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Inquiry and Debate in Science Learning: Potential Strategy for Improving Students' Scientific Argumentation Skills

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Abstract

Scientific argumentation skills are a key component of science learning practices needed by students in the 21st century. Where the essence of scientific argumentation is to support the argument with evidence and reasoning and then refute the claims and evidence of the opponent's argument. Supporting arguments with evidence and reasoning can be facilitated through inquiry activities. Meanwhile, refuting claims and evidence from opposing arguments can be facilitated through debate activities. Inquiry and debate can be a solution to improving students' scientific argumentation skills. This study aims to prove the truth of this statement through a systematic literature review by applying the PRISMA 2020 criteria which are expanded by bibliometric analysis with the help of the VOSviewer software. The results of the study show that research related to inquiry, debate, and their influence on students' scientific argumentation skills has a pretty good trend. In Indonesia the research climate is still quite good, research topics are still in great demand, and it is very possible to carry out research innovations on related topics. Another finding is that the integration of inquiry and debate in science learning can be a potential strategy to improve students' scientific argumentation skills.

Introduction

Scientific argumentation is a higher-order thinking skill that is a major focus in education in the 21st century (Guilfoyle & Erduran, 2021; Noviyanti et al., 2021). This is because scientific argumentation is one of the skills that students must have to be successful in academics, careers, and life in the current era (Haug & Mork, 2021; Lobczowski et al., 2020; Noroozi et al., 2020; Noviyanti et al., 2019). These skills are needed in knowledge construction and contextual understanding (Greene et al., 2018; Jin & Kim, 2021; Larrain et al., 2019; Ping et al., 2020; Rahayu et al., 2020), and are closely related to critical thinking (Convertini, 2021; Giri & Paily, 2020; Hong & Talib, 2018; Kuhn, 2019), analytical thinking (Perdana et al., 2019), innovative thinking (Turabova, 2021), scientific reasoning (Sari & El Islami, 2020), scientific literacy (Archila et al., 2018; Chen, 2019; Yacoubian & Khishfe, 2018), supporting social collaboration (Henderson et al., 2018), and are also needed in expressing

opinions, making decisions, and solving problems in everyday life (Songsil et al., 2019).

Scientific argumentation is one of the core practices that must be applied in science learning (Loper et al., 2019; Mao et al., 2018; Mikeska & Lottero-Perdue, 2022). There are two types of arguments involved in learning science, the first is specific to science itself and the other is based on the view that learning requires dialogic interactions in explaining concepts, principles, laws, and/or theories in science. Argumentation from the point of view of science is the process of constructing knowledge through making claims, proving the truth of claims, and defending these claims from various contradictory criticisms (Osborne et al., 2019). This is what scientists do in constructing and defending their scientific ideas (Roviati & Widodo, 2019) by making, supporting, opposing, or enhancing scientific claims that lead to validation and credible conclusions based on empirical data and evidence (Evagorou & Osborne, 2013; Lin & Mintzes, 2010; Songsil et al., 2019).

Scientific argument is one of the skills that play an important role in constructing knowledge, which is rarely applied in the science learning process (Kurniasari & Setyarsih, 2017; Muna & Rusmini, 2021; Rahayu et al., 2020). This resulted in the dominant quality of students' scientific argumentation skills at level 1, namely arguments consisting of simple claims and students sometimes making claims based on inaccurate conceptual understanding (Wardani et al., 2018). This statement is also reinforced by findings based on a preliminary study conducted at a state university in East Java, Indonesia, which shows that 66.67% of students have scientific argumentation skills which are included in the low category. Where more than 50% of students can make claims quite well, but most students are still in the low category for the other four components of scientific argument, namely evidence, reasoning, counterclaim, and rebuttal (see Figure 1).

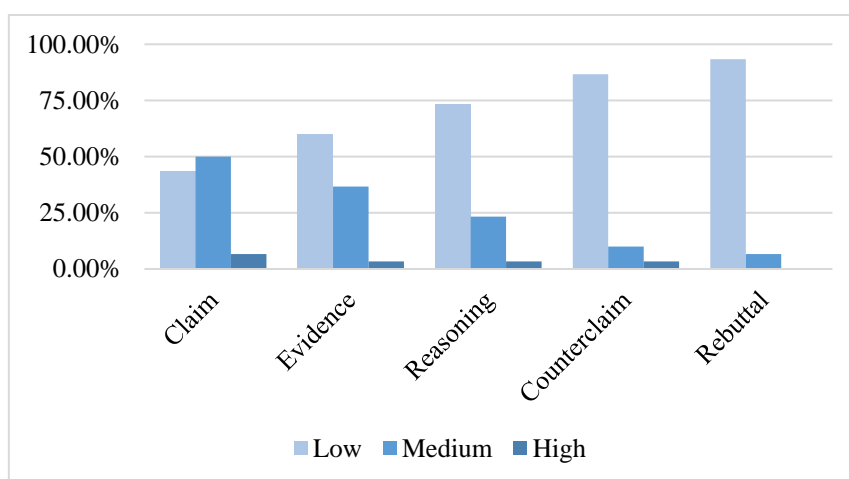


Figure 1. Quality of Students' Scientific Argumentation Skills

Improving students' scientific argumentation skills in science learning can be difficult to do. Teaching higher-order thinking skills, such as argumentation requires long-term and ongoing engagement (Guilfoyle & Erduran, 2021). This is because argumentation is a complex and time-consuming process. After all, argumentation requires the construction of rational and reasonable arguments (Archila et al., 2021). An argumentation schema is an inference pattern that connects a set of premises to a conclusion, which represents a stereotyped pattern of students' reasoning (Lawrence & Reed, 2020).

Providing opportunities for students to participate in productive scientific arguments requires a structured and scaffolding learning transformation (Mikeska et al., 2022). The learning strategy used should give students more opportunities to build and criticize arguments, make claims, and use evidence in the process of reasoning based on inquiry activities (Mikeska & Howell, 2020). To help achieve this transformation, educators must design learning designs that can support and increase student participation in the practice of scientific argumentation in science learning (Andrews-Larson et al., 2019; Conner, 2022; Siswanto et al., 2018; Wallon et al., 2018; Wambsganss et al., 2020).

Science learning designed to improve students' scientific argumentation skills must pay attention to that argument is the core practice of scientific inquiry. It consists of generating inquiry questions, planning investigations, collecting and analyzing data, and drawing conclusions (Driver et al., 2000; Duschl & Osborne, 2002; Ford, 2008; McNeill & Pimentel, 2009; Sampson et al., 2011). In the view of science, arguments supported by evidence play an important role in constructing explanations of natural phenomena (Jiménez-Aleixandre & Erduran, 2007). On the other hand, authentic science learning can be achieved by engaging in arguments based on scientific claims and evidence while conducting an inquiry, not just memorizing the knowledge imparted by the teacher (Driver et al., 2000; McNeill & Knight, 2013; Osborne et al., 2004). Therefore, the developed science learning design does not only focus on explaining concepts, principles, laws, and/or theories but must provide students with opportunities to engage in arguments which can be facilitated through inquiry activities.

Another thing that must be considered in developing science learning designs to improve students' scientific argumentation skills is the essence of argumentation (the process of building and criticizing arguments, and debating claims) is to support arguments with evidence and reasoning and then refute claims and evidence from opposing arguments (Woolfolk, 2016). Scientific argumentation can also be seen as a dialectical process involving construction and criticism, that is competence which is a complex reasoning process used in situations requiring knowledge of scientific content to establish and/or criticize proposed relationships between claims and evidence (Osborne et al., 2016). This requires a science learning design that sees arguments as having important components that require evidence of justification and denial or rebuttal. Debate is felt to be an alternative solution to facilitate this (Dawson & Carson, 2017; Felgenhauer & Xu, 2019; Lytos et al., 2022; Martini et al., 2021; Mohammed et al., 2019; Suraya et al., 2019; Turabova, 2021).

The debate can improve argument structure, content understanding, and students' knowledge (Torres & Cristancho, 2018). In learning activities, debate departs from a formal situation, where one party presents their argument and the other party has the opportunity to take turns rebutting it, to a more informal situation, where it is based on the opposing party's argument (Bonwell & Eison, 1991). Through debating activities, students not only defend their claims but also engage constructively with the arguments of their peers (Nielsen, 2013). This can create a need for students to respect each other's ideas by making the explicit goal of the activity the construction of a consensus, which can only be achieved if students are present and respond to claims and evidence that contradict each other (Berland & Reiser, 2011).

Based on the explanation previously described, inquiry and debate can be used as potential strategies in developing

science learning designs to improve students' scientific argumentation skills. This study aims to prove the truth of this statement through a systematic literature review. This study will examine and analyze significant research trends and issues that show the link between inquiry, debate, and their influence on students' scientific argumentation skills to obtain a hypothetical model for learning design that will be developed later. This is the first step in developing a science learning design to improve students' scientific argumentation skills.

Method

To obtain various information related to inquiry, debate, and its influence on students' scientific argumentation skills, the systematic literature review method (Snyder, 2019) is considered the most fulfilling the requirements. A systematic literature review aims to summarize the existing literature on inquiry, debate, and its influence on students' scientific argumentation skills through the synthesis and evaluation of selected articles. This method is carried out in four basic steps, namely searching, filtering, selecting (inclusion and exclusion), and extracting data based on the PRISMA 2020 criteria (Page et al., 2021). The literature extraction steps for this study are presented in Figure 2. The systematic literature review was also expanded with bibliometric analysis and evaluation with the help of VOSviewer software. This is used to identify relevant research trends and issues to construct hypothetical models for learning designs that will be developed later.

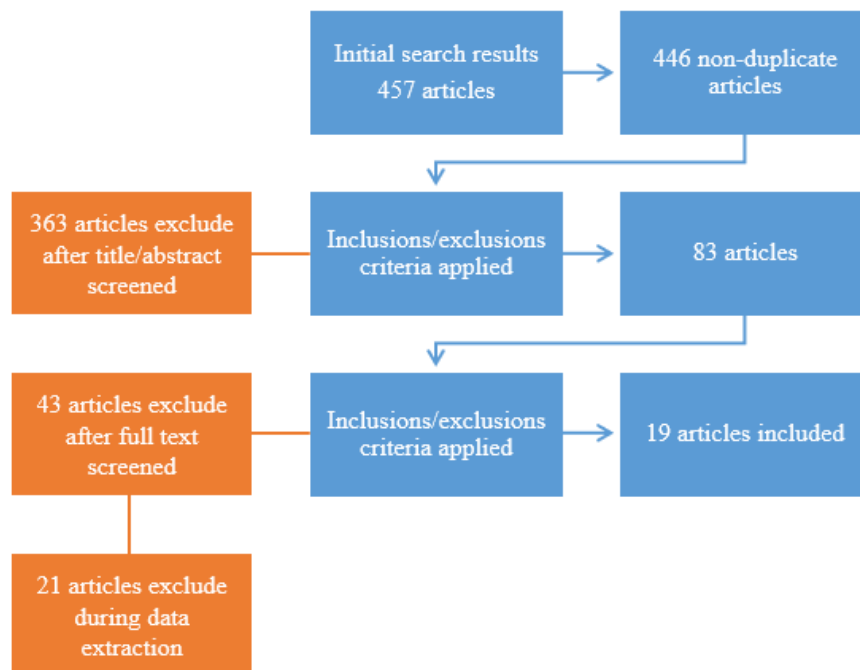


Figure 2. The Literature Extraction Steps

The search focused on articles that had been published in reputable international journals which were included in the Scopus database. A series of keywords that consider various terms including all subjects related to inquiry, debate, and their influence on students' scientific argumentation skills have been considered and determined to obtain as many publications with specific studies as possible. Various combinations of search terms, strings (such as 'argumentation*'), and Boolean operators (AND, OR, and NOT) have been used as a method of narrowing

down a large number of search results and ensuring their relevance for this study. Furthermore, the search process on the Scopus website is carried out using keywords (TITLE-ABS-KEY (inquiry) OR TITLE-ABS-KEY (debate) AND TITLE-ABS-KEY (student AND scientific AND argumentation AND skill) OR TITLE-ABS-KEY (scientific AND argumentation AND skill) OR TITLE-ABS-KEY (scientific AND argumentation)).

The literature search process aimed at all published articles before 2023, resulting in 457 related articles. After checking for duplication and exclusion of duplicate articles, 446 articles were obtained. Furthermore, an inclusion/exclusion process is carried out to ensure that each selected article comes from research results published in a reputable international journal (not from a book, book chapter, and/or conference proceedings) and is a quantitative article (Snyder, 2019). The first inclusion/exclusion process, in which the screening results were carried out on the titles and/or abstracts of the articles, resulted in 363 excluded articles and 83 selected articles. The second inclusion/exclusion process obtained that 43 articles were excluded after full-text screening and 21 articles were excluded during data extraction. The final results of data extraction obtained 19 articles for further analysis and study.

Results

The initial search of relevant literature with inquiry, debate, and its influence on students' scientific argumentation skills resulted in 457 related articles. The literature consists of several types of documents such as articles, conference papers, book chapters, reviews, books, conference reviews, editorials, notes, and short surveys. The types of documents, their frequency, and their percentage are presented in Table 1.

Table 1. Types of Documents Obtained Based on Initial Search

Type of Document	Frequency	Percentage
Article	295	64,55%
Conference Paper	68	14,88%
Book Chapter	35	7,66%
Review	32	7,00%
Book	14	3,06%
Conference Review	8	1,75%
Editorial	3	0,66%
Note	1	0,22%
Short Survey	1	0,22%
Total	457	100,00%

The information that can be obtained based on Table 1 is that the majority of the literature obtained is in the form of research publication articles. Other interesting information obtained based on the initial search results data are relevant published articles dominated by social science subjects (see Figure 3). This shows that research that is relevant to inquiry, debate, and its effect on students' scientific argumentation skills is mostly conducted in the educational sector.

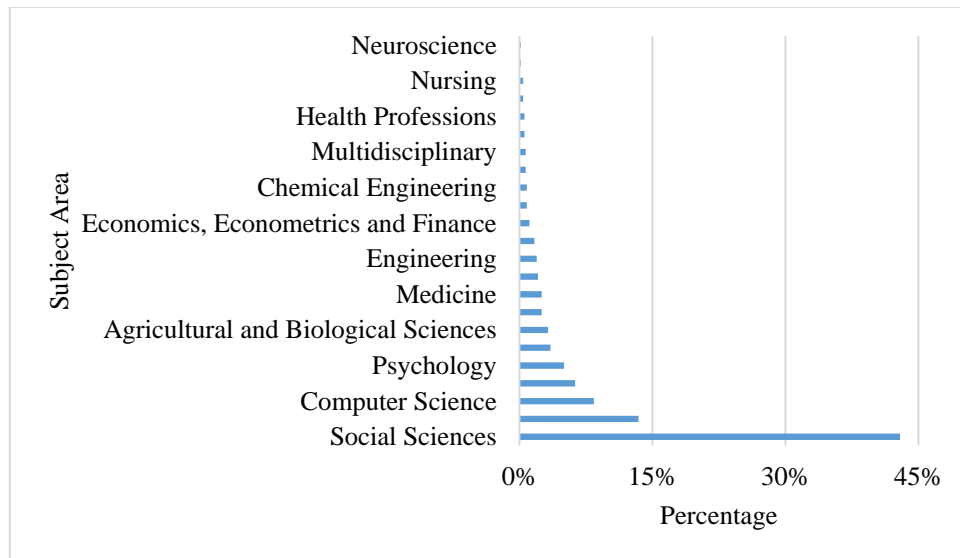


Figure 3. Documents Subject Area

Integration of inquiry and debate to improve students' scientific argumentation skills seems to be very rarely done. This is indicated by the limited number of articles that focus on the integration of inquiry and debate to improve students' scientific argumentation skills. The majority of research that has been done, that is inquiry and debate each stand alone in facilitating and improving students' scientific argumentation skills (see Table 2). Where Table 2 contains 19 articles on the final results of data extraction based on the PRISMA 2020 criteria. The selected articles will be analyzed and studied further to obtain the information needed, that is potential strategies for improving students' scientific argumentation skills involving inquiry and debate.

Table 2. Article Results of Final Data Extraction Based on the PRISMA 2020 Criteria

No.	Author(s) & Year	Grounded Theory	Research Area	Educational Target	Source Title
1	Agell et al. (2015)	Debate	Education-Science	High School Student	Journal of Biological Education
2	C.-H. Lin et al. (2018)	Inquiry	Education-Science-Technology	Elementary School Student	Journal of Computer Assisted Learning
3	Chin & Osborne (2010)	Inquiry	Education-Science	Middle School Student	Journal of Research in Science Teaching
4	Clark & Sampson (2007)	Inquiry	Education-Science-Technology	Middle School Student	International Journal of Science Education
5	Cramer & Dauphin (2020)	Debate	Education-Science	University Student	Journal for General Philosophy of Science
6	Gray & Kang (2014)	Inquiry	Education-Science	Middle School Student	International Journal of Science Education

No.	Author(s) & Year	Grounded Theory	Research Area	Educational Target	Source Title
7	Horng et al. (2013)	Inquiry	Education-Science	University Student	International Journal of Science Education
8	Johnson (2011)	Debate	Education-Science	University Student	Biochemistry and Molecular Biology Education
9	Katchevich et al. (2013)	Inquiry	Education-Science	High School Student	Research in Science Education
10	McNeill (2009)	Inquiry	Education-Science	Middle School Student	Science Education
11	Molinatti et al. (2010)	Debate	Education-Science	High School Student	International Journal of Science Education
12	Moon et al. (2017)	Inquiry	Education-Science	Elementary School Student	Journal of Research in Science Teaching
13	Nam & Chen (2017)	Inquiry	Education-Science	University Student	EURASIA Journal of Mathematics Science and Technology Education
14	Stanford et al. (2016)	Inquiry	Education-Science	Elementary School Student	Journal of Chemical Education
15	Telenius et al. (2020)	Inquiry	Education-Science	High School Student	Education Sciences
16	Vörös (2020)	Debate	Education-Science	High School Student	Canadian Journal of Physics
17	Walker et al. (2019)	Inquiry	Education-Science	University Student	Journal of Chemical Education
18	Y.-R. Lin (2019)	Debate	Education-Science-Technology	High School Student	Computers & Education
19	Ziman (2000)	Debate	Education-Science	Community	Social Epistemology

Discussion

The practice of learning science focuses more on developing scientific thinking skills than memorization skills, which places great emphasis on scientific practices such as argumentation (Boğar, 2019). As conceptualized in the literature, scientific argumentation emphasizes the importance of students' social and epistemic interactions for the purpose of developing and critiquing knowledge (Grooms et al., 2018). This plays an important role in learning science because with a heuristic approach, students can achieve conceptual and epistemic goals, and the argumentation process can foster students' scientific thinking and reasoning in the process (Osborne et al., 2004; Ural & Gençoğlan, 2019).

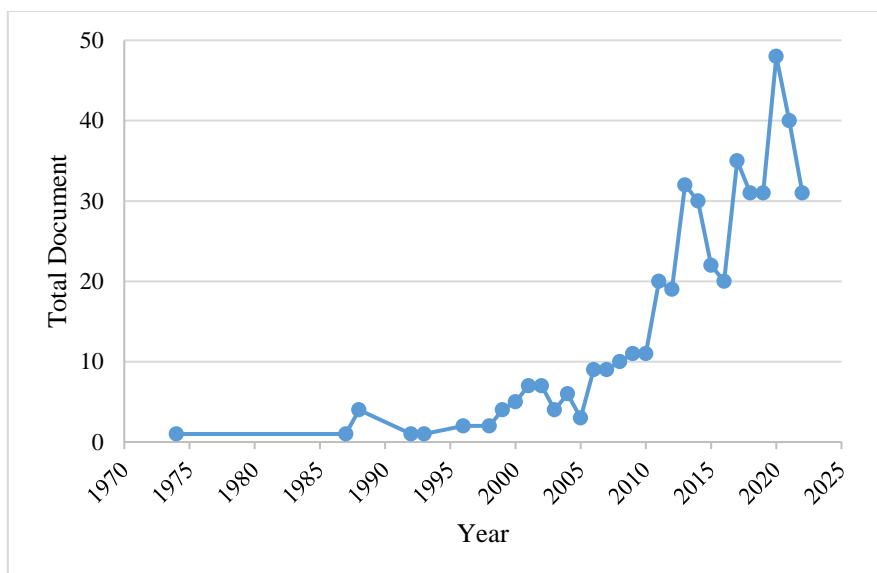


Figure 4. Trends in Related Research Publications

Scientific argumentation skills are a key component of science learning practices (Osborne et al., 2019) that students need in the 21st century (Haug & Mork, 2021; Lobczowski et al., 2020; Noroozi et al., 2020; Noviyanti et al., 2019). This makes scientific argumentation skills a focus of research in the last few decades. Based on the initial search results, information was obtained that articles that were relevant to inquiry, debate, and their influence on students' scientific argumentation skills were first published in 1974, reached their peak in 2020, and continue to this day (see Figure 4). This indicates that related research trends continue to develop and opportunities for development and innovation in this research are still very open.

The flow of scientific argumentation research as a 21st-century skill continues to move forward and develop (Henderson et al., 2018). This makes scientific argumentation a central issue among science education experts and researchers (Kim & Roth, 2018; Nazidah et al., 2022; Valero Haro et al., 2019; Wang et al., 2022; Wulandari et al., 2019). The concept of scientific argumentation has subsequently become a core competency in the process of science education and learning and has become an attraction among policymakers in various parts of the world (Admoko et al., 2021; Henderson et al., 2018). Based on the initial search results, it is known that the top five countries for related research publications are the United States, United Kingdom, Spain, Indonesia, and Germany (see Figure 5). An interesting finding is that Indonesia is one of the top five most productive countries in research publications related to inquiry, debate, and their influence on students' scientific argumentation skills. This shows that in Indonesia, a similar research climate is still quite good, the research topic is still in great demand, and it is very possible to carry out research innovations in related topics.

Bibliometric analysis and evaluation were applied to the initial search results to identify related research issues and topics. This is the application of various methods to ascertain qualitative and quantitative changes in the subject of scientific research, the establishment of a profile of publications for a particular subject, and the identification of structural aspects and trends in a discipline that is the subject of bibliometrics (Bahri et al., 2022; Huertas-Valdivia et al., 2020; Suseelan et al., 2022). The results of the bibliometric analysis map based on the help of the VOSviewer software are presented in Figure 6.

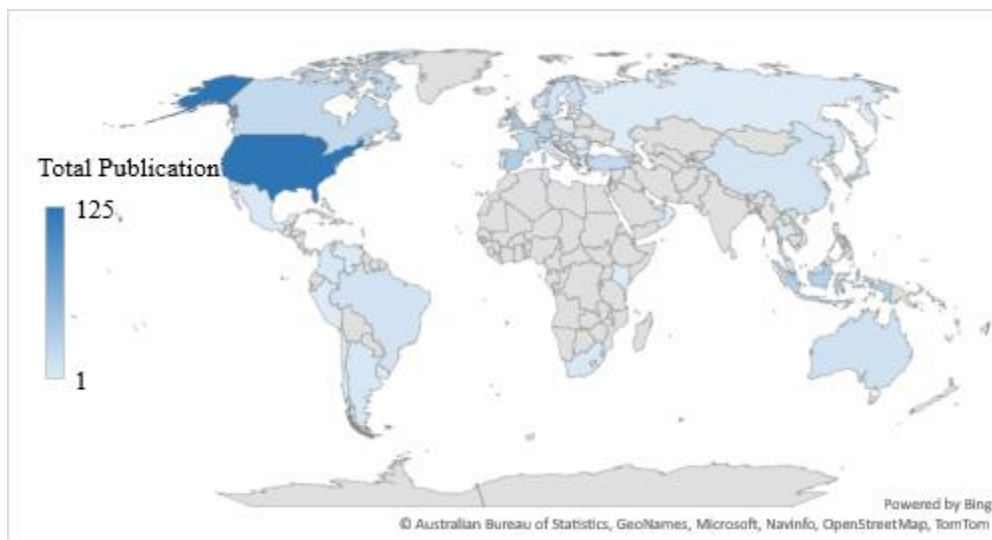


Figure 5. Geographical Distribution of Publications

VOSviewer analysis based on the initial search results data obtained information that there are 10524 terms, 262 meet the threshold. For each of the 226 terms, then the relevance score is calculated. Based on these scores, the most relevant terms will be selected. The default choice of VOSviewer is to select 60% most relevant terms. The results of the analysis selected 157 terms that met the requirements.

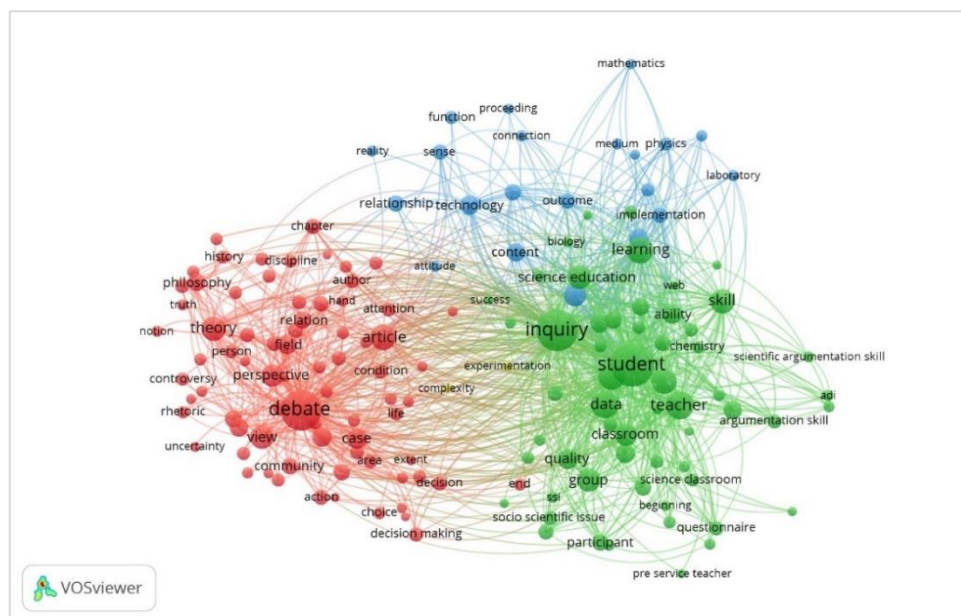


Figure 6. Keyword Network Maps

Terms that meet the requirements are divided into four clusters which are illustrated in a different color for each cluster (see Figure 6). Of the four clusters, three of them are large clusters. The first cluster is red, which describes the relationship between standard terms based on the analytical framework, namely debate, perspective, theory, philosophy, view, field, case, value, community, article, controversy, uncertainty, history, decision, etc. The second cluster is green, which describes the relationship between standard terms based on the unit of analysis,

such as students, teacher, classroom, inquiry, learning, skill, argumentation skill, scientific argumentation skill, science education, participant, data, quality, group, student ability, preservice teacher, etc. The third cluster is blue, which describes the relationship between standard terms based on practical or operational values, namely function, implementation, technology, relationship, content, effect, effectiveness, project, outcome, laboratory, high school student, etc. The last cluster is yellow, which is a minor cluster that contains complexity and experimentation.

The terms which are divided into four clusters describe the scope and subject area of students' scientific argumentation skills. Where the scope emphasizes activities that show the role of scientists, argumentation goals, and scientific evidence in the process (Aydeniz & Ozdilek, 2015). Therefore, there are many terms such as laboratory, theory, uncertainty, controversy, perspective, view, case, and a project which describe activities that show the role of scientists. The terms debate, skill, argumentation skill, scientific argumentation skill, decision, student, teacher, classroom, learning, and science education describe the argumentation goals. The terms inquiry, data, and experimentation describe scientific evidence in the process. Moreover, given that the research that emerges is in a variety of different subject areas (see Figure 3), it is not surprising that researchers also use a variety of units of analysis, analytic frameworks, and operational definitions in their studies (Henderson et al., 2018).

A series of processes of searching, filtering, selecting (inclusion and exclusion), and extracting the literature that has been carried out resulted in 19 final articles. Analysis of the article obtained information that 2 grounded theories are used in improving students' scientific argumentation skills, namely inquiry and debate. Where 12 articles use inquiry as grounded theory ((Chin & Osborne, 2010; Clark & Sampson, 2007; Gray & Kang, 2014; Horng et al., 2013; Katchevich et al., 2013; C.-H. Lin et al., 2018; McNeill, 2009; Moon et al., 2017; Nam & Chen, 2017; Stanford et al., 2016; Telenius et al., 2020; Walker et al., 2019) and 7 articles using debate as grounded theory (Agell et al., 2015; Cramer & Dauphin, 2020; Johnson, 2011; Y.-R. Lin, 2019; Molinatti et al., 2010; Vörös, 2020; Ziman, 2000) (see Table 2).

Inquiry and argumentation are the main components of the science learning process that can be used to provide tutoring and enable students to acquire scientific ways of thinking and practice, as well as encourage the development of the knowledge and skills needed to form a meaningful understanding of science concepts (Aldahmash & Omar, 2021; Zhai et al., 2020). Inquiry-based learning is defined as a multifaceted construction, which in the learning process integrates various components such as conceptual, social, procedural, and epistemological activities (Forbes et al., 2020). It has tremendous potential in developing and improving students' scientific argumentation skills (Akili et al., 2022; Andrews-Larson et al., 2019; Conn et al., 2020; Hendratmoko et al., 2016; Mariam et al., 2020; Muntholib et al., 2021; Nam & Chen, 2017; Pitorini et al., 2020; Psycharis, 2016; Rohayati et al., 2022; Roja et al., 2020; Sandhy et al., 2018; Septyastuti et al., 2021; Stanford et al., 2016).

Studies show that scientific knowledge develops through processes of decision-making and discovery, and that argumentation is an important part of the practice of science itself. Therefore, students must be supported in understanding the practice of scientific argumentation as part of learning about scientific inquiry (Clark &

Sampson, 2007). Just as scientific knowledge is constructed based on different modes of inquiry (e.g. experimental or historical), arguments constructed during science lessons can also vary depending on the mode of inquiry that underlies the topic of the argument (Gray & Kang, 2014). The inquiry mode that underlies the arguments based on the selected articles (see Table 2) is presented in Figure 7.

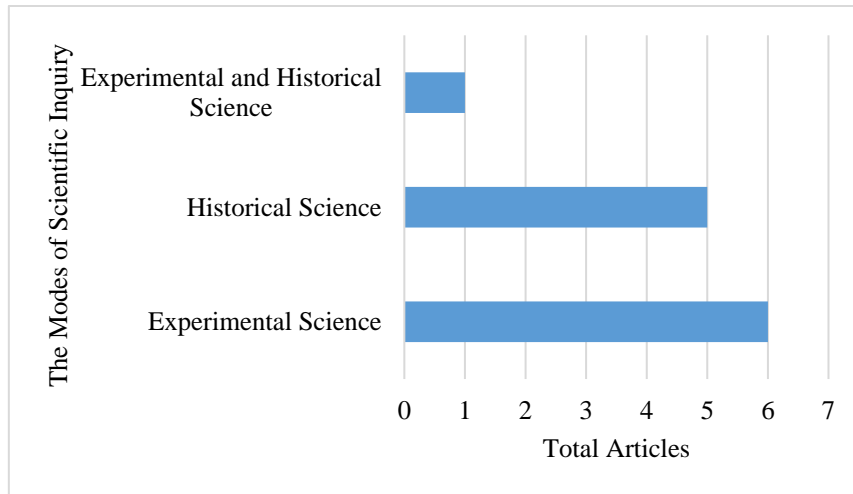


Figure 7. Inquiry Modes Underlying Arguments

According to Gray & Kang (2014), experimental science is done by asking questions to trigger the emergence of experimental activities. In this mode, arguments are built through controlled experiments in which natural phenomena are manipulated, often to test the truth of a theory. Theories are evaluated based on the consistency between predictions and experimental results, as well as the ability to generalize to various phenomena in various contexts. Meanwhile, historical science collects evidence through observation because direct experimentation is usually not possible. This mode makes use of observational evidence to investigate ultimate causes from the past whose effects must be interpreted from complex causal sequences of events. Thus, arguments are often based on adequate explanations rather than successful predictions because they are based on the study of complex and unique entities that have a low probability of repeating correctly. The comparison between experimental and historical science by adapting from Dodick et al. (2009) is presented in Table 3.

Table 3. Comparing Experimental and Historical Sciences

	Experimental Science	Historical Science
Epistemic goals	To build an argument from a general theory or statement	To build arguments from ultimate and contingent causes
The nature of the observed object	Uniform and interchangeable entity	Complex and unique entity
Methods of constructing evidence for an argument	Manipulation of nature	Observation of nature
Quality standards	Based on effective claims	Based on an effective explanation

Findings from Gray & Kang (2014) reveal that less and sometimes no evidence is used to support claims during

the experimental mode, while more evidence is used during the historical mode. Other findings suggest that different modes of inquiry in which the complexity and scope of the topic can affect the amount of evidence presented. The arguments developed based on the two modes of inquiry are rather simple in structure because they lack qualifiers and rebuttals. Despite the simple structure, the resulting arguments reflect the inherent differences between the two modes of inquiry. Therefore, the differences between the two modes can offer a starting point for generating a variety of scientific arguments in science learning.

In the context of scientific argumentation, students gain knowledge through a series of confirmations by presenting the results of investigations, discussions related to the results of scientific investigations and debates (Fakhriyah et al., 2021). Debate is an active learning strategy that encourages students to develop knowledge, skills, and see topics from various perspectives (Wolla, 2018). Integrating debate into learning activities is one of the innovative methods to promote the development of critical thinking skills, communication, public speaking, research methods, and collaboration (Lampkin et al., 2015), and is proven to be able to facilitate and improve students' scientific argumentation skills (See Table 2). In addition, debate in science learning can also improve argument structure, content understanding, and help increase students' knowledge (Torres & Cristancho, 2018).

The debate between peers appears to be a pedagogical strategy to help students think about open and complex problems and to develop argumentative skills (Molinatti et al., 2010). Where the application of debate in science learning activities can ultimately affect the improvement of students' scientific argumentation skills (Dawson & Carson, 2017; Felgenhauer & Xu, 2019; Lytos et al., 2022; Suraya et al., 2019; Turabova, 2021). However, to bring up debate in science learning activities, learning scenarios using certain topics are needed (Ziman, 2000). Several topics that can become topics of debate that are known based on the results of a literature review (see Table 2) are presented in Figure 8.

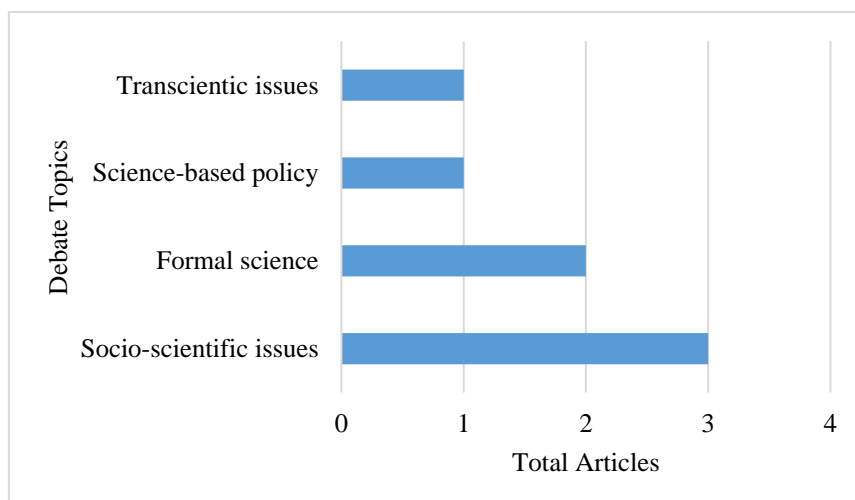


Figure 8. Debate Topics in Improving Students' Scientific Argumentation Skills

Based on Figure 8, it is known that four topics can be used to generate debate in science learning activities. These topics are transcientific issues (Ziman, 2000), science-based policy (Vörös, 2020), formal science (Cramer &

Dauphin, 2020; Johnson, 2011), and socio-scientific issues (Agell et al., 2015; Y.-R. Lin, 2019; Molinatti et al., 2010). Socio-scientific issues seem to be a topic that is often used as a stimulus in debate activities in the classroom.

The topic of the debate is also used to condition students into two groups that are debating with each other. These groups are affirmative groups and opposition groups on certain topics. In general, it is assumed that students who argue in affirmative or oppositional positions when participating in two-sided debate activities have the same opportunity to argue. However, it was reported that students who took oppositional positions were more active and critical than students who took affirmative positions, especially in the context of scientific argumentation (Y.-R. Lin, 2019). Therefore, more attention must be given to affirmative groups to construct critical arguments like the opposition groups.

Scientific argumentation is a skill that has a structure consisting of various components. Based on a literature review, the structure of scientific argumentation commonly used in science learning consists of three components, namely claims, data or evidence, and warrants or justification or reasoning (Gouvea et al., 2022; Hardwicke & Ioannidis, 2019; Henderson et al., 2018; McNeill et al., 2018; Sampson & Schleigh, 2013). This structure is a simple argumentation structure that only focuses on building arguments for itself. This simple structure can become more complex if counterclaims and rebuttals are added which are advanced argumentation structures (Anisa et al., 2019b) and can produce high-level arguments (Akbayrak & Namdar, 2019). Counterclaims and rebuttals are key elements in argumentation, this is a skill to oppose arguments by presenting counterarguments. It is an important skill, not easy to learn, and valued in many fields such as politics and science (Orbach et al., 2019). When these are added, the arguments become more complex and increase the quality of students' scientific argumentation (Anisa et al., 2019; Capkinoglu et al., 2020).

The grounded theory that is used in argumentation is generally adapted to the structure of the argument to be trained in students. The inquiry has advantages in facilitating claims, evidence, and reasoning. However, the inquiry is not good enough to generate counterclaims and rebuttals. This is to the findings of Hakim et al. (2020) which state that inquiry-based learning can train scientific attitudes, facilitate investigations to find scientific evidence, develop explanations based on scientific evidence, and familiarize students with discussions in accepting and rejecting opinions which will ultimately have an impact on the quality of students' scientific arguments.

Meanwhile, the debate makes it possible to facilitate and increase claims, reasoning, counterclaims, and rebuttals. However, the debate has not provided sufficient opportunities for students to find evidence. This is because the debate is the practice of speaking skills and intelligent behavior in dealing with different points of view (Pudjantoro, 2015). This can encourage students to convey, refute, and defend ideas or opinions (Al Giffari et al., 2021; Darman, 2022; Wagu & Riko, 2020). Both inquiry and debate have their advantages and disadvantages in facilitating students' scientific argumentation skills. The relationship between inquiry, debate, and scientific argumentation skills based on bibliometric analysis with the help of VOSviewer software is presented in Figure 9.

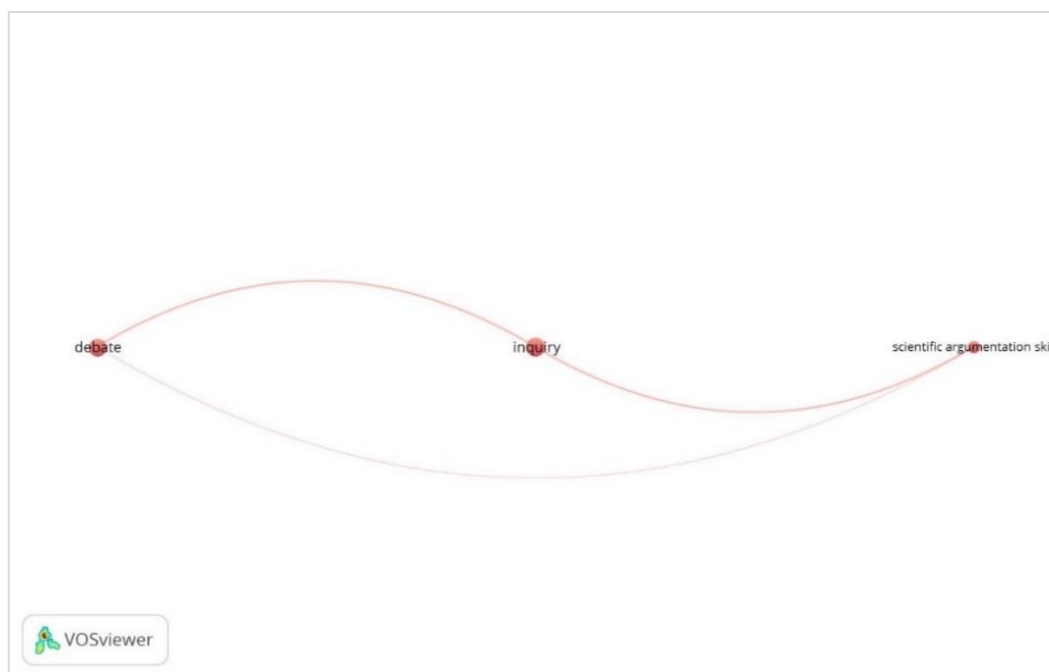


Figure 9. The Relationship of Inquiry, Debate, and Scientific Argumentation Skills

Figure 9 shows that inquiry and debate can influence students' scientific argumentation skills. The debate does not have a more significant effect on students' scientific argumentation skills than inquiry. This is because most research that applies debate emphasizes the claim vs claim aspect or generates counterclaims rather than focusing on constructing effective arguments. Interestingly, based on Figure 9, the debate has a fairly strong relationship with the inquiry. However, based on the data in Table 2, there is no integration of debate and inquiry as a grounded theory for argumentation. Debate and inquiry each stand alone in facilitating and enhancing students' scientific argumentation skills. Figure 9 and data in Table 2 indicate that there are opportunities for development and innovation in research by integrating inquiry and debate in improving students' scientific argumentation skills. It can also bring out the novelty of the research.

Integration between inquiry and debate can be a potential strategy in optimally improving students' scientific argumentation skills. Through inquiry activities, students can construct scientific arguments for themselves. Furthermore, the arguments that have been constructed are then brought into debate activities to bring up counterclaims and rebuttals which are components of complex scientific argumentation. Therefore, as a follow-up to this study, it is suggested to develop a science learning design that integrates inquiry and debate. Where the learning design can be a potential strategy for improving students' scientific argumentation skills.

Conclusion

Scientific argumentation skills are a key component of science learning practices needed by students in the 21st century. Where the essence of scientific argumentation is to support the argument with evidence and reasoning and then refute the claims and evidence of the opponent's argument. Supporting arguments with evidence and reasoning can be facilitated through inquiry activities. Meanwhile, refuting claims and evidence from opposing

arguments can be facilitated through debate activities. Based on the literature review, it was concluded that the implementation of inquiry and debate in science learning can facilitate and improve students' scientific argumentation skills.

Research trends related to inquiry, debate, and their influence on students' scientific argumentation skills continue to grow today. Opportunities for development and innovation in this research are still very open. Especially to be carried out in Indonesia, where a similar research climate is still quite good, the research topic is still in great demand, and it is very possible to carry out research innovations in related topics.

The results of a systematic literature review by applying the PRISMA 2020 criteria and bibliometric analysis with the help of the VOSviewer software show that the integration of inquiry and debate in science learning can be a potential strategy for improving students' scientific argumentation skills. Through inquiry activities, students can construct arguments for themselves. Furthermore, the arguments that have been constructed are then brought into the debate to bring up more complex scientific arguments. Integration of inquiry and debate in science learning can also bring out the novelty of research related to students' scientific argumentation skills.

Recommendations

Based on the conclusions from the studies that have been conducted, it is known that the integration of inquiry and debate in science learning can be a potential strategy for improving students' scientific argumentation skills. Therefore, as a follow-up to this study, it is suggested to develop a science learning design that integrates inquiry and debate to improve students' scientific argumentation skills. The development of the learning design can also be an innovation and have novelty in research related to students' scientific argumentation skills.

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