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Science Reasoning: A Review and Bibliometric Analysis

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Abstract: Improving critical thinking in science classes can be accomplished by developing reasoning thinking approaches. The goal of studying science reasoning in science classes is to see how much of this strategy is used in solving science problems and developing Higher Order Thinking Skills (HOTS) that are based on critical thinking. Between 2015 and 2021, a total of 100 articles were retrieved from the Google Scholar database and the Publishing or Perish (PoP) program. Mendeley desktop, a referencing management software, was then used to handle the selected references. Once the database was handled, this research employed VOS viewer software to categorize and visualize it. In general, this study provides a solid foundation for further research into "science reasoning."

Keywords: Bibliometric analysis; Science reasoning; Reasoning critical thinking; HOTS Science.

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Introduction

Critical thinking, as a thinking talent and approach, must be based on the universal laws of formal logic. Informal logic, a clear distinction between the effective and invalid reasoning forms is essential for proper critical thinking: an argument based on the invalid reasoning form is unpersuasive, and only the effective reasoning form can provide a persuasive argument (Jing, 2021).

Scientific reasoning, in general, is a sort of thinking that involves students developing and evaluating hypotheses, particularly about how things work. Individuals prefer to correlate the examined phenomena with prior information during the reasoning process, and new knowledge is sought once the previous knowledge is rectified and integrated (Zulkipli et al., 2020).

Scientific thinking does not indicate a greater understanding of science. Rather, we use the term scientific reasoning to refer to the ability to comprehend scientific inquiry's methods and principles, as well as the acquisition of the skills needed to formulate, test, and revise theories and reflect on the evidence-gathering process; or, more precisely, it refers to the "application of scientific inquiry's methods or principles to reasoning or problem-solving situations" (Zimmerman, 2007).

The findings reveal that scientific reasoning, mathematics reasoning, and mathematics application are all linked in a beneficial way. However, by the use of mathematics, we discovered a strong indirect effect from scientific reasoning to mathematics reasoning. As proposed by the Next Generation Science Standards and the Common Core State Standards for Mathematics, this outcome necessitates a shift in the focus of interdisciplinary initiatives to emphasize cognitive skills that students engage in learning mathematics and science (Hwang et al., 2020).

Motivated reasoning is a kind of warped thinking that is motivated by the desire to reach a certain conclusion or aim. that motivated thinking may block appropriate theory and data coordination, which is important to individual scientific cognition. It has the potential to impede the development of scientific knowledge and act as a mechanism in the process of

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exploiting science for certain socio-cultural ideas or objectives, so impeding the growth of science and technology-based on logical and objective scientific thought (Sein et al., 2018).

However, there is still a need for a review that explains the ideas of science reasoning in order to strengthen student critical thinking in the context of Higher Order Thinking Skills (HOTS) questions. There hasn't been a bibliometric study of the term science reasoning' yet. In light of the foregoing reasons, the purpose of this work is to address a research gap by conducting a comprehensive bibliometric analysis of the literature on science reasoning. We examined and classified the author distribution and affiliation of publications published and indexed by Google Scholar (GS). This study may provide light on which research subjects are garnering the most interest, as well as on potential future science reasoning' issues that might result in more research. The study was conducted using the bibliometric analysis technique, which comprised the processes associated with the installation of GS data-based software and publish or perish (PoP). Then, using the VOS viewer, present the findings, followed by a discussion session and conclusions drawn from the literature review based on the completed bibliometric analysis.

Method

This bibliometric evaluation of the literature is based on a systematic and straightforward method (Garza-Reyes, 2015) or on a mind mapping technique stressing knowledge limitations (Tranfield et al., 2003). As seen in Figure 1, this research technique is composed of five stages (Tranfield et al., 2003; Setyaningsih et al., 2018).

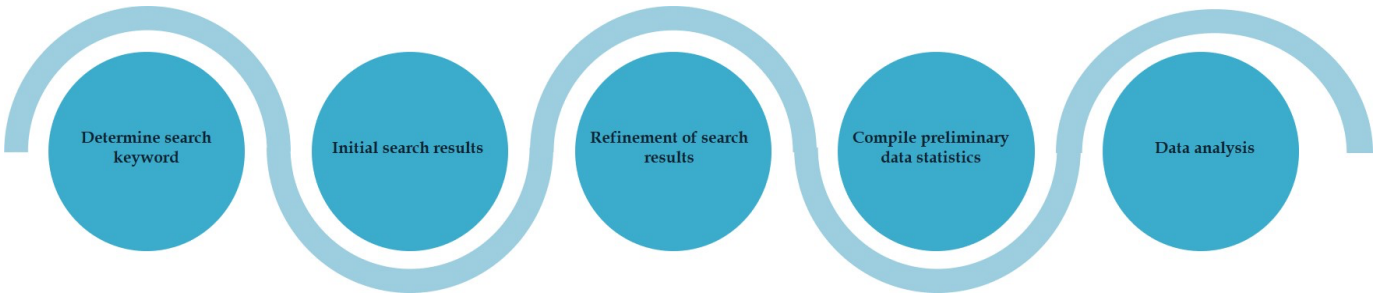

Figure 1. Five-stage method bibliometric analysis

Determine search keywords

In October 2021, a literature search using the keyword 'Science Reasoning' was conducted. Publish or Perish was selected because it has been shown to be the most successful method of locating papers on the GS, and Google Scholar was chosen because it is the biggest database presently available (Baneyx, 2008). The first search was conducted using the query language of the PoP program and the phrase 'Science Reasoning'.

Initial search results

Only 'journals', 'title words', and the years '2015-2021' are included in this search. A total of 100 objects were located during the first search. All relevant article information is collected in the Research Information Systems (RIS) format, including paper titles, author and affiliation names, abstracts, keywords, and references.

Refinement of search results

The GS database is filtered and indexed for applicable elements. Proceeding, newspapers, books, book reviews, and book chapters are not included in this data. Only journal papers were considered. The file is then saved as a RIS file so that the appropriate revisions may be made. To import RIS data, the Mendeley desktop application is utilized. The resulting RIS file is used to do further data analysis.

Compile preliminary data statistics

The acquired data was stored in the form of RIS. At the start, the journal articles' entire components (publication year, volume, number, page, etc.) were reviewed, and any missing data was added. The data were evaluated in order to classify the papers by year, publishing source, and publisher.

Data analysis

The PoP software was used to perform the bibliometric analysis for this study (Baneyx, 2008; Parmar, Ganesh, & Mishra, 2019). The VOS viewer tool is used to investigate and display bibliographic networks (Martinez-López et al., 2019; Shukla et al., 2020). The VOS viewer is widely used because to its capacity to work well with big data sets and to generate a variety of visually appealing charts, analyses, and studies (Van Eck & Waltman, 2010). Additionally, the VOS viewer can build maps of publications, authors, and journals, as well as keyword maps based on shared networks, using co-citation networks.

Result and Discussion

Publications and bibliographies

To determine the most frequently occurring terms, the output is examined using the PoP program in combination with the VOS viewer software. On the other hand, the amount of frequently occurring keywords is altered to match the needs of data collection and analysis. Bibliographic maps are seen using the VOS viewer. This program demonstrates bibliometric mapping using three separate visualizations: tissue, overlay, and density.

Between 2015 and 2021, this data was rigorously reviewed using the GS database's keyword 'science reasoning'. Initial data include around 100 papers with 1676 citations (279.33 citations/year). Following refining, 97 articles from the GS database were aggregated. Citation's data also altered, increasing to 1657 citations and 276.17 cities each year. Table 1 contains the entire findings of the metrics data comparison between the first and upgraded searches.

Table 1. Comparison matric

Matric data	Initial search	Refinement search
Source	"Science Reasoning"	"Science Reasoning"
Publication Year	2015-2021	2015-2021
Papers	100	97
Citations	1676	1657
Cities/year	279.33	276.17
Cites/paper	16.76	17.08
Authors/paper	2.88	2.88
h-indeks	25	25
g-indeks	38	38
hI,norm	14	14
hI,annual	2.33	2.33
hA-index	10	10

The researcher attempts to emphasize the most significant contributions in this paper. The first step is to compile a list of the top 100 articles that include the phrase "Science Reasoning" (top 10 articles cited). The following results were achieved, as indicated in Table 2.

Table 2. Top 10 cited articles

Cites	Authors	Title	Year	Source	Publisher
124	SS Guzey, TJ Moore, M Harwell, M Moreno	STEM integration in middle school life science: Student learning and attitudes	2016	Journal of Science Education and Technology	Springer
100	G Caniglia, N Schäpke, DJ Lang, DJ Abson, ...	Experiments and evidence in sustainability science: A typology	2017	Journal of Cleaner Production	Elsevier
99	E Zuriguel Perez, MT Lluch Canut, ...	Critical thinking in nursing: Scoping review of the literature	2015	International journal of Nursing Practice	Wiley Online Library
80	E Etkina	Millikan award lecture: Students of physics—Listeners, observers, or collaborative participants in physics scientific practices?	2015	American Journal of Physic	aapt.scitation.org
59	PY Lin, CD Schunn	The dimensions and impact of informal science learning experiences on middle schoolers' attitudes and abilities in science	2016	International Journal of Science Education	Taylor & Francis
59	P Vincent-Ruz, CD Schunn	The increasingly important role of science competency beliefs for science learning in girls	2017	Journal of Research in Science Teaching	Wiley Online Library
58	CT Chen, HC She	The effectiveness of scientific inquiry with/without integration of scientific reasoning	2015	International Journal of Science and Mathematics Educations	Springer
57	SB Piasta, JAR Logan, CY Pelatti, ...	Professional development for early childhood educators: Efforts to improve math and science learning opportunities in early childhood classrooms.	2015	Journal of Educational Psychology	psycnet.apa.org
51	A Bicer, P Boedeker, R Capraro, ...	The effects of STEM PBL on students' mathematical and scientific vocabulary knowledge	2015	International Journal of Contemporary Educational Research (IJCER)	dergipark.org.tr
51	BJ Reiser, S Michaels, J Moon, T Bell, ...	Scaling up three-dimensional science learning through teacher-led study groups across a state	2017	Journal of Teacher Education	journals.sagepub.com

Table 3 is listing the top six publications that publish papers on this subject.

Table 3. Top 6 publishers who publish science reasoning topic

Publisher	Articles
Taylor & Francis	12
Springer	10
Wiley Online Library	9
Journal.lww.com	6
ERIC	4
Journals.sagepub.com	4

Table 4 is lists journals with pertinent papers.

Table 4. The top seven publications that publish papers on scientific reasoning

Journal	Articles	Cites
Journal of Science Education and Technology	12	124
Canadian Journal of Science, Mathematics and Technology Educations	10	7
Turkish Journal of Computer and Mathematics Education (TURCOMAT)	1	0
Journal on Efficiency and Responsibility in Education and Science	4	10
The Electronic Journal for Research in Science & Mathematics Education	2	33
Journal of Experiential Education	4	0
Journal of Physics	3	5

Figure 2 illustrates the data network visualization of GS data connected to the refined search term 'Science Reasoning,' whereas Figure 3 illustrates the overlay visualization and Figure 4 illustrates the density visualization.

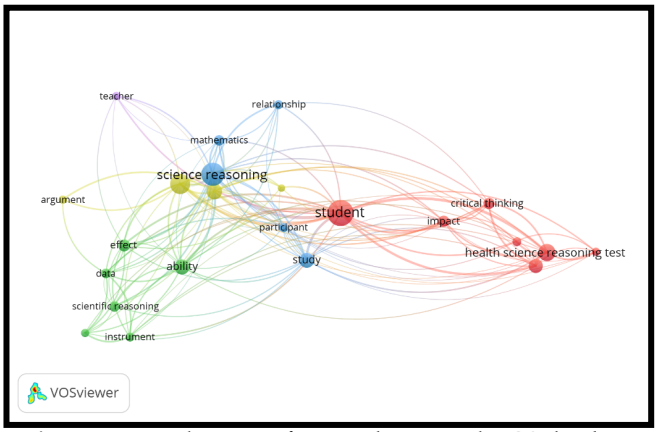

Figure 2. Visualization of networks using the GS database

On the basis of network visualization, an extensive study on the value of scientific reasoning has started. It is established that based on the findings of the cluster 2 study. Students, influence, critical thinking, validity, study, mathematics, relationships, effect, ability, data, scientific reasoning, instrument, participant, and instructor all play a role in science reasoning research.

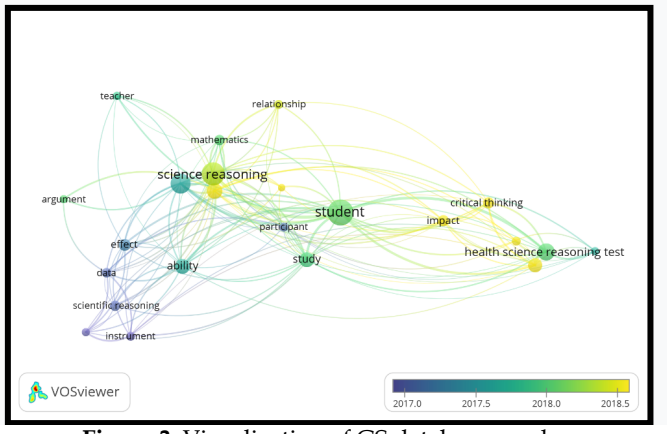

Figure 3. Visualization of GS database overlays

According to the conclusions of an assessment of the visualization of overlays in the GS database, recent research on scientific reasoning focuses on health science reasoning examinations, critical thinking, impact, and even the usefulness of reasoning itself.

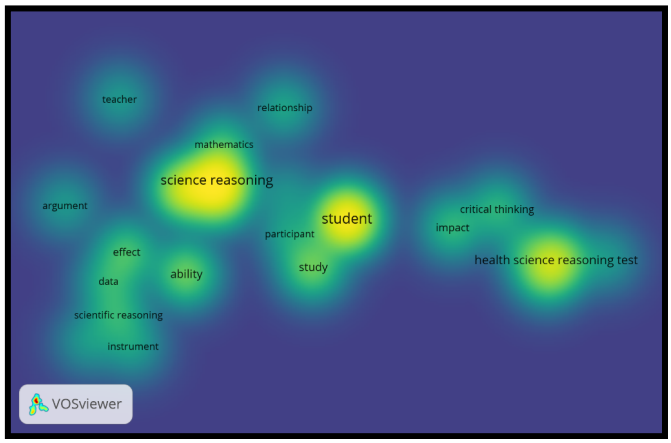

Figure 4. Visualization of density in GS database

According to the visualization of density findings, there is a big gap in research on scientific reasoning. Topics that have been widely investigated, such as scientific reasoning, students, and health science reasoning assessments, are highlighted in bold yellow. Concerning areas that have received less attention, they are highlighted in green, including critical thinking, relationships, and instructors. This large gap is likely to stimulate scholars to do further research on this subject.

The title, keywords, and abstract were extracted, with the minimum number of events set to five. Around 23 items were uncovered that met the 946-item criterion. This section does not include popular terminology. Each item that corresponds to the keyword is added, as shown by the size of the node. In other words, the size of the node indicates the co-

occurrence frequency of the term. This section recognizes five separate categories. The flow of study science reasoning is shown in Table 5 by the phrases in each cluster.

Table 5. Each cluster is represented by a keyword

Cluster	Element
The first cluster (red)	clinical reasoning (32), critical thinking (41), health science reasoning (93), hsrt (65), impact (46), student (190), validity (23),
The second cluster (green)	ability (73), data (47), effect (55), instrument (36), science reasoning tasks (31), scientific reasoning (24)
The third cluster (blue)	mathematics (41), participant (22), relationship (27), science reasoning (135), study (65)
Fourth cluster (yellow)	argument (18), reasoning (89), science (107), technology (22)
The fifth cluster (purple)	teacher (20)

Authors and relationships of co-authorship

Figure 5 displays a study of collaborative authors and networks in relation to patterns of interpersonal collaboration. Each node in this network represents the author's connection with writing. This analysis may include a large number of independent dimensions to illustrate groups and relationships between dimensions or temporal changes. Figure 5 illustrates a study of the authors' network throughout the course of a year in which they worked. In this case, the authors' relationship may be classified as annual. Six authors are linked. Shunn has been determined to be the author with the most connections. Meanwhile, current research, such as that conducted by Bathgate, is emphasized in yellow.

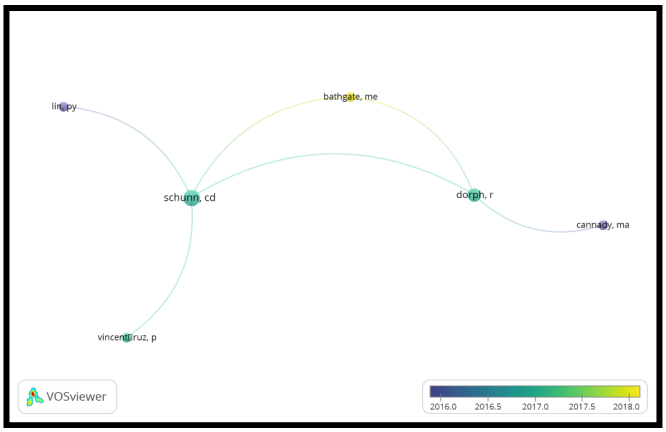

Figure 5. Visualization of the GS database's overlay authors and co-authorship relationships

The study's primary contribution is the number of citations. According to table 2, the papers of Guzey S. S et al. 2016 get the most citations. The purpose of this essay is to address the integration of STEM subjects into middle school life science: student learning and attitudes. This paper has been referenced in 124 other academic publications. Meanwhile, according to the statistics, there is one publisher that receives the most citations: Taylor & Francis.

Additionally, the publisher that supplied the greatest number of papers to this research was assessed. Twelve articles were published by large publishers, mainly Taylor & Francis, followed by Springer with ten, Wiley Online Library with nine, Journal.lww.com with six, and ERIC and Journals.sagepub.com with four apiece. Other publications often publish a single piece on this topic. Along with the number of papers published by each publisher, the subject is evaluated in terms of the journal's importance. The results from the top six journals that have articles on this subject. There are journals with the highest citation counts, including the Journal of Science Education and Technology. This demonstrates that publications on scientific reasoning are dispersed among various periodicals, while there are others as well.

The analysis overlay and density visualizations are used to uncover the key themes that run across each piece of study or body of knowledge. This is performed by the calculation of keyword pair co-occurrence (Liu et al., 2015). The research was carried out with the assistance of the VOS viewer application. Each cluster is associated with other words. This might suggest that the development of research on this subject is related. Additionally, network analysis permits the determination of the author's authority (Bilik et al., 2019). Joint author analysis is a common bibliometric technique for assessing authors who cooperate on research in a certain field.

Conclusion

Taken together, these data support this study's goal of determining what research trends exist in the science reasoning area during the last seven years. Certain terms that are not often used are expanded upon. As a consequence, additional topics may be generated with the help of these keywords. The factors listed above may assist in conducting a more complete investigation. The elements listed above may assist in conducting a more thorough analysis. Articles are retrieved by the PoP program from the General Serials database. Then, from 2015 through 2021, 100 articles were chosen. To accomplish the study goals, all publications were categorized by author, year of publication, publisher journal, citation count, and author. Depending on the author's objective, the possibility for science reasoning about students' critical thinking abilities in responding to HOTS questions may

be pursued. This is evident from the findings of the bibliometric study, particularly the display of the still-low density.

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