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The Effect of Problem Based Learning Model in Improving Students Argumentation Skills: Systematic Literature Review

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Abstract
The purpose of this study is to determine the application of the Problem Based Learning (PBL) learning model affects the ability in learning chemistry in high school. The research was conducted through a literature review from various reliable sources published in 2020-2024. Compared to the traditional learning model, the application of PBL improves students' argumentation skills consistently. This improvement can be seen from the increase in post-test mean scores, N-Gain scores, and mastery of argumentation metrics such as claims, justifications, and refutations. In addition, the PBL model showed better results when used together with learning media, STEM approaches, or group discussions. Therefore, PBL helps students in problem-solving, critical thinking, and scientific communication skills in chemistry learning.

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INTRODUCTION

In the 21st century, improvement in various aspects of social life is obvious in many sectors education being one notable example.The primary aim of today's education is for students to master learning, and with it the ability to create new things (learning and innovation skills) (Mashudi, 2021)These skills involve being able to solve problems with clear-sighted thinking; communicate effectively (including listening), have a cooperative mindset/technique and personally create something new that is uniquely yours through innovation of any kind ye instant noodles etc (Jewaratnam 2020).One way in which these skills find use is in the art of argumentation.

Argumentation skills include two main competencies in the 21st century era, namely critical thinking skills and communication skills (Widiasri, 2024). Argumentation plays an important role in helping students develop metacognition and higher-order thinking skills. Through argumentation, individuals are encouraged to express their thoughts and the results of their reasoning in depth (Sinambela et al., 2023).

However, they cannot generalize. In fact, it may even lead to debate. It is important to listen to what they have to say, but a little refutation is necessary (Mystraue, 2003). The scale of low-performing students is not yet known. More research is needed to define this issue in more detail. One example of a PBL method, which has been shown to be effective in improving argumentation levels in the classroom (Lloyd et al., 2023), is PBLPA, an example of this type of innovation. PBL (Project-Based Learning) is a student-centered approach to learning, relying heavily on group work and problem solving. In many PBL models, the pattern of argumentation is non-traditional, with Toulmin's Argumentation Structure Model having

proven to be very diverse. In this context, students go through claims, evidence, and reasoning to move from a basic, less sophisticated understanding of one perspective to an understanding of three perspectives: their own, their opponent's, and a middle position that combines both (Ritchie & Wieman, 2009).

As a chemistry teaching method, the application of PBL is greatly influenced by students' background, stage of readiness, and necessary preparation. Research shows that clearly structured scaffolding can improve learning outcomes, especially in mathematical problem solving or modeling work. In contrast, the use of less structured scaffolding tends to be less effective. In addition, the effectiveness of PBL is more significant among students who have a strong foundation in chemistry; meanwhile, students with minimal understanding often face difficulties in developing good arguments (Chen et al., 2018; Hu et al., 2017).

The background of this study shows a gap in the literature related to the implementation of PBL in chemistry learning. However, previous research has not addressed the questions of how PBL can overcome the challenge low student reasoning and how its effect compares with other models such as IBL. Therefore, a more systematic literature review is necessary to find out how effective PBL is for students' argumentation skills and in the field of chemistry learning.

The purpose of this study is to analyze the effects of implementing Problem-Based Learning (PBL) on students' argumentation skills in chemistry. This research is expected to make a new contribution to chemistry learning strategies by showing the extent to which PBL can improve students' argumentation skills, identifying factors that moderate its success, as well as comparing it with other approaches such as IBL. Thus, the results of this study can provide an empirical basis for optimizing PBL-based learning designs in the future.

METHOD

This research is a systematic review of the literature, which is considered the standard method in literature review. It has the characteristics of replicability, transparency, objectivity, impartiality and rigor, making it superior to other review methods. A systematic literature review provides a structured and clear approach to collecting, analyzing and evaluating research results related to a specific topic or question.

The literature sources collected come from various references that discuss the effect of Problem-Based Learning (PBL) in improving students' argumentation skills in chemistry learning. This research aims to explore evidence from publications that identify the effectiveness of PBL in helping students develop argumentation skills in chemistry subjects. In addition, this research also seeks to map the effect of PBL based on student levels and formulate appropriate strategies, so that it can be used as a basis for improving the quality of chemistry learning.

The publication sources collected consisted of journals that have a high impact factor and have gone through a peer-review process. The publication range is limited to the last 5 years, from 2020 to 2024. The search was conducted by utilizing relevant keywords, such as “Problem-Based Learning in Chemistry,” “PBL and Argumentation Skills,” and “Argumentation in Chemistry Education.” Databases used included Scopus, Web of Science, SpringerLink, and ScienceDirect, in addition to Google Scholar to complete the initial search. The data analysis used in this study was thematic analysis and data extraction with the following criteria: (1) articles written in English or Indonesian, (2) discuss the effect of PBL model in chemistry learning, (3) explain in detail how PBL improves argumentation skills in chemistry learning, and (4) use clear and valid research methods. In the initial search, by considering the existing criteria, the number of publications obtained was 99 articles.

The 99 articles obtained were then determined for eligibility based on a selection method consisting of 4 stages, namely identification, research needs, publication selection procedures, screening, eligibility, and inclusion. This selection process was modified from the PRISMA guidelines, as shown in Figure 1.

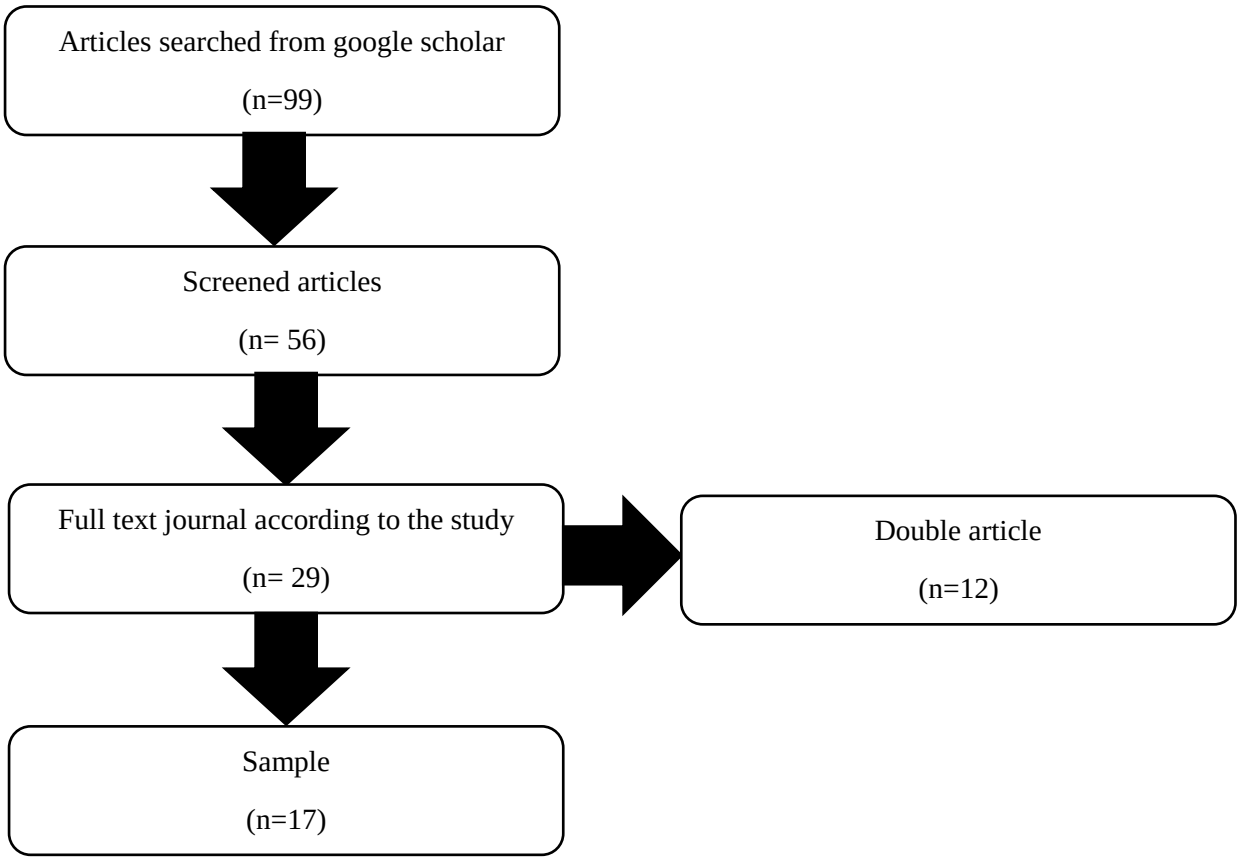

Figure 1. Scheme of Selection Method

Potential errors in interpretation by the authors may arise due to differences in the use of data in each literature. Therefore, this systematic review focuses on the effect of Problem-Based Learning (PBL) on students' argumentation skills in learning Chemistry. Articles that fit the selection criteria were further analyzed. The articles were grouped based on three main categories, namely year of publication, learning model, and learning material. Grouping by year was done by arranging articles according to the year of publication. This research is focused on the Senior High School (SMA/SMK/MA) education level. In addition, learning materials are classified based on Chemistry topics taught in the analyzed articles.

RESULTS AND DISCUSSION

From the search and identification of research articles, 17 articles were found. Details of all the articles are presented in Table 1.

Table 1. Primary Study of the Effect of Model Based Learning (PBL) on the argumentation skills of high school students in Chemistry learning

No	Author's name	Journal	Persentase	Category
1.	Dedet Agus setiawan & Muhyiatul Fadilah, 2023	Bionatural	82,45%	High

No	Author's name	Journal	Persentase	Category
2.	Parlindungan, Siti Fatimah Azzahra, 2024	Cendekia: Jurnal Pendidikan dan pengajaran	64%	Medium
3.	Nurhasanah et al., 2020	EDUBIOLOGICA: Jurnal Penelitian Ilmu dan Pendidikan Biologi	89,4%	High
4.	Jumadi et al., 2021	International Juornal Of Evaluation and research in education (IJERE)	43%	Medium
5.	Prifes & Okmarisa, 2024	Hidrogen: Jurnal Kependidikan Kimia	28,8%	Fair
6.	Puspitaningsih et al., 2023	Gunung Djati Conference Series	66,64%	Medium
7.	Deke et al., 2022	Gunung Djati Conference Series	66,88%	Medium
8.	Hayati & Fadilah, 2023	BJSME: Borneo Juornal Of Science and Mathematics education	6,35%	Medium
9.	Anisa Puspita Sari, 2021	Jurnal Pendidikan Tambusai	68%	Medium
10.	Witri et al., 2020	Jurnal Pendidikan Kimia	49%	Medium
11.	Putri, M. D. et al., 2023	JPPIPA Jurnal Penelitian Pendidikan IPA	97%	High
12.	Aurelia et al., 2023	The 5th international conference on mathematics and science education (ICoMSE) 2021	51%	Medium
13.	Sarira, Desy Fajar Priyayi, dan Susanti Puji Astuti 2023	Gunung Djati Conference Series	38%	Medium
14.	Dwi Wulandari et al., 2023	Jurnal Pendidikan MIPA		
15.	Fadlika et al., 2022	Jurnal Pendidikan IPA	42,6%	Medium
16.	Piati, 2022	Jurnal Pendidikan Kimia Unkhair (JPKU)	50%	Medium
17.	Zaroh et al., 2022	ORBITAL: JURNAL PENDIDIKAN KIMIA	30%	Fair

Based on the analysis of 17 articles reviewed, it was found that Problem-Based Learning (PBL) is consistently able to improve students' argumentation skills. This is due to the PBL approach which focuses on students as the center of active learning (Rachmawati & Rosy, 2020). In PBL, students are exposed to real problems relevant to everyday life so that they are encouraged to analyze, evaluate, and find solutions based on scientific evidence. This problem-solving process trains students to develop logical, structured, and data-based arguments (Pradana, 2024). In addition, group discussions in PBL provide space for students to exchange ideas, defend their opinions, and improve their arguments based on input from peers (Umar, 2024).

In this way, PBL not only helps students understand chemistry conceptually but also develops critical thinking skills and effective communication abilities.

However, further analysis shows that there are variations in the effectiveness of PBL implementation in these studies. A total of five articles showed high category results, such as research by Nurhasanah et al. (2020) with a percentage of 89.4% and Putri et al. (2023) with 97%, which shows significant success. This success is generally due to the application of structured scaffolding, the use of authentic problems, and the long duration of implementation. In contrast, two articles recorded results in the low category, such as the study by Prifes and Okmarisa (2024) with 28.8% and Zaroh et al. (2022) with 30%. Factors contributing to this low effectiveness include lack of explicit support, problem vagueness, and short learning duration. Meanwhile, 10 other articles showed results in the medium category, such as Parlindungan and Azzahra (2024) with a percentage of 64% and Aurelia et al. (2023) with 51%. The variation in results in the moderate category is influenced by factors such as a greater level of student autonomy without explicit guidance and the diversity of problem complexity levels.

In theory, the PBL approach is in accordance with constructivism proposed by Piaget and Vygotsky. Piaget emphasized the importance of cognitive conflict in promoting critical thinking, while Vygotsky highlighted the role of social interaction in learning through the zone of proximal development (ZPD). In PBL, cognitive conflict arises when students solve complex problems, while group discussions help them construct more mature arguments. Toulmin's argumentation model is also relevant as it provides a framework for building logical and evidence-based arguments. Thus, this study makes an important contribution in supporting the main objective, which is to improve students' argumentation skills. The learning environment created by PBL encourages critical analysis, evidence-based problem solving and collaborative discussion, all of which play an important role in improving the quality of chemistry learning.

The results also confirm that PBL not only helps students understand chemistry subject matter more deeply but also develops critical thinking and argumentation skills. Therefore, this study underscores the importance of a structured learning design with scaffolding support and the use of relevant problems to achieve optimal learning outcomes.

CONCLUSION

This article discusses the effect of the Problem Based Learning (PBL) learning model in improving students' argumentation skills in chemistry learning based on a literature review. The results showed that PBL was significantly more effective than the traditional learning model. This is reflected in the increase in average post-test scores, N-Gain scores, and mastery of argumentation elements such as claims, justifications, and refutations. The advantage of PBL lies in its approach that involves students actively through group discussions, analysis of real problems, and development of data-based solutions. In the context of chemistry learning, PBL helps students understand abstract material by linking it to relevant situations, such as environmental issues and industrial processes. This approach strengthens the integration of chemistry concepts with problem-solving skills. In addition, the application of PBL is more optimal when combined with additional learning media, STEM approaches, or group discussions. Theoretically, PBL is supported by Piaget and Vygotsky's constructivism theories, as well as Toulmin's argumentation model, which provides a framework for constructing logical and evidence-based arguments. In conclusion, PBL not only improves students' argumentation ability, but also prepares them with critical thinking, collaboration and effective communication skills relevant to 21st century needs.

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