



Systematic Literature Review: Students' Scientific Argumentation Skills in Chemistry Learning

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Abstract

Developing argumentation skills through learning activities needs to be done with the aim that students can provide rational explanations accompanied by the right reasons. Argumentation skills guide students in including evidence, facts and the right theory to support statements to solve a problem. The topic of scientific argumentation skills is important to research. This study aims to identify, evaluate, and review articles from 2014 - 2024 that have the topic of scientific argumentation skills. The method used in this research is *Systematic Literature Review* (SLR) with supporting questions, namely, factors that affect students' scientific argumentation skills. This research provides an overview of the condition of students' scientific argumentation skills in chemistry learning. The low argumentation ability of students is caused by several factors including students' understanding of the material tested, students' lack of involvement in activities that contain argumentation, cognitive skills and students' experience.

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INTRODUCTION

Chemistry is one of the lessons that has abstract and complex concepts that make it difficult for students to understand these concepts. Understanding of chemistry concepts owned by students is still far from the expected goals. Chemistry learning tends to discuss concepts, laws and theories without presenting the process of discovering a concept, law, and theory. This makes the absence of a scientific attitude that grows and develops in students (Khery, et. al, 2016). The level of success of an educator can be seen from the learning activities in which consist of teachers and students. This can be seen from the existence of maximum learning outcomes in learning as one of the keys to success in the learning process (Syafi'i. et al, 2018).

Chemistry learning in the 2013 Curriculum is described by four Core Competencies (KI), namely KI-1, KI-2, KI-3, and KI-4. KI-1 is an emphasis on the formation of spiritual values related to the appreciation and experience of religious teachings embraced by students. KI-2 is the formation of attitudes related to the appreciation and experience of honest, disciplined, responsible, caring, polite, responsive and proactive behavior. KI-3 is the mastery of science that emphasizes on the understanding, application, and analysis of factual, conceptual, and procedural knowledge based on curiosity. KI-4 is the development of KI-3 which emphasizes the formation of the ability to process, reason, and present in the concrete and abstract domains (Permendikbud R. I. No. 69 of 2013). Meanwhile, the Merdeka Curriculum has specific learning outcomes in each phase. In achieving the objectives of these chemistry learning outcomes through the development of a number of existing knowledge, it aims to build noble morals and scientific attitudes such as honesty, objectivity, critical reasoning, creativity, independence, innovation, mutual cooperation, and global diversity (Kemdikbud Ristek, 2022).

Understanding concepts in chemistry learning can also be applied to help students in argumentation that can be adapted to existing chemical concepts. However, of the many objectives written in the learning outcomes of

understanding chemistry in the Merdeka curriculum, there is no aspect of developing students' scientific argumentation skills. Argumentation skills are needed to support students to achieve the end of learning objectives. Argumentation skills involve elaboration, reflection and reasoning for students. In addition, argumentation skills can make students learn argumentative structures and foster collaboration skills based on social awareness (Agusni, et. al, 2023). Developing argumentation skills through learning activities needs to be done with the aim that students can provide rational explanations accompanied by appropriate reasons. Argumentation skills guide students in including evidence, facts accompanied by the right theory to support statements to solve a problem (Robertshaw & Campbell, 2013). The low scientific argumentation ability of students is caused by several things, namely, the lack of understanding of the concept of material by students, the lack of cognitive skills of students, and the learning experience of students (Zaroh, et. al, 2022).

This study aims to systematically review the latest research results on scientific argumentation skills from 2014 to 2024. The articles reviewed are categorized on factors that influence scientific argumentation skills. The research questions made to guide the research were to identify the factors influence scientific argumentation skills in chemistry learning.

METHODS

The method used in this research is SLR (Systematic Literature Review). Researchers conducted this research by reviewing, evaluating, and interpreting articles from available research. This research used an online article search on Google Scholar. Based on the keywords used, namely "scientific argumentation skills" and "chemistry learning", 10 vulnerable articles were obtained from 2014 - 2024.

Data Collection Technique and Instrument

The data collection technique used in this research is purposive sampling. Data collection was carried out in several stages. The first stage was the search for articles related to the research topic to be studied, which then found 17 scientific articles with the keyword "scientific argumentation skills". The articles were then re-selected to separate the search for suitable articles. After selection, 10 articles were obtained that were suitable with the research topic discussed. A total of 7 articles were deleted because the method, and research objectives were not in accordance with the topic to be studied.

The collected articles were then analyzed using the descriptive analysis method. Descriptive analysis was conducted by examining the information and facts contained in each article.

FINDINGS AND DISCUSSION

Scientific argumentation is a person's ability to formulate a question accompanied by scientific evidence and reasons with the aim of providing justification for a belief, behavior, or value, defending and also influencing others (Farida, 2014). From this understanding, it can be concluded that scientific argumentation is an ability to string related sentences based on a statement that is considered true, with the aim of comparing relevant theories, presenting logical reasons, and supporting data. Scientific argumentation also provides justification for a belief, behavior, or value. Basically, scientific argumentation aims to influence others with scientific evidence and based on valid data.

The importance of applying scientific argumentation skills is so that students have argumentation skills gradually in solving problems. Learners who have argumentation skills can establish sociocultural activities by providing explanations, criticisms, and revisions to an argument. Learners also become easier and dare to express their ideas well because they are based on supporting evidence. Improving concept understanding and reasoning will be easier with supporting evidence found by students themselves (Handayani & Sardianto, 2015). Learners need specific skills to actively engage in scientific argumentation. These include the ability to understand and use conceptual frameworks when arguing about scientific issues as well as the appropriate use of basic knowledge to evaluate claims, and the skill of conveying ideas in a process of social interaction (Faize et. al, 2017).

Various studies have been conducted previously on the scientific argumentation skills of students in chemistry learning. Based on the articles that have been reviewed, there are several factors that affect the ability of scientific argumentation. The results of research related to scientific argumentation are presented in Table 1.

Table1 . Research related to scientific argumentation

Research and Year	Journal	Result Description
Wahdan <i>et al.</i> (2017)	Journal of Chemistry Learning	Based on the research conducted, the ability of scientific argumentation between SMA and MA students has a sufficient category. Some students use data that is not accompanied by scientific explanations to support <i>claims</i> . While the ability of scientific argumentation in students has a sufficient category. However, the results of the analysis of student answers have fulfilled the <i>claim</i> accompanied by <i>data</i> , <i>warrant</i> , and <i>backing</i> .
Sari & Nada (2021)	NCOINS: National Conference of Islamic Natural Science	The results showed that the average student's argumentation skills were at level 1-2 with a moderate category. So that there is a need for activities that involve argumentation skills and concept understanding.
Rahman <i>et al.</i> (2018)	Journal of Education: Theory, Research, and Development	Based on the research conducted, the average quality of students' scientific argumentation is at levels 1 and 2 in the middle and lower categories. Most students answer questions with intuition and verbal language to express reasons for a problem so that the quality of scientific argumentation cannot be identified.
Utami <i>et al.</i> (2022)	Journal of Education: Theory, Research, and Development	The results of scientific argumentation in students with experimental classes using the ADI method are higher than those in control classes using the inquiry method. Most students were at level 2 and 3 at the time of the posttest. Most were only able to express <i>claims</i> during the pretest but, during the posttest, most students were able to express <i>claims</i> , <i>data</i> , and <i>backing</i> .
Zaroh <i>et al.</i> (2022)	ORBITAL: Journal of Chemical Education	The results show that students have not been able to observe and analyze the evidence implied in the experimental data or questions. Students have not been able to provide evidence that supports the claims mentioned.
Siska <i>et al.</i> (2020)	Edu Sains: Journal of Science and Mathematics Education	The SSI approach can improve students' scientific argumentation skills. This is because the SSI learning process presents issues from the perspective of scientific knowledge so that students are required to evaluate the social issues presented.
Akili <i>et al.</i> (2022)	JIPK: Journal of Chemical Education Innovation	Based on the results of the scientific argumentation skills test given to a number of students, it shows that students' scientific argumentation skills are still relatively low. This is shown in making an argument students do not provide evidence and justification for the <i>claims</i> they make.
Haruna & Nahadi (2021)	JIPK: Journal of Chemical Education Innovation	The results showed that the ability to argue is closely related to the ability of students to answer critical thinking questions, however, some students still have weaknesses in the

Research and Year	Journal	Result Description
Parlan <i>et al.</i> (2020)	TADRIS: Journal of Keguruan and Tarbiyah Science	K4 criteria, namely the ability to analyze problems. Based on the research that has been conducted, students' ability to distinguish statements that include claims, evidence and explanations is very good. However, students' ability to provide explanations is the lowest compared to the other two aspects. Some students had difficulty in providing relevant explanations as to why evidence can support claims.
Devi <i>et al.</i> (2018)	JKPK: Journal of Chemistry and Chemical Education	Student argumentation on buffer solution material is mostly at level 2 with the category of arguments only containing <i>claims</i> without data. Students' argumentation skills appear mostly during discussions.

The scientific argumentation skills used were proposed by Toulmin, known as the *Toulmin Argumentation Pattern* (TAP). TAP has several aspects including *claim*, *data*, *warrant*, *qualifier*, *backing*, and *rebuttal* (Amelia *et al.*, 2023). A claim is a statement submitted in response to an issue. Data is evidence supporting the claim. *Warrant* is evidence that states the relationship between claims and data. *Backing* is the support of the *warrant*, and *qualifier* is a term that indicates the possible nature of the claim (Wahdan *et al.*, 2017). Based on the articles reviewed, most of them state that students' argumentation skills are still relatively low. Learners tend to express arguments with data without being accompanied by supporting claims (Wahdan *et al.*, 2017). This is influenced by several factors presented in Table 2.

Table 2 . Factors affecting scientific argumentation skills

Research and Year	Journal	Factors that influence
Wahdan <i>et al.</i> (2017)	Journal of Chemistry Learning	Factors that influence scientific argumentation skills are students' understanding of the material and students' involvement in argumentation activities.
Sari & Nada (2021)	NCOINS: National Conference of Islamic Natural Science	During the online learning process, students have difficulty understanding the material, are shy to ask questions, and are not used to <i>arguing</i> .
Rahman <i>et al.</i> (2018)	Journal of Education: Theory, Research, and Development	Factors caused include different school conditions, different teaching teachers, student abilities and teacher supervision factors when the test is carried out. Some students have forgotten the material taught.
Utami <i>et al.</i> (2022)	Journal of Education: Theory, Research, and Development	Factors that cause weak scientific argumentation skills include students being easier to submit claims and evidence rather than rebuttal and warrant.
Zaroh <i>et al.</i> (2022)	ORBITAL: Journal of Chemical Education	Weak scientific argumentation skills can be caused by three things, namely, students' conceptual understanding, students' cognitive skills, and students' learning experiences.
Siska <i>et al.</i> (2020)	Edu Sains: Journal of Science and Mathematics Education	Little knowledge or insight makes it difficult for learners to provide scientific data, even minimal understanding of concepts can make it difficult for learners to provide scientific data to support claims.

Akili et al. (2022)	JIPK: Journal of Chemical Education Innovation	Factors that influence the low argumentation skills are in the learning tools that emphasize more on students' concept understanding and no development of scientific argumentation skills.
Haruna & Nahadi (2021)	JIPK: Journal of Chemical Education Innovation	The weakness found in the way students argue is the lack of ability of students to identify the data provided in relation to the claims stated. Students actively discuss without considering the claim.
Parlan et al. (2020)	TADRIS: Journal of Kejuangan and Tarbiyah Science	The main cause of students' low scientific argumentation skills is due to the lack of students practicing and presenting their arguments. Teacher learning in the classroom is dominated by conventional models so that students have little opportunity to argue with their peers.
Devi et al. (2018)	JKPK: Journal of Chemistry and Chemical Education	Factors that influence students' argumentation skills include students' prior knowledge.

The low and weak scientific argumentation skills of students are caused by students' understanding. Several articles state that students' understanding greatly affects the existence of scientific argumentation skills (Siska et al., 2020). Skills and habituation of argumentation skills in learning are also one of the factors for the low scientific argumentation skills of students (Wahdan et al., 2017). The online learning process can also affect students' argumentation skills. As a result, learners' involvement in participating in learning is hampered. Learners have difficulty and tend to be embarrassed to ask questions (Sari & Nada, 2021). Many learners' statements given when stating argumentation are still not fulfilled. Learners are more focused on identifying the data provided without paying attention to claims, backing, and rebuttal (Haruna & Nahadi, 2021; Siska et al., 2020; Utami et al., 2022). The number of studies that state the low scientific argumentation skills of students in chemistry learning, so further research is needed to investigate more factors that affect students' scientific argumentation skills.

CONCLUSION

Based on the results and discussion that has been presented, it can be concluded that the scientific argumentation skills of students are still relatively low. This is accompanied by several factors including students' understanding of the material tested, students' lack of involvement in activities that contain argumentation, cognitive skills and students' experience. Learners find it easier to submit claims and butts than to state rebuttal and warrant. Thus, it is necessary to apply the right learning strategies, learning media, and learning models that can support students' scientific argumentation skills so that they can improve students' argumentation skills.

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