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Bibliometric Computational Mapping Analysis of Publications on Science Process Skill Using VOSviewer

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Abstract.
This study examines the development of “science process skill” research through a bibliometric approach to computational mapping analysis using VOSviewer. The article data was obtained from the Google Scholar database using the publish or perish reference manager application. The title and abstract of the article are used to guide the search process by referring to the keyword “science process skill”. Nine hundred sixty-seven articles were found that were considered relevant. The study period used as the study material is the Google Scholar-indexed article for the last six years (2018 to 2023). The results showed that science process skill research can be separated into 3 terms: science process skill, process skill, and science process. The first term is “science process skill” that is included in cluster 1, which has 71 links, a total strength of 4342 links, and 888 occurrences. The second term is “process science”. This term is included in cluster 4, which has 61 links, a total link strength of 278, and 47 occurrences. The third term is “process skill”. This term is included in cluster 3, which has 67 links, a total link strength of 570, and 100 occurrences. There was an increase in the number of publications from 2018 to 2021. However, it experienced a decline in 2022 up to July 2023. This indicates a decreasing trend in the number of publications in research on science process skills in the last three years, from 2021 to 2023. The results show that research related to science process skills still has a high enough opportunity to be researched. Several keywords related to “science process skills” have not been or are rarely used in research, some of which are an integration of learning models, prospective teachers/pre-service teachers, mixed methods research, assessment of learning, assessment as learning, and assessment for learning. This review can serve as a starting point for research related to other materials.

Keywords: bibliometric, computational mapping, science process skill, VOSviewer

1. INTRODUCTION

Applying scientific processes, known as scientific process skills, is important for science teachers as it is an integral part of science education. Teachers with strong scientific process skills are believed to help students understand and use scientific principles correctly [1]. Proficiency in science process skills is highly effective in assisting educators in guiding students to conduct experiments, formulate hypotheses, analyze data, interpret data, make predictions, and draw conclusions or make informed decisions.

The government's policy, particularly the Ministry of Education and Culture (Kemdikbud), strongly emphasizes process standards in science education. This policy promotes inquiry-based, discovery-based, problem-based learning, and project-based learning approaches [2]. By incorporating these active and hands-on learning strategies into the curriculum, the government aims to foster a generation of learners who are not just passive recipients of information but active participants in their education, capable of exploring, discovering, and applying scientific principles to real-world challenges. This approach aligns with global trends in education, preparing students to thrive in an increasingly complex and dynamic world [3]. However, in the field of research, it is still uncertain whether science process skills are still in great demand or not, especially in the field of educational research. One of the analytical techniques that can be used to determine the development of research in the field of education, especially research on science process skills, is bibliometric analysis. Bibliometric analysis is a form of meta-analysis of research data that can help researchers study the bibliometric content and citation analysis of journal articles and other scientific articles.

There have been many studies on bibliometric analysis, including bibliometric analysis in artificial intelligence [4, 5], bibliometric analysis in research on mobile learning [6], online courses [7–9], STEM Education [10, 11], big data [12], professional development teacher [13], innovation in education [14], and industry 4.0 and education [15].

However, research on computational mapping of bibliometric analysis of published data in the field of science process skill which has been carried out specifically to determine the development of the research has not been carried out. Especially bibliometric analysis for research in the last 6 years in the period 2018 to 2023 through the VOSviewer application.

Therefore, this research was conducted to carry out computational research on mapping bibliometric analysis of articles indexed by Google Scholar using VOSviewer software. This research was conducted with the hope that it can be a reference for researchers to conduct and determine the research themes to be taken, especially those related to the field of mechanical engineering education.

2. RESEARCH METHOD

The article data used in this study was based on research from publications that have been published in Google Scholar indexed journals. We selected Google Scholar in this study because the Google Scholar database is an open source [16]. To obtain research data, a manager reference application was used, namely Publish or Perish. Publish or Perish software was used to conduct a literature review on our chosen topic [17]. The research was conducted through several stages:

1. Collection of publication data using the publish or perish application,
2. Verification of the search results. Articles sourced from books, articles without publishers, and articles from unclear publishers were removed.
3. Exporting data from the Publish or Perish application. The exported data are in the form of research information systems (.*ris*) and comma-separated value format (*.*csv*).
4. Processing bibliometric data of the obtained articles using Microsoft Excel. Data processing aims to map the development of research from 2018 to 2023. Additionally, an analysis was conducted to map the top 20 journal articles with the highest citations.
5. Computational mapping analysis of bibliometric publication data using the VOSviewer application, and
6. Analyzing and interpreting the results of the computational mapping analysis.

The data article search in Publish or Perish was used to filter publications using the keywords “Science Process Skills” and “SPS”. Publish or Perish conducts article searches based on the titles and abstracts available on Google Scholar. Data collection was carried out in July 2023. VOSviewer was employed to create 3 variations of mapping publications, namely network visualization, density visualization, and overlay visualization based on the network (co-citation) between existing items. When creating a bibliometric map, the keyword frequency was set to be found at least 3 times. Therefore, obtained 72 terms and keywords that are less relevant were removed.

3. RESULT AND DISCUSSION

3.1. Publication Data Search Results

Based on data searches through the publish or perish reference manager application from the Google Scholar database, 967 articles were obtained that met the criteria between 2018 and 2023. The data is obtained as article metadata, including author name, title, year, journal title, publisher, number of citations, link to the article, and associated URLs. The number of citations of all articles used in this study is 5816, the number of citations per year is 1990.10, the average citation rate per paper is 9.59, the average author in the papers used is 2.70 and the average rank of Google Scholar is 344.32. Table 1 shows some examples of published data used in the VOSviewer analysis of this study. The sample data taken are the top 20 articles with the highest number of citations which can be viewed in Table 1.

3.2. Research Development in The Field of Science Process Skills

Table 2 shows the research development in science process skills published in the Google Scholar-indexed journal.

Based on Table 2, it can be observed that the highest number of publications was in the year 2021. There was an increase in the number of publications from 2018 to 2021. However, it experienced a decline in 2022 up to July 2023. This indicates a decreasing trend in the number of publications in research on science process skills in the last three years, from 2021 to 2023. This opens opportunities for researchers to conduct studies related to this topic. A graph of the development of the number of studies related to science process skills for the last six years, from 2018 to 2023, can be seen in Figure 1.

3.3. Visualization Science Process Skills Topic Area Using VOSviewer

Computational mapping was performed on the article data. VOSviewer is used in the computational mapping. The results of computational mapping found 72 items. Each item found related to science process skills in data mapping is divided into 5 clusters, namely:

1. Cluster 1 has 22 items marked in red. The 21 items are achievement, acquisition, approach, assessment, basic science process skill, biology, correlation, grade,

Table 1: Science process skills publication data.

No	Authors	Title	Year	Cites	Refs
1	F Harahap, NEA Nasution, B Manurung	The Effect of Blended Learning on Student's Learning Achievement and Science Process Skills in Plant Tissue Culture Course.	2019	190	[18]
2	N Af'idayani, I Setiadi, F Fahmi	The effect of inquiry model on science process skills and learning outcomes.	2018	130	[19]
3	D Darmaji, DA Kurniawan, I Irdianti	Physics Education Students' Science Process Skills.	2019	112	[20]
4	AIM Elfeky, TSY Masadeh, MYH Elbyaly	Advanced organizers in the flipped classroom via e-learning management system and promoting integrated science process skills.	2020	93	[21]
5	HJ Duda, H Susilo, P Newcombe	Enhancing different ethnicity science process skills: Problem-based learning through practicum and authentic assessment.	2019	90	[22]
6	A Winarti, L Yuanita, M Nur	The Effectiveness of Multiple Intelligences Based Teaching Strategy in Enhancing the Multiple Intelligences and Science Process Skills of Junior High School Students.	2019	88	[23]
7	R Haryadi, H Pujiastuti	PhET simulation software-based learning to improve science process skills.	2020	69	[24]
8	W Kurniawan, D Darmaji, A Astalini	Multimedia Physics Practicum Reflective Material Based on Problem-Solving for Science Process Skills.	2019	55	[25]
9	E Wiwin, R Kustijono	The use of physics practicum to train science process skills and its effect on the scientific attitude of vocational high school students.	2018	44	[26]
10	T Mulyeni, M Jamaris, Y Supriyati	Improving basic science process skills through inquiry-based approach in learning science for early elementary students.	2019	41	[27]
11	M Ekici, M Erdem	Developing science process skills through mobile scientific inquiry.	2020	39	[28]
12	A Solé-Llussà, D Aguilar, M Ibáñez	Video worked examples to promote elementary students' science process skills: a fruit decomposition inquiry activity.	2021	37	[29]
13	ILL Ping, L Halim, K Osman	Explicit Teaching of Scientific Argumentation as an Approach to Developing Argumentation Skills, Science Process Skills, and Biology Understanding.	2020	35	[30]
14	J Arantika, S Saputro, S Mulyani	Effectiveness of guided inquiry-based module to improve science process skills.	2019	35	[31]
15	YB Bhakti, IAD Astuti, IY Okyranida	Integrated STEM project-based learning implementation to improve student science process skills.	2020	33	[32]
16	R Haryadi, M Vita, IS Utami, I Ihsanudin	Briquettes production as teaching aids physics for improving science process skills.	2019	32	[33]

integrated science process skill knowledge learner, process, relationship, science, science education, science process skill, skill, sps, study, teacher, and understanding.

Table 1: Continued.

No	Authors	Title	Year	Cites	Refs
17	A Solé-Llussà, D Aguilar, M Ibáñez	Video-worked examples to support the development of elementary students' science process skills: a case study in an inquiry activity on electrical circuits.	2022	29	[34]
18	D Dewantara, S Mahtari, M Nur, L Yuanita	The Correlation of Scientific Knowledge-Science Process Skills and Scientific Creativity in Creative Responsibility Based Learning.	2020	29	[35]
19	H Artun, A Durukan, A Temur	Effects of virtual reality enriched science laboratory activities on pre-service science teachers' science process skills.	2020	28	[36]
20	RM Tan, RT Yangco, EN Que	Students' Conceptual Understanding and Science Process Skills in an Inquiry-Based Flipped Classroom Environment.	2020	27	[37]

Table 2: Development of science process skills research.

Year of Publications	Number of Publications
2018	113
2019	156
2020	175
2021	218
2022	204
2023	101
Total	967
Average	193,4

2. Cluster 2 has 18 items and is marked green. The 18 items are analysis, covid, development, effectiveness, implementation, improve science process skill, indicator, instrument, junior high school, junior high school student, learning process, outcome, pandemic, project, research, science learning, student worksheet, and student science process skill.

3. Cluster 3 has 13 items marked in blue. The 13 items are application, aspect, concept, data, description, high school student, impact, improvement, inquiry, inquiry model, mastery, process skill, and student science process skill.

4. Cluster 4 has 13 items marked in yellow. The 13 items are ability, activity, child, critical thinking, critical thinking skill, difference, effect, influence, learning, model, problem, science process, and scientific process skill.

5. Cluster 5 has six items and is marked purple. The six items are attitude, physics, profile, science process skill test, scientific attitude, and student.

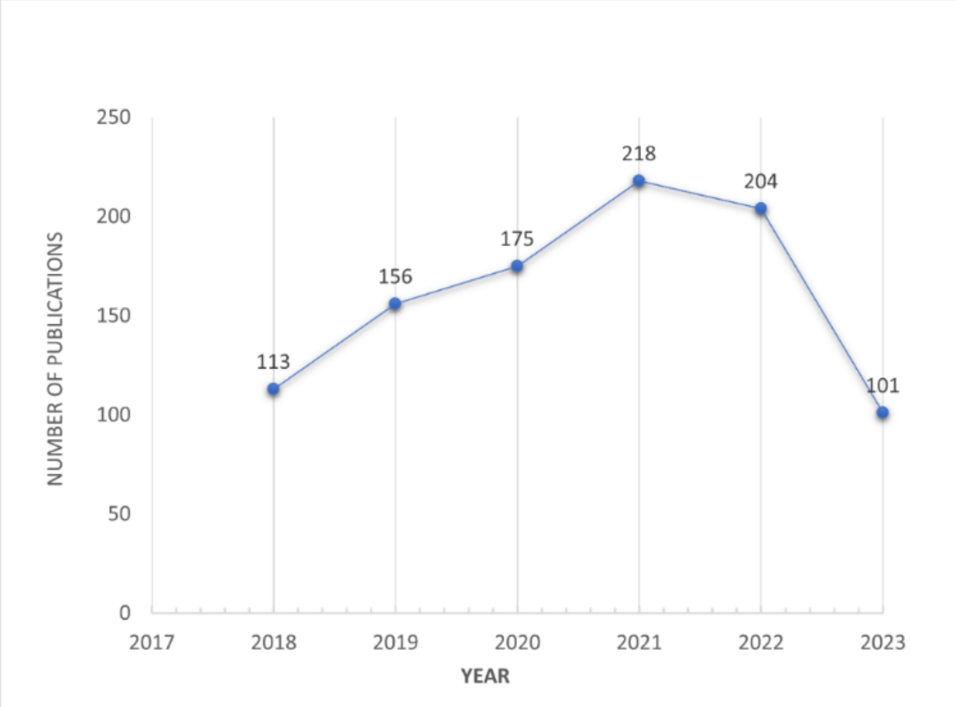

Figure 1: Level of development in science process skills research.

The relationship between one term and another term is displayed in each cluster present. Each term is marked with a colored circle. The circle size for each term varies according to the frequency of occurrence of the term [38]. Inscription circle size positively correlates with term occurrence in titles and abstracts. The more frequently a term appears, the larger the label size [17]. The mapping visualization analyzed in this study consists of three parts: the network visualization shown in Figure 2, the density visualization shown in Figure 3, and the overlay visualization shown in Figure 4.

Figure 2 shows the relationship between terms. The relationships between terms are described in an interconnected network. Figure 2 shows the clusters of each term that are often researched and associated with science process skill research topics. The network visualization clusters show that research on scientific process skills can be categorized into seven fields: scientific process skills, teaching and learning models, teacher, learning outcome, subjects, and types and research objectives.

From the clusters in the network visualization, the research on science process skills can be separated into three fields/terms. The first term is “science process skill”. This term is included in cluster 1, which has 71 links, a total strength of 4342 links, and 888 occurrences. The network visualization of this term can be seen in Figure 3.

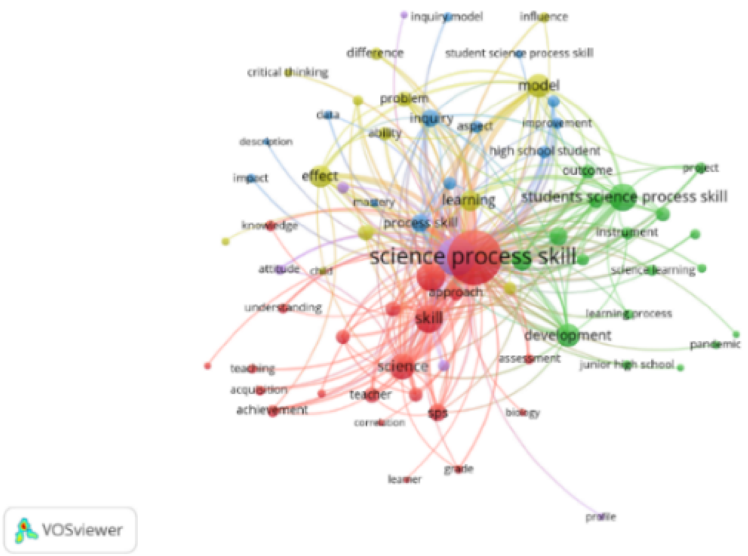

Figure 2: Network visualization of science process skills keyword.

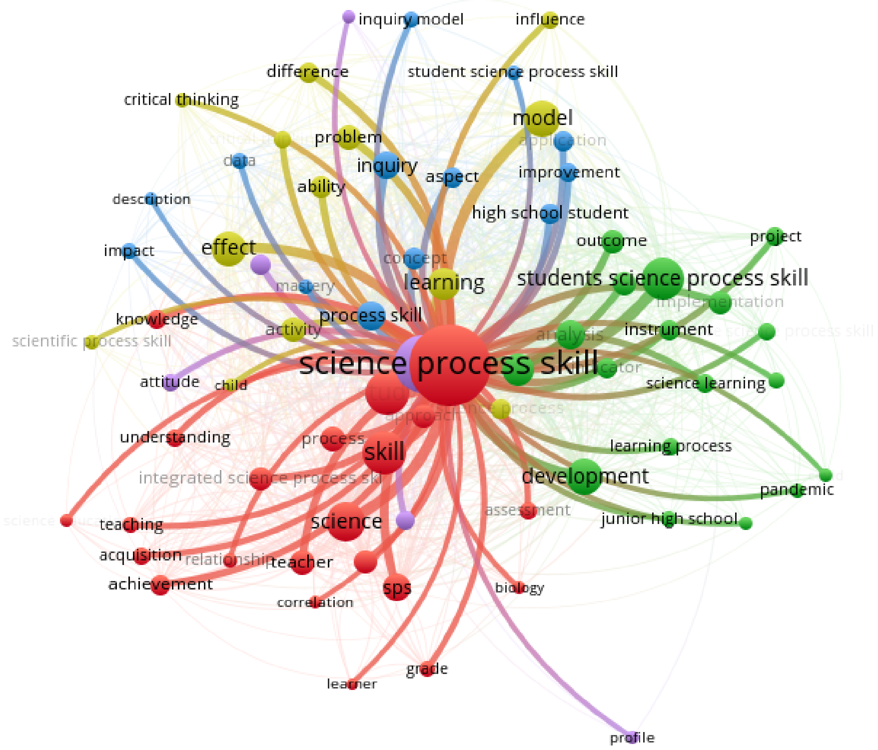

Figure 3: Network visualization of the 'science process skill 'term.

The second term is "process science". This term is included in cluster 4, which has 61 links, a total link strength of 278, and 47 occurrences. The network visualization of this term can be seen in Figure 4.

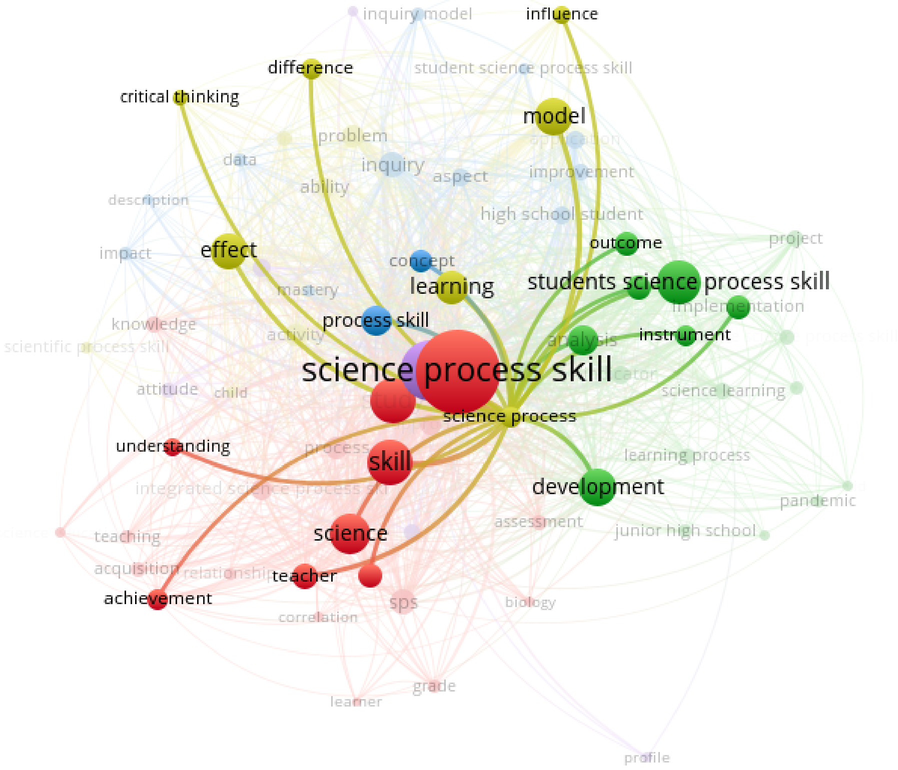

Figure 4: Network visualization of the ‘science process’ term.

The third term is “process skill”. This term is included in cluster 3, which has 67 links, a total link strength of 570, and 100 occurrences. The network visualization of this term can be seen in Figure 5.

Figure 6 shows the density visualization. Density visualization means that the brighter the yellow color and the larger the diameter of the circle of term labels, the more often the term appears [38]. This means that much research on related terms has been carried out. Vice versa, if the term’s color fades close to the background colour, then the number of studies on the term is negligible.

Based on Figure 6, it can be observed that the keywords or terms related to “science process skills” that are frequently used in articles are “science process skills,” “skills,” “science,” “student science process skills,” “development,” “model,” “effect,” “inquiry,” and others.

Figure 7 shows the overlay visualization in science process skill research. This visualization overlay shows the novelty of research on related terms [39].

Figure 7 shows that the highest number of publications using the keyword “science process skills” in the last six years occurred from February 2020 to August 2020. In Figure 7, it is also evident that during this period, the color in February 2020 is the

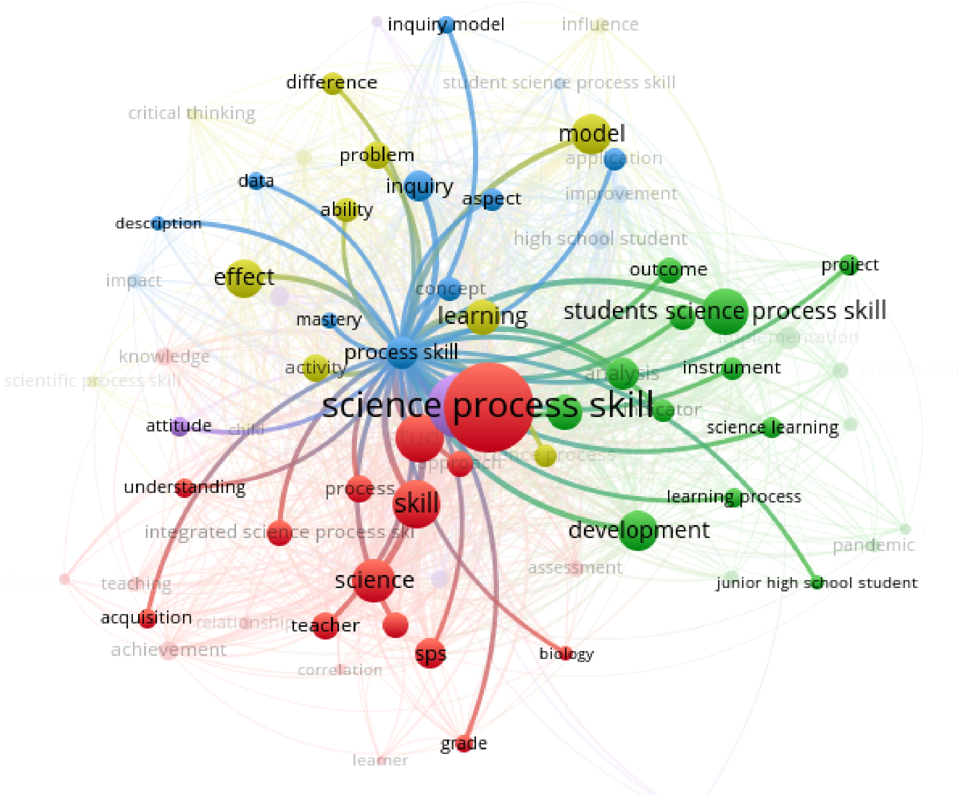

Figure 5: Network visualization of process skill term.

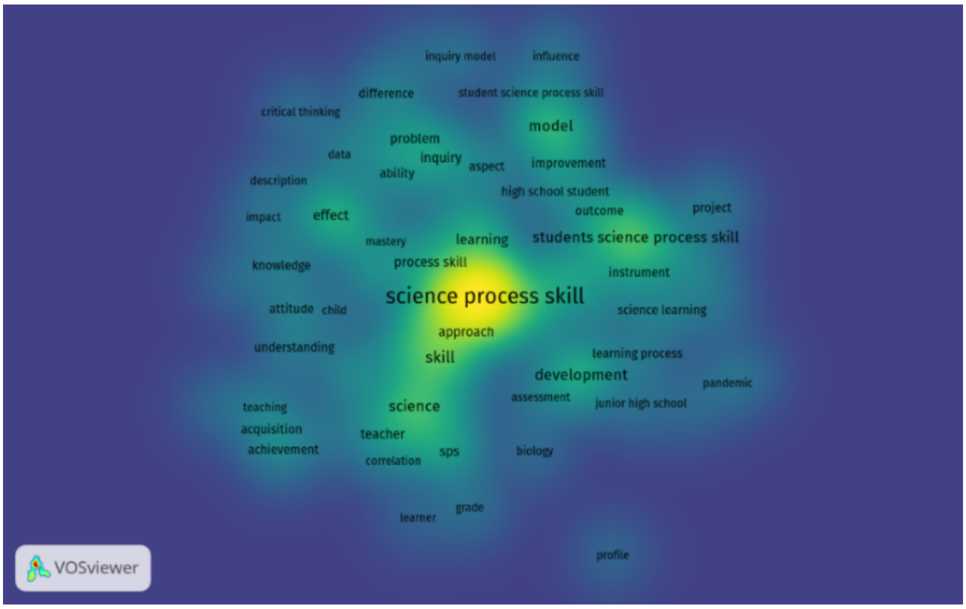

Figure 6: Density visualization of science process skills keyword.

darkest, and it gradually fades until August 2020, indicating a significant decrease in the number of publications. The keyword mapping data related to "science process

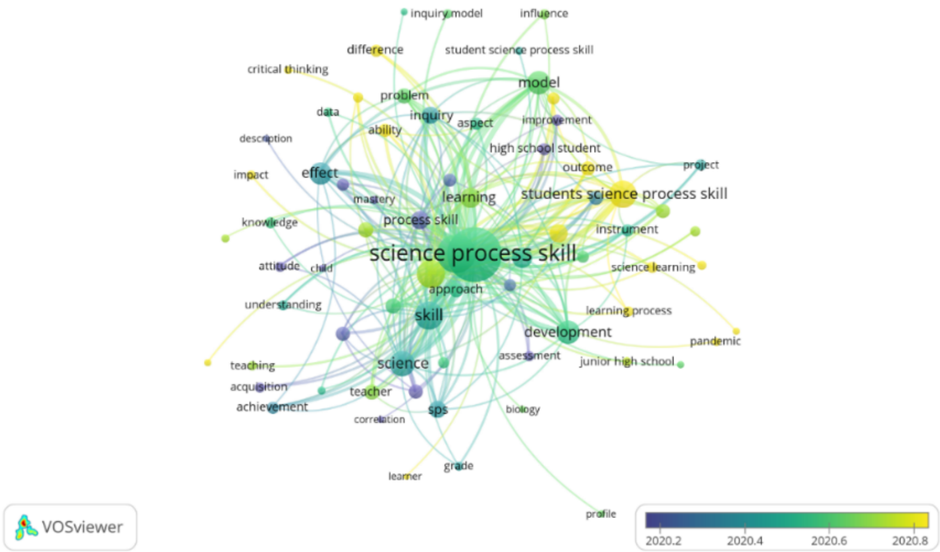

Figure 7: Overlay visualization of science process skills keyword.

skills" based on the topics of teaching and learning models, teacher, learners, learning outcomes, subjects, types, and research objectives can be seen in Table 3.

Based on Table 3, the keywords related to the "teaching & learning models" topic that is most frequently used include science learning, Inquiry model, project, problem, student worksheet, integrated science process skill, and others. The keywords used are quite diverse, but among all the keywords used, none integrate one model with another learning model. This presents an opportunity for researchers interested in studying science process skills by integrating various teaching and learning models. There is already a considerable variety of keywords in the "teacher" and "learners" topics. However, the keyword "prospective teacher or pre-service teacher" is missing. This also presents an opportunity for further investigation, such as research on science process skills among prospective or pre-service teachers. Regarding the "learning outcomes" topic, it is quite comprehensive. However, there are still opportunities for specific topics such as assessment of learning, assessment as learning, and assessment for learning, each of which is not in Table 3. The "subjects" and "types and research objectives" are already quite comprehensive. However, mixed-method research is missing in the "types and research objectives" topic. This also represents an opportunity for further research. Based on the mapping results that have been conducted, several keywords related to science process skills are still rarely used in research, such as learning model integration, prospective teacher, pre-service teacher, mixed-method research, assessment of learning, assessment as learning, and assessment for learning.

TABLE 3: Total link, link strength, and term occurrences in each field.

No	Topics	Term	Links	Total link strength	Occurrences
1	Science Process Skills	Science Process Skill	71	432	888
		Process Skill	67	570	100
		Process	66	446	76
		SPS	66	511	90
		Scientific process skill	36	98	20
2	Teaching & Learning Models	Model	67	969	165
		Teaching	47	179	29
		Science Learning	54	216	42
		Data	47	162	29
		Inquiry model	47	151	28
		Inquiry	65	555	94
		Project	50	261	39
		Indicator	60	256	47
		Problem	63	448	73
		Learning process	52	207	35
		Student worksheet	45	135	26
		Application	56	282	47
		Activity	60	384	70
		Integrated science process skill	60	342	63
		Approach	66	391	67
3	Teacher	Teacher	58	383	73
4	Learners	Learner	39	93	13
		Junior High School	44	140	26
		High School Student	53	243	45
		Student	71	2383	440
		Child	37	88	18
5	Learning outcomes	Skill	71	1283	245
		Understanding	48	214	36
		Critical Thinking	48	166	24
		Critical thinking skill	48	211	36
		Achievement	53	278	48
		Science process skill test	36	98	20
		Basic science process skill	60	354	67
		Student science process skill	38	108	22
		Knowledge	55	212	37
		Concept	67	355	56

Table 2: Continued.

No	Topics	Term	Links	Total link strength	Occurrences
		Outcome	60	363	61
		Ability	60	317	57
		Assessment	50	184	31
		Scientific attitude	39	94	15
		Acquisition	52	182	34
		Instrument	56	258	44
		Mastery	45	130	24
		Improve science Process skill	41	157	30
6	Subjects	Physics	52	253	45
		Biology	39	108	19
		Science	70	1054	191
		Science Education	35	102	19
7	Types and Research Objectives	Correlation	34	81	16
		Relationship	38	111	23
		Improvement	53	230	42
		Description	38	97	17
		Difference	51	254	49
		Impact	49	172	26
		Implementation	64	346	59
		Development	67	823	164
		Influence	44	174	32
		Effectiveness	60	362	63

4. CONCLUSION

The results show that research related to science process skills still has enough opportunity to be researched. Several keywords related to “science process skills” have not or are still rarely used in research, some of which is integration of learning models, prospective teachers, pre-service teachers, mixed methods research, assessment of learning, assessment as learning, and assessment for learning. This is an opportunity.

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