential role in shaping research and discourse in this area.

Figure 13

The journals with the highest number of citations (co-citation analysis)



3.9. Trends of the ten most cited articles on science process skills in science education

A comprehensive content analysis of the relevant studies was performed to analyze the ten most frequently cited articles. The analysis encompassed a range of dimensions, including the country of publication, the target demographic group, the methodological approach, the data analysis techniques employed, the data collection tools utilized, and the results obtained. This systematic review aimed to offer a more nuanced perspective on the prevailing trends in SPS-related studies in science education. The findings from this review are described in Table 2.

Table 2

Trends in the Ten Most Cited Articles on SPS in science education

ID	Title	Journal	Year	Country	Field	Method	Sample Populations	Sample Sizes	Data collection tools	Data analysis methods	Results	Citations
1	The Development Of Science Process Skills In Authentic Contexts	Journal Of Research In Science Teaching	1993	Canada	Physic	Qualitative	Grade 8-11-12	60	Video recordings, student lab reports, and reflective journals	Content Analysis	They found that science process skills do not need to be taught separately but develop simultaneously.	177
2	Science learning pathways for young children	Early Childhood Research Quarterly	2004	USA	Preschool Science	Qualitative	Teachers	-	Observations	Content Analysis	They have developed an educational approach that supports constructivist learning.	168
3	Design and Reflection Help Students Develop Scientific Abilities: Learning in Introductory Physics Laboratories	Journal Of The Learning Sciences	2010	USA	Algebra-based Physics	Quasi-experimental	Undergraduate	186	Lawson's test of scientific reasoning, lab report, Observations, open-ended questions	two-way ANOVA Content analysis	They stated that the Investigative Science Learning Environment, which includes the design itself, reflection, and self-assessment, enriches students' learning opportunities.	148
4	The effects of GIS on students' attitudes, self-efficacy, and achievement in middle school science classrooms	Journal Of Geography	2003	USA	Earth science	Quasi-experimental	8-grade middle school	164	Surveys, Performance Assessments	T-tests, Descriptive Statistics	Attitude, self-efficacy in science as technology, and student achievement in science process skills were measured. The study found significant improvement in attitudes toward technology, self-efficacy toward science, and modest yet significant improvements in geographic	80

											data analysis for students who used GIS.	
5	The Effect of Guided-Inquiry Instruction on 6th Grade Turkish Students' Achievement, Science Process Skills, and Attitudes Toward Science	International Journal Of Science Education	2014	Turkey	Elementary Grade 6 Science	Quasi-experimental	6th grade students in middle school	304	Achievement Test Science Process Skills Test Attitudes Toward Science Questionnaire	Repeated analysis of variance (ANOVA)	Guided inquiry provided more effective learning than traditional methods, supported the development of SPS, and promoted cognitive and affective development in students.	63
6	Teaching science process skills in kindergarten	Energy Education Science and Technology Part B- Social and Educational Studies	2011	Turkey	Science	Qualitative	Teachers	30	interviews	Content analysis	Teachers believed they taught science process skills and helped children develop them. However, the teachers' definitions, examples, and answers to further questions suggested that they had not truly internalized the meaning of the science process skills.	60
7	A Curriculum Strategy That Expands Time For In-Depth Elementary Science Instruction By Using Science-Based Reading Strategies - Effects Of A Year-Long Study In Grade 4	Journal of Research In Science Teaching	1992	USA	Elementary Science	Quasi-experimental	4th grade	128	Basic Skills Tests Metropolitan Achievement Test	multivariate covariance analysis	An integrative curriculum strategy emphasizing science process skills and hands-on activities significantly improved the achievement of the experimental group students.	58
8	Student performances in the science processes of	Journal of Research In	1996	USA	Seventh-grade science '	Qualitative	Seventh-grade	364	research rubric	Percent, ratio	The results highlighted critical areas for improvement in student understanding and performance of scientific	48

	recording data, analyzing data, drawing conclusions, and providing evidence	Science Teaching									inquiry processes, suggesting a need for targeted instructional strategies	
9	Simple production experiment of poly (3-hydroxy butyrate) for science laboratories and its importance for science process skills of prospective teachers	Energy Education Science and Technology Part B-Social and Educational Studies	2010	Turkey	Chemistry	Qualitative	Undergraduate	6	laboratory reports	Content analysis	In the study, it was determined that the SPS of preservice teachers improved during the experiment process.	43
10	The Influence of Science Summer Camp on African-American High School Students' Career Choices	School Science And Mathematics	2011	USA	Science	Quasi-experimental	grades 9-12.	313	Questionnaire	ANOVA	The science camp to promote scientific process skills showed positive changes in students' attitudes toward science.	38

As indicated by the data presented in Table 2, the USA is the leading publisher of articles in the top 10 most cited articles. The frequency of publication of qualitative and quantitative articles is comparable. Questionnaires and tests are predominant in quantitative articles, while ANOVA is the most commonly employed data analysis method. Qualitative studies predominantly utilize the observational technique, and content analysis is widely employed. It is noteworthy that the two most frequently cited articles are also qualitative. Furthermore, while studies were predominantly conducted in primary and secondary schools, the sample size ranged from 6 to 364. The publication years of the studies ranged from 1992 to 2011, with the most cited article published in 1993. The findings of these studies indicate that SPS occupies a significant role in science education, is more frequently assessed in inquiry-based activities and laboratory studies, and that the development of each skill does not necessitate discrete examination. The analysis further suggests that the appropriate method and technique are conducive to developing these skills.

CONCLUSION, DISCUSSION ANDS RECOMMENDATION

This study builds on the initial investigation of SPS in science education, published in the WoS database. It employs bibliometric mapping analysis to examine the subsequent studies conducted in this field. The study's findings indicated that the initial WoS publication was in 1992, the greatest number of publications were produced in 2020, and the mean number of publications over the previous five years was 8. It was observed that publications about SPS in science education were predominantly within the "Education, Educational Research" category and least within the "Biology" category within the WoS categories. This indicates that SPS is predominantly addressed in educational studies, with a relatively limited examination in the natural sciences. The analysis of the indexes included in WoS revealed a notable increase in the frequency of publications in the SSCI and ESCI indexes. In contrast, the SCI-E index showed a decline in publications and a corresponding reduction in the number of books or book chapters written. These findings indicate that researchers tend to favor journals in the social sciences, with relatively few publications in the natural sciences. A principal outcome of examining the distribution by countries in the WoS database is the notable ranking of Turkey in the first place. This result demonstrates that SPS and science education are critical in our country. This phenomenon may be further substantiated by the educational policies implemented in Turkey, particularly the recent curriculum updates and the emphasis on a skills-based approach in science education (Ministry of National Education [MoNE], 2024). Indeed, the observed increase in science scores in the latest PISA and TIMMS results compared to previous years, although not yet at the desired level, supports this result (İdil et al., 2024). The fact that Hacettepe University ranked first and Gazi University ranked third in the distribution of publications related to SPS according to institutions lends support to the assertion that Turkey is the leading country in terms of the number of publications and demonstrates that these universities are Turkey's leading institutions in science education. These findings are corroborated by the fact that they consistently perform well in the Times Higher Education (THE) rankings in Turkey (Damar et al., 2020; Korucuk, 2024; Urapcenter, 2020). The research yielded further insights, indicating that the most frequently utilized keywords are "assessment," "conceptual understanding," and "inquiry." The results demonstrating the distribution of studies by year indicate that inquiry, primary school, teacher education, evaluation, and preschool learning have recently gained considerable traction. In primary school, most discourse focused on teacher education, inquiry, and assessment. Conversely, in preschool, the emphasis was placed on assessment and science education variables. The results demonstrated that the evolution of these competencies was assessed in studies about the development of SPS in science education. Furthermore, the results demonstrated a correlation between inquiry and conceptual understanding in science education, underscoring the significance of prioritizing these elements. Indeed, an inquiry-based learning environment has positively affected conceptual understanding, facilitating effective science teaching (Cengiz &

Arıcı, 2024). The most frequently occurring terms in the abstracts of the articles are "process skills," "science," "science education," "learning," and "development." A review of the studies according to publication year reveals a growing focus on inquiry, effectiveness, and science learning in more recent articles. In this regard, it can be stated that inquiry-based learning is a prevalent approach in science education (Idris et al., 2022), and this method has been demonstrated to be effective in facilitating effective science teaching in primary school and preschool settings (Dikici et al., 2020; Gunsen et al., 2018; Kefi & Yildiz, 2024; Yildiz & Yildiz, 2021). Furthermore, an analysis of the network in the graphs revealed a shift in the focus of research on learning in experimental studies after 2014, with no such concentration observed prior to this period. This finding suggests that experimental studies have increasingly prioritized the development of SPS and the factors influencing its advancement rather than concentrating on science teaching. This observation is corroborated by the content analysis results of the most cited studies (Koksal & Berberoglu, 2014). Another outcome of the research pertains to the foremost researchers investigating SPS in the context of science education. The researchers in question are Kamısah Osman, Hatice Zeynep İnan, Susan A. Kirch, V. M. Chabalengula, Harlen W., P.J. German, W.M. Roth, and N.G. Lederman. While it is encouraging to see researchers from Turkey among the researchers' ranks, striving for an even greater representation is crucial. Indeed, the ability of a university to be regarded as a leading institution within the global context is contingent upon its capacity to attract and retain a highly skilled and dedicated workforce (Wang et al., 2012; Froumin, 2012). The quality of the faculty employed represents a critical factor for these universities in achieving their stated objectives (Damar et al., 2020). Therefore, it is important to provide researchers with the support they require to enhance the quality and visibility of their work. Further analysis of the number of citations in recent times reveals that Muammer Çalık, Sibel Er NaS, and Tulay Senel Coruhlu have emerged as the preeminent researchers in this field since 2010. An examination of the network relations between authors indicates that Muammer Ç Balık has been the most cited researcher by various authors. This finding suggests that the recent quality studies conducted by the researcher have been adopted by other authors, thereby contributing to the dissemination and advancement of knowledge in the field. In conclusion, the most prominent journals publishing studies on SPS in science education are as follows: The following journals are considered the most relevant for publishing studies on SPS in science education. Such journals may be regarded as shaping the field of science education. A cursory review of the most frequently cited journals reveals the absence of Turkish journals, except the Journal of Hacettepe University Faculty of Education. Despite its absence from the graphs depicting the number of citations, this journal is anticipated to emerge as a leading publication in Turkey within this discipline in the forthcoming years. This assertion is substantiated by its incorporation into the comprehensive analysis and the observed augmentation in the number of citations and publications. In this context, in addition to increasing the visibility of the research output of our scholars, it is possible to enhance the quality of our national journals and transform them into an international publication outlet (Damar et al., 2020). The analysis results of the most cited articles indicate that, while the most cited study is from Canada, the USA is the leading publisher of the most cited articles. Turkey has three studies included in the analysis. The analysis revealed that half of the ten studies were quantitative, while the remaining half were qualitative. Notably, there was an absence of studies that employed a mixed methods approach among the top ten cited studies. In quantitative articles, questionnaires and tests are prevalent, while ANOVA is the most frequently employed data analysis method. In qualitative studies, observation techniques are predominantly employed, and content analysis is commonly used, though the design is not specified. It is noteworthy that the two most frequently cited articles are also qualitative. Furthermore, the studies were predominantly conducted in primary and secondary schools, with small samples in qualitative studies, while the number of samples varied in quantitative studies. The most frequently cited article was published in 1993. The findings of these studies indicated that BSB plays a significant role in science education, is examined more frequently in inquiry-based activities and laboratory settings, and that the development of each skill is not distinct but rather occurs concurrently.

In alignment with the research, the study is subject to certain limitations, which can be enumerated as follows: The bibliometric analysis was conducted using the WoS database exclusively. Nevertheless, including other databases, such as Scopus and ERIC, could have provided a more comprehensive analysis. Studies in other databases may have been overlooked due to this limitation. The study evaluated data exclusively on publications accessible until 9 August 2024. New studies published after this date or still need to be indexed may not reflect the current trends in SPS. The leading journals in which studies on SPS in science education were published were examined, although it is possible that not all relevant journals were included. This was determined by the number of search terms related to the topic included in the analyses. The number of repetitions of terms with different frequencies may impact the results. The study may have omitted other significant or high-impact journals, which could be considered a limitation in scope. The lack of inclusion of Turkish journals in the analysis may have reflected the visibility of Turkish researchers in science education, SPS, and national publishing activities from a limited perspective. The selected indexes may have contributed to this limitation despite numerous reputable journals in Turkey. The research output of a cohort of distinguished scholars was subjected to a systematic examination over a defined period, with the analysis conducted by pre-established criteria. Nevertheless, a more comprehensive qualitative analysis was not undertaken, and other lesser-known researchers who have made significant contributions to this field may have been inadvertently omitted. These limitations may restrict the scope of the study, and the overall findings may require corroboration through a more comprehensive review of the literature.

In light of the findings yielded from our bibliometric mapping analysis of studies on SPS in science education, we propose the following recommendations: The study's findings indicate that most studies on SPS are focused on educational research. Nevertheless, integrating SPS with other scientific disciplines, such as biology, can enhance the depth of knowledge in this area. Furthermore, observing a paucity of publications in the SCI-E index indicates a need to encourage interdisciplinary studies in this field. While the majority of studies were published in peer-reviewed journals, it was observed that SPS were examined less frequently in theses and conference proceedings. Further attention to such studies would facilitate a more comprehensive understanding of SPS in science education, thereby advancing the field of education. It was established that Turkey has made a notable contribution to science education through the development of SPS, mainly through the efforts of Hacettepe and Gazi Universities. This finding indicates a need for increased investment in policies and research funding for science education in Turkey. It is recommended that integrating SPS into teacher education be expanded within the scope of educational policies. The study of SPS was associated with several keywords, including conceptual understanding, inquiry, and evaluation. In future studies, researchers may consider identifying keywords more strategically to increase the visibility of their research and build on these themes. The findings indicated a notable increase in elementary and preschool science education studies in recent years.

Consequently, further research into developing SPS at an early age will facilitate the establishment of children's scientific thinking abilities. Significant research on SPS is being published in journals with high-impact factors. Therefore, researchers should be encouraged to publish their studies in such journals. Furthermore, conducting a more detailed analysis of the articles published in these journals and integrating the findings into educational policy is crucial. International collaboration in the field of science education research may facilitate the undertaking of comparative studies of the SPS taught in different countries. This will contribute to enhancing science education on a global scale and effectively integrating SPS.

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GENİŞLETİLMİŞ ÖZET

Giriş

21. yüzyılda bilgi ve teknolojinin hızla gelişmesi, bireylerin bilimsel ve teknolojik okuryazarlığının toplumsal ve ekonomik refah açısından kritik bir öneme sahip olduğunu göstermektedir. Bu bağlamda, fen eğitimi, bireylerin bilimsel bilgiye erişimlerini, bu bilgiyi anlama ve uygulama becerilerini geliştiren temel bir eğitim alanı olarak öne çıkmaktadır. Özellikle ilkokul düzeyindeki fen eğitimi, öğrencilere bilimsel düşünme, problem çözme ve karar verme yeteneklerini kazandırarak çevrelerine duyarlılık geliştirmeyi hedefler. Öğrencilerin bilimsel süreç becerilerini (BSB) edinmeleri, fen eğitiminde önemli bir yere sahiptir; bu beceriler, öğrencilerin bilimsel bilgiye ulaşma, bu bilgiyi işleme ve sonuçları değerlendirme yetilerini geliştirmelerine olanak tanır.

Fen eğitiminin temel amacı, öğrencilere sadece bilimsel bilgi kazandırmakla kalmayıp, aynı zamanda onları bilimsel düşünme süreçleri ile tanıştırmak ve bu süreçleri etkili bir şekilde kullanmalarını sağlamaktır. BSB, gözlem yapma, hipotez oluşturma, deney tasarlama, veri toplama ve analiz etme gibi temel bilimsel yöntemleri içerir. Bu beceriler, öğrencilerin bilimsel bilgilere nasıl eriştiklerini, bu bilgileri nasıl sorguladıklarını ve anlamlandırdıklarını belirler. Araştırmalar, BSB'nin öğrencilerin aktif katılımını ve eleştirel düşünme yeteneklerini artırarak, bilimsel bilginin derinlemesine anlaşılmasını sağladığını göstermektedir.

BSB'nin geliştirilmesi, öğrencilerin yalnızca bilimsel bilgi edinmelerinin yanı sıra, bu bilgiyi uygulayarak problemlerine çözüm bulmalarını da teşvik eder. Özellikle ilkokul düzeyinde bu becerilerin kazandırılması, öğrencilerin bilimsel meraklarını ve keşfetme isteklerini artırarak, bilime olan ilgilerini uzun vadede sürdürebilmelerine yardımcı olur. Bu nedenle, fen eğitiminde bu becerilerin nasıl öğretildiği ve değerlendirildiği büyük bir öneme sahiptir. Sorgulamaya dayalı öğrenme ve deneysel öğrenme gibi yöntemler, bu becerilerin geliştirilmesinde etkili araçlar olarak kabul edilmektedir ve öğrencilerin aktif katılımlarını destekler.

Sonuç olarak, BSB, öğrencilerin bilimsel düşünme becerilerini geliştirmelerine ve bilimsel bilgiye eleştirel bir bakış açısıyla yaklaşmalarına olanak tanır. Bu becerilerin kazandırılması, öğrencilerin bilimsel konulara olan ilgilerini ve motivasyonlarını artırarak, bilimsel bilgiye olan tutumlarını olumlu yönde etkiler. Ayrıca, eleştirel düşünme ve problem çözme becerilerini geliştirmeleri, bilimsel bilgiye daha güçlü bir bağ kurmalarını sağlar. Literatürde, bilimsel süreç becerilerinin öğrencilerin yaratıcı düşünme kapasitelerini artırdığı ve bilimsel okuryazarlığın kazanılmasında önemli bir rol oynadığına dair birçok çalışma bulunmaktadır.

Bu bağlamda, fen eğitiminde BSB'nin etkin bir şekilde öğretilmesi ve değerlendirilmesi, öğrencilerin bilimsel başarılarını ve motivasyonlarını artırmada önemli bir yer tutmaktadır. Bibliyometrik analizler, bu alandaki mevcut bilgi birikimini ve araştırma eğilimlerini ortaya koyarak, gelecekteki çalışmalar için yönlendirmeler sunmaktadır. Bu makalenin amacı, fen eğitiminde BSB ile ilgili literatürü bibliyometrik bir bakış açısıyla incelemek ve araştırma boşluklarını belirlemektir. Bu süreç, fen eğitiminde daha etkili yöntemlerin geliştirilmesine ve uygulamaya konulmasına katkıda bulunmayı hedeflemektedir.

Yöntem

Bibliyometrik analiz, belirli bir araştırma alanındaki literatürü niceliksel olarak değerlendirmek için kullanılan bir yöntemdir. Bu yöntem, yayınlanmış makaleler, yazarlar, atıflar ve anahtar kelimeler gibi bibliyografik verileri analiz ederek, araştırma alanındaki eğilimleri, boşlukları ve bilimsel etkileri ortaya koyar. Fen eğitiminde BSB ile ilgili yapılan çalışmaların gelişimini, ilgi gören konuları ve yaygın araştırma yöntemlerini belirlemek amacıyla bibliyometrik bir analiz gerçekleştirilmiştir. Bu süreçte VOSviewer programı kullanılmıştır. Ayrıca en çok atıf alan makalelerde eğilimleri belirlemek için yöntem, veri toplama araçları, veri analizi yöntemleri, örneklem büyüklüğü ve sonuçlarla ilgili inceleme için içerik analizi kullanımıştır. İçerik analizi ile bibliyometrik sonuçların detaylı analizi yapılarak çalışmanın derinliği artırılmıştır.

Araştırmanın kapsamı için Web of Science veritabanında fen eğitiminde BSB ile ilgili yayınlar incelenmiştir. Gelişmiş arama yapılarak, "science education," "science teaching," "science learning," "science process skills," "Skills in the scientific process" ve "Science Process Knowledge" anahtar kelimeleri kullanılmıştır. Bu arama sonucunda toplamda 137 çalışma elde edilmiştir (son erişim tarihi: 09.08.2024). Araştırma, 1992 yılından 2024 yılına kadar yayınlanmış olan tüm çalışmaları kapsamaktadır ve zaman, endeks veya diğer sınırlamalar uygulanmamıştır.

Sonuç ve Öneriler

Bu çalışma, fen eğitiminde BSB'ni inceleyen önceki araştırmalara dayanarak bibliyometrik ve içerik analizi ile gerçekleştirilmiştir. 1992 yılından itibaren en fazla yayının 2020'de yapıldığı, son beş yılda ortalama 8 yayının üretildiği belirlenmiştir. Yayınlar, çoğunlukla "Eğitim" kategorisinde yer almakta, "Biyoloji" kategorisinde ise daha az sayıda bulunmaktadır. Türkiye, WoS veritabanında BSB ile ilgili en fazla yayına sahip ülke olarak öne çıkmaktadır; Hacettepe Üniversitesi ve Gazi Üniversitesi bu alanda en çok yayına sahip kurumlar olarak sıralanmaktadır.

Araştırmada, "değerlendirme," "kavramsal anlayış" ve "soruşturma" gibi anahtar kelimelerin sık kullanıldığı gözlemlenmiştir. Ayrıca, ilkokul ve okul öncesi eğitimde son yıllarda soruşturma ve değerlendirme gibi konuların ön plana çıktığı görülmüştür. Araştırma sonuçları, soruşturma temelli öğrenme ortamlarının kavramsal anlayışı olumlu etkilediğini göstermektedir.

Araştırmanın sınırlamaları arasında yalnızca WoS veritabanının kullanılması, diğer veritabanlarının dahil edilmemesi ve Türk dergilerinin göz ardı edilmesi yer almaktadır. Bu durum, Türk araştırmacılarının görünürlüğünü sınırlayabilir.

Öneriler arasında, BSB'nin diğer bilim alanlarıyla entegre edilmesi, öğretmen eğitiminde BSB'nin kapsamının genişletilmesi ve anahtar kelimelerin daha stratejik belirlenmesi yer almaktadır. Ayrıca, Türkiye'deki fen eğitimi için daha fazla araştırma fonu ve politika yatırımı önerilmektedir. Uluslararası iş birliği ile karşılaştırmalı çalışmalar yaparak, küresel ölçekte fen eğitiminin geliştirilmesine katkı sağlanması hedeflenmektedir.