



Science Process Skills in Education: Bibliometric Analysis and Review

*Anis Elliyani, Suryanti, Zainul Arifin Imam Supardi, Binar Kurnia Praharani, Hitta Alfi Muhimmah

Department of Master in Basic Education, Faculty of Education, Universitas Negeri Surabaya
Jl. Babatan UNESA, Surabaya 60213, Indonesia

*Corresponding Author e-mail: anis.22015@mhs.unesa.ac.id

Received: December 2023; Revised: March 2024; Published: April 2024

Abstract

This research aims to view and review published research on Science Process Skills (SPS) in 2020–2023 using VOSViewer. Article data from Google Scholar database journals collected using Publish or Perish. In 2020–2021 the number of articles published experienced a significant increase, but starting from 2022–2023 it experienced a drastic decline. Topics such as science process skills, students, development, effects, models, analysis, and learning have often been discussed by researchers. In contrast to keywords such as correlation, STEM, self efficacy, case, comparison, improvement, argumentation, and POGIL, these are research topics that are rarely researched and too broad to be studied in more depth. The results of the review of the top 10 articles cited tend to examine strategies for mastering science process skills which include experimentation, minds-on, inquiry approaches, discovery learning, strategic manipulation, debate skills, ICT, STEM, student-centered teaching, use of a variety of learning tools, hands-on exercises, group activities, PhET, mobile scientific investigations, guided inquiry, PBL, PjBL, learning cycles, use of learning media, modules and worksheets. The novelty of this research is a bibliometric analysis and review of the latest research in the field of SPS. The implication of this research is contributes and support Kurikulum Merdeka's science learning outcomes. Future researchers can use these insights to improve science education, helps focus on their studies, and pinpoint SPS research trends.

Keywords: Science Process Skills; Bibliometric Analysis; Vosviewer; Publish or Perish

How to Cite: Elliyani, A., Suryanti, S., Supardi, Z., Prahani, B., & Muhimmah, H. (2024). Science Process Skills in Education: Bibliometric Analysis and Review. *Prisma Sains : Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram*, 12(2), 328-337. doi:<https://doi.org/10.33394/j-ps.v12i2.10294>



<https://doi.org/10.33394/j-ps.v12i2.10294>

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INTRODUCTION

Current and future science process skills must be taught in an interesting way (Mirana, 2019) because through science process skills, students can study real-life problems, take responsibility for their learning while growing, find solutions, communicate with classmates, and actively participate in learning (Pay & Taş, 2022) assessed through observation, performance and written questions (Kurniawati, 2021). Mushani's research (2021) illustrates that there is an uneven integration of SPS in curriculum and their implementation in all levels of science education in both developed and developing countries. There are only a few studies on 21st century science process skills so that educational institutions must evaluate teacher preparation, curricular integration, and implementation of knowledge about Skills 21st century promoted by science process skills (Mushani, 2021). Olowu's (2023) research explains that in improving science process skills, teachers can create science practicum activities, problem solving, inquiry, PjBL, and other direct scientific training are examples (Olowu, 2023).

Research conducted by several researchers found that STEM (Dilek et al., 2020; Apaivatin et al., 2021), laboratory activities (Kalemkus et al., 2021; Ratamun & Osman, 2018), usage video (Solé-Llussà et al., 2021), argumentation (Işiker & Emre, 2021; Kalemkus et al., 2021), student-centered science learning techniques (Özge & Yaman, 2022), model-based science learning (Demirçali & Selvi, 2022), process-based observation and investigation

(Güder et al., 2022), gamification and game-based activities (Macayan et al., 2022), online modules that utilize ICT, internet and social media (Ahmad & Iksan, 2021), problem solving learning (Audu, 2022), and HANDLE project (Bibon, 2022) could enhance students' process skills.

The background of this research is that foundational science education experiences play a large role in determining the long-term course of science for many people, and that successful science education is critical to creating a science-literate student population. However, the low level of science process skills due to the lack of these skills has limited the scope of basic science education (Deehan et al., 2024), students are not used to carrying out experimental or practical activities so that students lack science process skills (Raharjo & Puspita, 2024), and science process skills that were utilized previously, but in their application they do not acquire the greatest outcomes, so that science process skills in pupils do not improve (Tangahu et al., 2024). The implication of this research is contributes and support Kurikulum Merdeka's science learning outcomes. Future researchers can use these insights to improve science education, helps focus on their studies, and pinpoint SPS research trends by determining the most important topics.

In comparison with previous researchers such as Anjugam and Chellamani (2024) and Idris et al. (2022), who conduct a systematic literature review. Anjugam and Chellamani (2024) focused their analysis on research trends in science process abilities at the primary school level, secondary school level, and tertiary level, utilizing 23 Scopus papers from 2019 to 2024. Meanwhile, Idris et al. (2022) focused on theme analysis of strategies for acquiring science process skills, employing 104 papers from 2015 to 2021, including 62 from Scopus pieces and 40 from Web of Science articles. It also differs from Mushani (2021), who conducted a literature review analysis and confined his research to examining research trends in scientific process skills in developed and developing nations utilizing 198 publications published between 1987 and 2018.

This study differs from previous research in several ways. First, this study provides a bibliometric analysis to assess trends in the expansion of research on science process skills in education, including network, overlay, and density analysis. Second, this study relies on a smaller data set than previous studies, focusing on the period 2020-2023. Third, we found reviews of the ten most cited articles. Fourth, we chose to evaluate the findings of the ten most popular papers from 2020 to 2023 and provide recommendations for future research.

The novelty of this research is a bibliometric analysis and review of the latest research in the field of Science Process Skills. The criteria for selecting 10 articles were based on the most frequently appearing keywords on VOSViewer during 2020-2023. Bibliometric analysis is very important to help and serve as a reference for researchers in determining research topics to be carried out, especially those related to the Science Process Skills research field. So, this research aims to look at the latest research published on Science Process Skills in 2020–2023.

METHOD

This research uses bibliometric analysis to analyze research quality, research topics, and future research projections. Discovering keywords, initial search outcomes, filtering results, providing data information, and interpreting data are stages in this research (Rostiany & Tjandra, 2022). The available article data comes from Google Scholar, which can be used to create comprehensive bibliometric maps and facilitate understanding of relationships between articles. The world's largest citation-based academic database containing summaries of scientific research and peer-reviewed literature can be found on Google Scholar. One of the key factors in choosing this database is how well it visualizes, crawls, and analyzes articles.

This research uses bibliometric analysis across keywords using Publish or Perish to examine search data as a form of co-occurrence research. This tool was chosen because Publish or Perish (PoP) is a software application that facilitates the search for metadata in the Google Scholar database. Analysis of the Science Process Skills literature with the keyword 'science

process skills' produced 939 articles that were evaluated according to the selected topic. Articles published in 2020–2023 were collected and saved in *.ris format for research. Data collection limitations revealed that a number of journals could not be opened, which hampered data collection on this topic.

This research analyzes research patterns on bibliometric maps and creates data mapping visualizations from database sources that have been prepared using VOSviewer. This research uses network data mapping visualization, overlays, and computational density to gather information about the development of Science Process Skills research. Mapping network visualizations to show strong long-term associations, overlay visualizations to increase the recency of research terms and show how fresh a phrase is from year to year and to show that many keywords in yellow represent well-studied topics, while keywords that are missing or inaudible indicates under-researched topics using density visualization (Sidabutar et al., 2022).

RESULTS AND DISCUSSION

After interpreting data, research results were found such as publication data, research development, visualization of topic areas for each cluster, data mapping using networked visualization, overlay visualization, and density visualization.

A total of 200 articles were collected through data searches carried out using Publish or Perish, using the keyword 'Science Process Skills'. The data obtained is presented as article metadata, including author's name, title, year of publication, journal name, publisher, number of citations, article link and related URL. The amount of citations for all articles used in this research is 3795. The annual number of citations is 1265.00. The number of citations for each article is 4.04. The average authorship in publications is 2.58. On average, articles show an h index of 29 and a g index of 39.

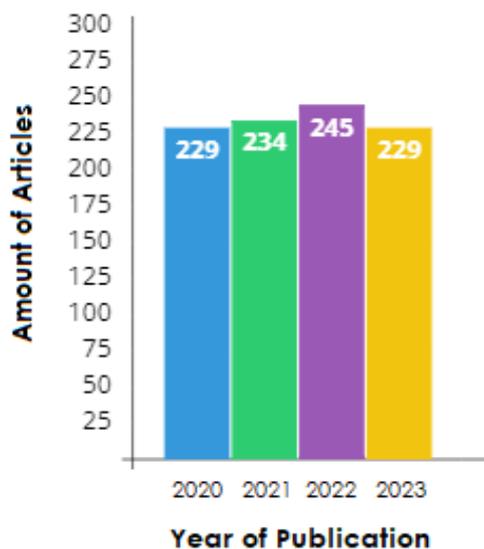


Figure 1. Development of the Number of Scientific Process Skills Research Publications in 2020-2023

Figure 1 depicts research trends on Science Process Skills from 2020 to 2023. In 2020, a total of 229 articles were published on this topic. Furthermore, the number of articles increased to 245 articles in 2021. It again decreased to 234 articles in 2022 followed by a slight decrease to 229 articles in 2023. From the available literature, it is evident that Science Process Skills have been the subject of extensive investigation over the last three years, with a marked decline in research activity seen in recent years. Figure 1 below illustrates the development of the number of SPS research publications published in Google Scholar indexed journals to show the threshold of development of SPS research during the 2020-2023. Next, the most frequently appearing keywords are analyzed before mapping the visualization. 10 keywords were obtained and presented in Table 1.

Table 1.Top 15 Keywords for Science Process Skills Research for 2020-2023

Keywords	Occurence	Total Link Strength
Science Process Skills	527	3688
Student	187	511
Development	132	307
Effect	120	339
Model	115	467
Analysis	76	162
Learning	69	206
Inquiry	65	189
Science	57	164
Implementation	49	136
Effectiveness	49	145
Project	48	155
Problem	44	126
Outcome	41	152
Application	40	116

It can be seen that the keyword that appears most often and has the highest total link strength is Science Process Skills with 527 occurrences and a total link strength of 3688. Followed by Student in second place with 187 occurrences and a total link strength of 511. Then Development is in third place with 132 occurrences and total link strength 307. Effect is fourth with 120 occurrences and total link strength 339. Model is fifth with 115 occurrences and total link strength 467. Analysis is sixth with 76 occurrences and total link strength 162. Learning is in seventh with 69 occurrences and total link strength of 206. Inquiry is eighth with 65 occurrences and total link strength of 189. Science is ninth with 57 occurrences and total link strength of 164. Implementation is tenth with 49 occurrences and total link strength of 136. Effectiveness is eleventh with 49 occurrences and total link strength of 145. Project is twelfth with 48 occurrences and total link strength of 155. Problem is thirteenth with 44 occurrences and total link strength of 126. Outcome is fourteenth with 41 occurrences and total link strength of 152 and Application is fifteenth with 40 occurrences and total link strength of 116.

The articles obtained were then subjected to computational mapping bibliometric analysis using the VOSViewer tool. A total of 77 words were identified through the use of computational mapping techniques. The categorization of each identified item related to Science Process Skills is divided into 7 clusters with 1009 links and a total link strength of 3688. Strong relationships between terms are displayed in extensive bibliometric maps in network visualization mapping, which is the basis of the first mapping in this research (Sidabutar et al, 2022).

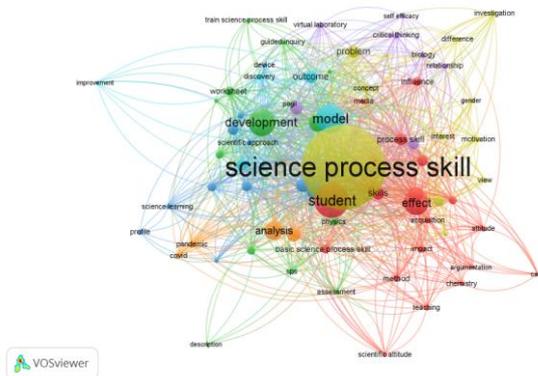


Figure 2. Networked Visualization of Science Process Skills Research on 2020-2023

debate skills, ICT, STEM (Idris et al., 2022), student-centered teaching, use of a variety of learning tools, hands-on exercises, group activities (Gizaw & Sota, 2023), PhET (Haryadi & Pujiastuti, 2020), mobile scientific investigations (Ekici & Erdem, 2020), guided inquiry, PBL, PjBL, learning cycles, use of learning media, modules and worksheets (Syazali et al., 2021) can train and improve students' science process skills.

Finally, students' scientific interests, attitudes and processing abilities are interrelated (Ernawati et al., 2022). However, practical activities and assessing science process skills are rarely carried out so that without direct experience, students' science process abilities and critical thinking skills are less developed, seen from the test results which are still below average (Rini & Aldila, 2023) because students can better understand the topic learning if you have strong scientific process skills (Inayah et al., 2020) so that involvement and science process skills are needed which can improve student progress, learning and achievement (Budiarti et al., 2022) to allow urban as well as rural pupils have the skills strong scientific process (Kurniawan et al., 2020).

In contrast to the keywords that are popularly discussed, keywords such as correlation, STEM, self efficacy, case, comparison, improvement, argumentation, and POGIL, these are research topics that are rarely researched and are too broad to be studied in more depth in relation to Science Process Skills.

The findings of this study reveal that, although researchers around the world have contributed to the field of science process skills, their research is consistent by country. Analysis of the extracted keywords revealed that the researchers' main focus remained on strengthening scientific process capabilities. However, like any research, this study has limitations. First, our dataset only includes publications published between 2020 and 2023, thereby reducing earlier and later articles. Second, the keywords we obtain, as well as other keywords, may or may not appear again in the future.

Future research possibilities for educators, curriculum designers, and policymakers in work to improve learning outcomes in the Merdeka Curriculum include investigating approaches that incorporate STEM, self-efficacy, case, comparison, improvement, argumentation, and POGIL as learning frameworks into schools and specifically, by including the most significant research outcomes from Q1. This research helps future researchers to pinpoint the most relevant topics for further exploration by combining multiple databases, such as Scopus, Google Scholar, and WoS, allowing researchers to quickly limit current issues and enrich the keywords acquired in the domain of this research. Furthermore, cross-country and multi-country research are required since they aid in the application of a wide range of issues and demographics. Age, background, education, country, and ethnicity are all examples of demographic variety that require more investigation. As a result, future researchers have the chance to focus their research on this area in order to generate a fuller understanding.

There are several contributions to this research. First, this study investigates publication trends in science process skills by evaluating publications over a given period of time. Second, this study collected and examined the ten most cited publications on science process skills research from 2020 to 2023. Third, we mapped keywords with networked analysis, overlay, and density visualization to help researchers avoid stagnation and advance the matter. Fourth, through bibliometric analysis, this study provides a complete and objective examination of the topic under consideration. Fifth, we noted numerous limitations in our study. This study identifies prospective areas for future research on science process skills.

CONCLUSION

This research aims to view and review published research on Science Process Skills in 2020–2023 using VOSViewer. Article data from Google Scholar database journals collected using Publish or Perish. In 2020-2021 the number of articles published experienced a significant increase, but starting from 2022-2023 it experienced a drastic decline. Topics such as science process skills, students, development, effects, models, analysis, and learning have

often been discussed by researchers. In contrast to keywords such as correlation, STEM, self efficacy, case, comparison, improvement, argumentation, and POGIL, these are research topics that are rarely researched and too broad to be studied in more depth. The results of the review of the top 10 articles cited tend to examine strategies for mastering science process skills which include experimentation, thinking-on, inquiry approaches, discovery learning, strategic manipulation, debate skills, ICT, STEM, student-centered teaching, use of a variety of learning tools, hands-on exercises, group activities, PhET, mobile scientific inquiry, guided inquiry, PBL, PjBL, learning cycle, use of learning media, modules and worksheets. The novelty of this research is a bibliometric analysis and review of the latest research in the field of Science Process Skills.

This study reveals that although researchers around the world have contributed to the field of scientific process skills, their goal remains the same across countries. The research focuses on building scientific process capabilities, but the dataset only includes publications published between 2020 and 2023, reducing earlier and later articles. Future research could include exploring approaches integrating STEM, self-efficacy, cases, comparison, improvement, argumentation, and POGIL as learning frameworks in schools. Combining multiple databases such as Scopus, Google Scholar and WoS helps identify relevant topics for further exploration. Cross-national and multi-country research is needed to address a wide range of questions and demographics, such as age, race, education, country, and ethnicity. The study also examines publication trends on scientific process skills, collects and examines the ten most cited publications, maps keywords using network analysis, overlay and density visualization, and provides a comprehensive and objective examination of the subject. Despite its limitations, the study identifies potential areas for future research into scientific process skills.

The implication of this research is to find several examples of research trends regarding Science Process Skills so that this study might be an acknowledged for further research. This research can also find the most relevant issues regarding Science Process Skills. Thus, this also limits further trends that can be developed in this area of research.

RECOMMENDATION

Enhance learning by providing students with a variety of opportunities to engage in developing and improving science process skills through implementing a variety of learning strategies that can grow students' science process skills by exploring topics such as correlation, STEM, self efficacy, case, comparison, improvement, argumentation, and POGIL.

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