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IMPLEMENTATION OF PROBLEM-BASED LEARNING ASSISTED BY STRUCTURED STUDENT WORKSHEETS TO IMPROVE JUNIOR HIGH SCHOOL STUDENT'S SCIENTIFIC ARGUMENTATION SKILLS

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Abstract

Scientific argumentation is a critical 21st-century competency that remains underdeveloped among junior secondary school students. This study aimed to improve the scientific argumentation skills of seventh-grade students (Class VII E) at SMP Negeri 11 Jember through the implementation of a Problem Based Learning (PBL) model supported by structured Student Worksheets in the topic of the Solar System. A Classroom Action Research (CAR) design following the Kemmis and McTaggart model was employed, comprising four iterative stages: planning, acting, observing, and reflecting. The study involved 32 participants (17 male and 15 female students) and was conducted over two cycles, each consisting of two instructional sessions. Scientific argumentation ability was assessed using the McNeill and Krajcik (2006) rubric, which evaluates three core components: claim, evidence, and reasoning. Results demonstrated a meaningful improvement in mean argumentation scores, rising from 1.41 (sufficient category) in Cycle I to 1.70 (good category) in Cycle II. In Cycle II, all three components reached the good category, with claim obtaining the highest mean score (1.75), followed by evidence (1.69) and reasoning (1.67). These findings indicate that the integrated use of PBL and CER-based structured worksheets constitutes an effective instructional approach for enhancing scientific argumentation competency among junior secondary school students.

Keywords: Problem Based Learning, scientific argumentation, structured student worksheet

Abstrak. Kemampuan argumentasi ilmiah merupakan kompetensi penting abad ke-21 yang masih tergolong rendah pada siswa SMP. Penelitian ini bertujuan untuk meningkatkan kemampuan argumentasi ilmiah siswa kelas VII E SMP Negeri 11 Jember melalui penerapan model Problem Based Learning (PBL) berbantuan Lembar Kerja Murid (LKM) terstruktur pada materi Sistem Tata Surya. Jenis penelitian yang digunakan adalah Penelitian Tindakan Kelas (PTK) dengan desain model Kemmis dan McTaggart yang terdiri atas empat tahap: perencanaan, pelaksanaan, observasi, dan refleksi. Subjek penelitian adalah 32 siswa yang terdiri atas 17 siswa laki-laki dan 15 siswa perempuan. Penelitian dilaksanakan dalam dua siklus, masing-masing terdiri dari dua pertemuan. Kemampuan argumentasi ilmiah diukur menggunakan rubrik McNeill & Krajcik (2006) yang mencakup tiga komponen, yaitu klaim, bukti, dan alasan. Hasil penelitian menunjukkan peningkatan rata-rata skor argumentasi ilmiah dari 1,41 (kategori cukup) pada Siklus I menjadi 1,70 (kategori baik) pada Siklus II. Seluruh komponen argumentasi ilmiah pada Siklus II berada pada kategori baik, dengan klaim memperoleh skor tertinggi (1,75), diikuti bukti (1,69), dan alasan (1,67). Temuan ini menunjukkan bahwa kombinasi model PBL dan LKM terstruktur berbasis CER secara efektif meningkatkan kemampuan argumentasi ilmiah siswa SMP.

Kata-kata Kunci : Problem Based Learning, LKM terstruktur, argumentasi ilmiah.

Background

Science education at the junior high school level plays an important role in developing students' scientific thinking skills, problem-solving abilities, and understanding of concepts related to natural phenomena. Based on preliminary observations conducted at SMP Negeri 11 Jember, it was found that the learning process still tends to be teacher-centered. This condition results in limited student participation during classroom activities. Consequently, students are not adequately trained to express opinions, provide reasoning, and present scientific evidence effectively. In practice, teacher-dominated instruction encourages students to receive information passively. This situation is inconsistent with the objectives of science education, which emphasize scientific processes and active student engagement. Therefore, an instructional model that encourages active participation and independent knowledge construction is needed, one of which is the Problem-Based Learning (PBL) model.

The Problem-Based Learning (PBL) model is an instructional approach that places problems as the starting point of the learning process. Through this model, students are encouraged to analyze real-world problems, seek relevant information, and formulate solutions collaboratively. Therefore, PBL is able to develop critical thinking skills, problem-solving abilities, and students' capacity to construct scientific arguments. Previous studies have shown that problem-based learning helps students gain a deeper understanding of concepts through investigation and group discussion processes (Ayu et al., 2024; Ling Yu & Zuhana, 2023). In addition, PBL encourages students to become more active, creative, and responsible for their own learning process, while teachers act as facilitators and guides (Pamungkas & Franita, 2019; Sari et al., 2019). Thus, the implementation of PBL can serve as an alternative solution to overcome passive learning practices in the classroom.

However, to ensure the optimal implementation of Problem-Based Learning (PBL), appropriate instructional materials are needed to guide students throughout the learning

process. One of the instructional tools that can be utilized is a structured student worksheet. A structured worksheet is a learning resource containing instructions, procedural steps, and systematically designed tasks to assist students in understanding learning concepts. Through structured worksheets, students are able to follow the learning process in a more organized manner, beginning from observation and problem identification to data collection and conclusion drawing (Damanik & Berlian, 2024; Cahyana et al., 2024). In addition, structured worksheets can support students in developing scientific arguments gradually, as each activity step is designed to guide students in constructing claims, reasons, and evidence (Syaroh & Mustika, 2024). Therefore, the use of structured worksheets can support the successful implementation of PBL in the learning process.

The urgency of developing scientific argumentation skills is highly evident, as this competence is considered an essential skill in the twenty-first century (Zahra et al., 2025). Scientific argumentation requires students to express opinions supported by logical reasoning and relevant evidence (Rianti, 2024). This ability is closely related to critical thinking and problem-solving skills. However, various studies have indicated that junior high school students' scientific argumentation skills remain relatively low. Students tend to express opinions without providing strong reasoning and supporting evidence, resulting in arguments that are incomplete and insufficiently scientific (Hardianti, 2025; Mayung, 2023). This condition suggests that current learning practices have not fully trained students to construct scientific arguments systematically.

The low level of students' scientific argumentation skills is influenced by learning processes that remain teacher-centered and provide limited opportunities for students to think critically and express their opinions actively (Janna, 2024). Lecture-dominated instruction causes students to be insufficiently trained to independently construct claims, reasons, and evidence (Apriyani & Alberida, 2023). Therefore, a learning approach that actively engages students in critical thinking and scientific discussion is needed. Previous studies have shown that the implementation of Problem-Based Learning (PBL) can improve students' scientific argumentation skills by providing problem-based learning experiences and encouraging discussion and investigation activities (Jayati, 2026). Furthermore, the use of structured worksheets assists students in developing arguments gradually and systematically (Rianti, 2024).

Based on the explanations above, it can be concluded that students' scientific argumentation skills are strongly influenced by the instructional strategies employed in the learning process. Therefore, this study aims to investigate the effect of implementing the Problem-Based Learning (PBL) model assisted by structured student worksheets on improving

the scientific argumentation skills of seventh-grade students at SMP Negeri 11 Jember in the 2025/2026 academic year.

Method

This study was classroom action research (CAR) that combined both quantitative and qualitative methods. Classroom action research is a type of research conducted during the learning process to optimize instructional practices. It begins with a reflection stage to identify classroom problems. The teacher then designs an intervention to address the identified problems. At the end of the intervention, the teacher analyzes the impact of the action through observation activities (Saputra et al., n.d.). The purpose of this study was to improve junior high school students' scientific argumentation skills through the implementation of the Problem-Based Learning model assisted by structured Student Worksheets on the topic of Earth and the Solar System.

The design of this CAR followed the Kemmis and McTaggart model. The Kemmis and McTaggart model is a spiral model of reflective practice consisting of four stages: planning, acting, observing, and reflecting, followed by re-planning (Utomo et al., 2024).

This research was conducted at SMPN 11 Jember in class VIII-E, consisting of 32 students, including 17 male students and 15 female students. The study was carried out in the second semester of the 2025/2026 academic year on the topic of Earth and the Solar System through two learning cycles. The research process involved one student researcher acting as the model teacher, one supervising teacher as an observer, and one student observer responsible for observing students' activities and behavior during the learning process. The data collection technique used in this study was the assessment results of structured Student Worksheets (LKM), which contained indicators of students' scientific argumentation skills. The research instruments consisted of Student Worksheets and a scientific argumentation assessment rubric.

According to McNeill & Krajcik (2006), the components of scientific argumentation were divided into three parts to make them easier for students to understand, namely claim, evidence, and reasoning, commonly known as CER. The aspects of scientific argumentation were described as follows (Ekawati et al., 2025):

1. Claim is a statement that answers the initial question, representing the initial opinion of the arguer without justification or evidence, and is considered Level 1.
2. Evidence refers to scientific data and information that support the claim. This data can be obtained from investigations, observations, experiments, general information, or other sources.

3. Reasoning is the justification that links the evidence to the claim. In this component, students are encouraged to logically explain why the evidence supports the claim.

Table 1. Rubric for the Levels of Students' Scientific Argumentation Skills (Claim, Evidence, and Reasoning)

Component	Levels of Students' Scientific Argumentation		
	0	1	2
Claim A conclusion that answers the initial question.	Does not include a claim, or the claim is incorrect.	Includes a correct claim, but it is incomplete.	Includes a correct and complete claim.
Evidence Scientific data that supports the claim. The data must be appropriate and sufficient to support the claim.	Does not include evidence, or only includes incorrect evidence (the evidence does not support the claim).	Includes appropriate evidence, but it is insufficient to support the claim (may include a lack of empirical evidence). It may also include some or partially incorrect claims.	Includes appropriate and sufficient evidence (complete with empirical data) to support the claim.
Reasoning A justification that connects the claim and the evidence. It explains why the data are considered as evidence by using appropriate and adequate scientific principles.	Does not include reasoning, or only includes reasoning that does not connect the claim with the evidence.	Includes reasoning that connects the claim with the evidence. It repeats the evidence and/or includes scientific principles, but is not yet adequate.	Includes reasoning that connects the claim with the evidence. It incorporates appropriate and adequate scientific principles.

Source : (McNeill & Krajcik, 2006)

Result and Discussion

Result

In the planning stage of Cycle I, the researcher developed learning materials based on the Problem-Based Learning (PBL) model to improve students' scientific argumentation skills on the topic of Earth and the Solar System. The developed learning materials included a lesson plan, structured Student Worksheets, observation instruments, and a scientific argumentation assessment rubric based on Claim, Evidence, and Reasoning (CER). In addition, the researcher prepared instructional media and contextual problems related to students' daily lives to make the learning process more meaningful.

The selection of the PBL model in this study was based on the characteristics of science learning, which required students to actively think, discuss, and solve problems scientifically. In addition, the use of structured Student Worksheets was chosen to help students understand the stages of constructing scientific arguments in a more systematic way.

The learning design was also adjusted based on the initial observation results, which showed that students' scientific argumentation skills were still low because previous instruction was more teacher-centered. Therefore, the researcher designed problem-based learning to

encourage students to be more active in developing critical thinking and scientific argumentation skills.

The implementation of Cycle I was conducted in two meetings using the PBL model assisted by structured Student Worksheets. In the first meeting, the teacher opened the lesson, conveyed the learning objectives, and administered a pretest to determine students' prior knowledge. The teacher then presented contextual problems related to science content and divided the students into small groups. The students worked on structured Student Worksheets containing guidance for constructing claims, evidence, and reasoning, and then discussed their answers within their groups. Afterward, the students presented the results of their discussions, while other groups provided responses. In the second meeting, the teacher provided different problems that were still related to the same topic, and the students again constructed scientific arguments using the provided Student Worksheets.

The observation stage was carried out simultaneously with the implementation of the action stage. The observation activities were conducted by one supervising teacher and one student observer, who were responsible for monitoring the implementation of the PBL model and students' activities during the learning process. The observational data were collected using a learning implementation observation sheet that covered all phases of the PBL model. Quantitative data were obtained from students' scientific argumentation skill tests conducted in each meeting, which were analyzed based on three main indicators, namely claim, evidence, and reasoning, in accordance with the rubric developed by McNeill & Krajcik (2006).

Students' scientific argumentation skills were measured using essay tests in the LKM, which were assessed based on the McNeill & Krajcik (2006) rubric with three main components: claim, evidence, and reasoning. Each component had a maximum score of 2, resulting in a total maximum score of 2. The results of the Cycle I scientific argumentation skill test are presented in Table 2 and Table 3 below.

Table 2. Average Scores of Each Scientific Argumentation Component in Session I and II

Components of Scientific Argumentation	Session I	Session II	Average	Category
Claim	1,48	1,50	1,49	Fair
Evidence	1,46	1,49	1,47	Fair
Reasoning	1.28	1,30	1,29	Fair
Average	1,40	1,43	1,41	Fair

Table 3. Average Scores of Scientific Argumentation Results in Sessions I and II

Session	Total Score	Average Score	Category
Session I	2.154	1,40	Fair
Session II	2.368	1,43	Fair
Average	2.261	1,41	Fair

Based on the results of observation and analysis in Cycle I, the researcher identified several obstacles in the implementation of the learning process. Students still experienced

difficulties in distinguishing between claim, evidence, and reasoning; therefore, the arguments they constructed were not yet complete and systematic. In addition, the Student Worksheets used provided insufficiently clear instructions and had an unappealing layout, which caused some students to become confused in completing the tasks. Classroom discussion management was also not yet optimal because not all students actively expressed their opinions.

The reflection results showed that improvements in instruction were needed to help students better understand the structure of scientific argumentation. Therefore, the researcher made several improvements, such as clarifying instructions in the Student Worksheets, providing examples of CER-based scientific arguments, adding more structured answer sections, and arranging questions in a step-by-step manner (scaffolding).

In addition, learning activities were simplified so that students could focus more on constructing scientific arguments. These improvements were made as an effort to increase student engagement in learning and to improve the quality of scientific argumentation in Cycle II.

The planning stage in Cycle II was a refinement of the Cycle I plan developed based on the reflection results. The reflection findings from Cycle I revealed several weaknesses that needed improvement, namely: (1) the instructions provided in the structured worksheets were insufficiently clear, causing students to experience difficulties in distinguishing between claims, evidence, and reasoning; (2) the design of the structured worksheets was less engaging and did not provide adequate scaffolding; (3) classroom discussion management had not been implemented optimally due to time constraints; and (4) the examples of scientific argumentation provided were still limited. Considering these findings, the researcher developed the following improvement plan.

First, the researcher revised the instructional materials in the form of a PBL-based lesson plan that had been adjusted according to the reflection results from Cycle I. The lesson plan in Cycle II was designed with a more efficient time allocation and learning activities that were more focused on developing students' scientific argumentation skills.

Second, the researcher redesigned the structured student worksheets with several substantial improvements, namely: (a) clarifying the instructions related to scientific argumentation at the beginning of the worksheets by providing simple examples of the Claim–Evidence–Reasoning (CER) model as guidance for students; (b) improving the clarity of instructions in each section of the worksheets; (c) providing separate sections for each CER component to help students organize their responses more effectively; and (d) arranging the questions gradually through scaffolding, beginning with simple tasks and progressing to more complex ones. Third, the researcher prepared more varied instructional media and learning

resources, including visual examples that supported students' understanding of the Solar System topic as well as real-life case examples that could stimulate students' critical thinking skills in constructing scientific arguments.

Fourth, the researcher established the success criteria that served as the evaluation benchmarks for Cycle II, namely: (1) the average score of students' scientific argumentation skills reached the "good" category with a score of ≥ 1.50; and (2) students were able to construct the components of scientific argumentation, including claims, evidence, and reasoning, in a more complete and systematic manner through the use of structured worksheets assisted by the Problem-Based Learning (PBL) model. This study analyzed students' work on the structured worksheets in each meeting to identify the gradual improvement of their scientific argumentation skills.

The implementation of actions in Cycle II was conducted in two meetings. Each meeting applied the PBL model integrated with the revised structured student worksheets. All learning activities were carried out in Class VII E at SMP Negeri 11 Jember with 32 students participating as the research subjects. The learning process was observed by one supervising teacher and one observer.

The introductory activities in the first meeting began with the teacher opening the lesson and explaining the learning objectives to be achieved. The teacher then provided an apperception activity related to the Solar System topic to activate students' prior knowledge. Furthermore, the teacher gave a brief explanation of the concept of scientific argumentation, including claims, evidence, and reasoning. This improvement was made based on the findings from Cycle I, in which the initial explanation of scientific argumentation had not been adequately provided. The teacher also presented a simple example of the Claim, Evidence, Reasoning (CER) framework as a reference model for students in completing the structured worksheets.

The main learning activities were conducted for approximately 25–30 minutes. The teacher presented a contextual problem related to phenomena in the Solar System topic. Students were divided into small groups consisting of three to four members. Each group received the revised structured worksheets, which included clearer instructions, separate sections for the Claim–Evidence–Reasoning (CER) components, and questions arranged progressively from simple to complex levels. Students completed the worksheets by dividing responsibilities within their groups, including determining claims, identifying evidence, and constructing reasoning. Throughout the activity, the teacher actively guided the students and provided assistance when needed to groups experiencing difficulties.

The closing activities in the first meeting consisted of group representatives presenting the results of their discussions. The teacher and students then concluded the lesson together

and reinforced students' understanding of the scientific argumentation structure that had been learned.

The second meeting began with a brief apperception activity reviewing the Claim, Evidence, Reasoning (CER) concept that had been studied in the first meeting. The teacher ensured that all students understood the basic structure of scientific argumentation before proceeding to the main activities.

During the main learning activities, the teacher presented a new problem that was more challenging and complex than the one discussed in the previous meeting. Students completed the structured worksheets both collaboratively and individually using the CER format. In this meeting, students were required to construct more complete and systematic scientific arguments. The teacher provided more intensive guidance to students who still experienced difficulties. In addition, a classroom discussion was conducted to compare responses among groups, allowing students to learn from diverse perspectives. The closing activities of the second meeting consisted of a joint conclusion of the lesson conducted by both the teacher and the students.

The observation stage was conducted simultaneously with the implementation stage. The observation activities were carried out by one supervising teacher and one observer who were responsible for monitoring students' activities throughout the learning process. Quantitative data were obtained from students' scientific argumentation worksheets in each meeting, which were analyzed based on three main indicators, namely claims, evidence, and reasoning, in accordance with the rubric developed by McNeill and Krajcik (2006).

Students' scientific argumentation skills were measured using structured worksheet assessments evaluated based on the rubric developed by McNeill and Krajcik (2006), which consists of three main components: claims, evidence, and reasoning. Each component had a maximum score of 2, resulting in a total maximum score of 2. The results of the scientific argumentation skill assessment in Cycle II are presented in Tables 4 and 5 below.

Table 4. Mean Score of Each Scientific Argumentation Component in Meetings I and II (Cycle II)

Scientific Argumentation Components	Session I	Session II	Rata-rata	Category
Claim	1,68	1,82	1,75	Good
Evidence	1,66	1,71	1,69	Good
Reasoning	1,64	1,69	1,67	Good
Average	1,66	1,74	1,70	Good

Table 5. Average Scores of Scientific Argumentation Results in Sessions I and II

Session	Total Score	Mean Score	Category
Session I	2.440	1,66	Good
Session II	3.023	1,74	Good
Average	2731,5	1,70	Good

Based on the results of the data analysis, all predetermined success criteria were achieved in Cycle II. First, the average score of students' scientific argumentation skills reached 1.70, which falls into the "good" category and exceeds the minimum criterion set (score ≥ 1.50). Second, all indicators of scientific argumentation (claim: 1.75, evidence: 1.69, reasoning: 1.67) were categorized as good. Third, there was a consistent increase in the average score from Session I (1.66) to Session II (1.74) in Cycle II, as well as a significant improvement from the Cycle I average (1.41) to Cycle II (1.70). Thus, it can be concluded that the actions implemented in Cycle II successfully met all the established success criteria.

Discussion

According to Saputra et al. (2021), the planning stage in classroom action research was very important because it served as the foundation for the successful implementation of the actions in the learning process. Jayati et al. (2026) stated that the implementation of the Problem-Based Learning model could improve students' scientific argumentation skills because students were trained to express opinions based on scientific facts and evidence. According to Syaroh and Mustika (2024), CER-based worksheets helped students develop claims, evidence, and reasoning step by step, resulting in more complete arguments.

This condition was in line with the opinion of Apriyani and Alberida (2023), who stated that learning dominated by lecture methods caused students to be less trained in constructing scientific arguments independently. In addition, Riwayani et al. (2019) explained that problem-based learning could improve students' scientific argumentation skills through investigative activities and scientific discussions that actively involved students in the learning process.

According to Sari et al. (2019), the Problem-Based Learning model could increase students' engagement because students were directly involved in inquiry and group discussions. This is in line with the study by Ayu et al. (2024), which stated that problem-based learning could improve students' critical thinking and scientific argumentation skills through investigative and scientific discussion processes. Ambarwati and Fauziah (2024) stated that Problem-Based Learning could improve students' critical thinking skills, which are closely related to scientific argumentation skills, because students were trained to analyze problems and provide logical and scientific explanations.

Pamungkas and Franita (2019) stated that in the PBL model, the teacher's role was to guide students in discovering concepts independently through discussion and problem-solving activities. Rianti et al. (2024) explained that structured LKM could assist students in constructing scientific arguments step by step, making it easier for them to organize their responses. This statement was supported by Febianti et al. (2025), who stated that the use of

scaffolding in the Problem-Based Learning model could help students construct scientific arguments in a more systematic and complete manner.

Based on Table 1, all components of scientific argumentation (claim, evidence, and reasoning) in Cycle I were categorized as "fair." The claim component obtained the highest average score of 1.49, followed by the evidence component (1.47), and the reasoning component (1.29). The highest achievement was found in the claim component, indicating that students were increasingly able to formulate conclusions that correctly and completely answered the initial questions. This is consistent with the study by Hidayati et al. (2021), which showed that the claim indicator achieved higher results than evidence and reasoning because students found it easier to express initial opinions than to provide supporting evidence and in-depth scientific reasoning. This finding is also supported by Siska et al. (2020), who stated that the claim component develops earlier because students are relatively more capable of expressing opinions, whereas evidence and reasoning require the ability to logically connect data and scientific explanations.

Table 2 shows that students' scientific argumentation scores increased from the first meeting to the second meeting. In the first meeting, the total score reached 2,154 with an average of 1.40 (fair category), and then increased to 2,368 with an average of 1.43 (fair category) in the second meeting. The overall average score in Cycle I was 1.41, which was also in the fair category. These results indicated that students had begun to construct simple scientific arguments; however, they were still not optimal in providing relevant evidence and systematic scientific reasoning. According to McNeill and Krajcik (2006), a good scientific argument must include interrelated claims, evidence, and reasoning. However, in Cycle I, some students still experienced difficulties in connecting evidence with appropriate scientific reasoning. There were still students who struggled to construct complete scientific arguments, particularly in the evidence and reasoning components. This condition is in line with the study by Hardianti et al. (2025), which stated that junior high school students generally still experience difficulties in presenting appropriate scientific evidence and reasoning to support their arguments.

The difficulties experienced by students in constructing complete arguments indicated that they still required continuous practice in organizing scientific explanations. According to Riwayani et al. (2019), students' scientific argumentation skills develop gradually through repeated investigative and discussion activities in problem-based learning. According to Ekawati et al. (2025), the use of systematically designed argumentation-based LKM could help students understand the relationship between claim, evidence, and reasoning more clearly.

According to Mutiah et al. (2024), the use of structured LKM could help students understand learning steps more systematically, thereby improving conceptual understanding and learning organization. Setiawan and Fadilah (2023) also stated that the implementation of the Problem-Based Learning model had a significant effect on students' scientific argumentation skills because students were trained to provide scientific reasoning for a given problem.

A study conducted by Jayati, Supeno, and Budiani (2026) demonstrated that systematically designed instructional materials oriented toward the Claim–Evidence–Reasoning (CER) framework were effective in significantly improving junior high school students' scientific argumentation skills. Damanik and Berlian (2024) emphasized that systematically designed structured worksheets with step-by-step guidance are effective in helping students understand and construct scientific arguments more systematically.

Zahra et al. (2025) stated that problem-based learning combined with group discussions and presentation activities can significantly improve students' ability to construct scientific arguments systematically. Apriyani and Alberida (2023) explained that structured classroom discussions in problem-based learning can encourage students to refine their claims, strengthen their evidence, and improve their reasoning within scientific arguments.

Based on Table 3, all components of scientific argumentation, namely claims, evidence, and reasoning, in Cycle II were categorized as "good." The claim component achieved the highest average score of 1.75, followed by the evidence component with an average score of 1.69, and the reasoning component with an average score of 1.67. The greatest improvement occurred in the claim component, indicating that students became more capable of formulating conclusions that accurately and completely addressed the initial questions. This finding is consistent with the study conducted by Mayung et al. (2023), which reported that the claim component generally shows improvement earlier than the evidence and reasoning components because claims are the most directly practiced through problem-based discussions.

Table 4 shows that students' scientific argumentation scores increased from Session I to Session II. In Session I, the total score reached 2,440 with an average of 1.66 (good category), then increased to 3,023 with an average of 1.74 (good category) in Session II. The overall average score in Cycle II was 1.70, which falls into the good category. This value is higher than the Cycle I average, which only reached 1.41 (fair category). The increase of 0.29 points from Cycle I to Cycle II indicates that the implemented improvements were successful in significantly enhancing students' scientific argumentation skills. Jayati, Supeno, and Budiani (2026) reported similar findings, showing that the implementation of a systematically designed

PBL model assisted by structured worksheets consistently improves junior high school students' scientific argumentation skills across cycles.

Several factors contributed to the success of Cycle II. The first factor was the improvement of the structured student worksheets, which provided clearer guidance through separate Claim–Evidence–Reasoning (CER) columns and gradually scaffolded questions. This improvement helped students organize their thinking more systematically when constructing scientific arguments. Cahyana et al. (2024) emphasized that worksheets designed in a structured manner with step-by-step scaffolding are effective in helping students understand complex scientific argumentation processes.

The second factor was the provision of CER model examples at the beginning of the learning process. With concrete examples, students had a clear understanding of how a good and correct scientific argument should be constructed. Janna (2024) stated that modeling scientific argumentation prior to students' independent practice is an effective scaffolding strategy for improving junior high school students' argumentation skills.

The third factor was more structured classroom discussion management. In Cycle II, the teacher played a more active role in guiding discussions and encouraging students to respond to other groups' opinions. This helped students develop critical thinking skills and strengthen their arguments. Ayu et al. (2024) reported that the quality of group discussions in Problem-Based Learning (PBL) is positively correlated with the quality of students' scientific argumentation.

The fourth factor was the increased active engagement of students in the learning process. With a more structured worksheet format and clearly defined roles within groups, students became more motivated and actively participated in discussion activities and the construction of scientific arguments. Pamungkas and Franita (2019) stated that students' active engagement in problem-based learning is an essential prerequisite for improving scientific argumentation skills.

The improvement in students' scientific argumentation skills from Cycle I to Cycle II can be explained by the synergistic effectiveness of the Problem-Based Learning (PBL) model and structured student worksheets. The PBL model provides an authentic problem-based learning context, enabling students to become cognitively and affectively engaged in the processes of inquiry and decision-making. Meanwhile, the structured worksheets serve as step-by-step guidance that helps students systematically organize their thinking processes using the Claim–Evidence–Reasoning (CER) framework.

The claim component showed the most significant improvement in Cycle II. This indicates that students became more proficient in formulating clear, accurate conclusions that directly addressed the given questions. The evidence and reasoning components also showed

improvement, although the rate of increase was relatively slower compared to the claim component. This finding is consistent with the study by Mayung et al. (2023), which reported that the claim component is generally easier to improve in the early stages of argumentation training, whereas the evidence and reasoning components require more practice and habituation.

The use of structured worksheets equipped with separate Claim, Evidence, Reasoning (CER) columns has been proven to help students distinguish and differentiate the three components of scientific argumentation. Nurhalimah et al. (2024) stated that students who use structured worksheets with a clear CER format tend to produce more complete and well-structured arguments compared to those who do not use such guidance. This finding supports the conclusion that the combination of Problem-Based Learning (PBL) and structured worksheets is an effective instructional strategy for improving junior high school students' scientific argumentation skills.

Conclusion

This classroom action research demonstrated that the implementation of the Problem-Based Learning (PBL) model assisted by structured Student Worksheets was effective in improving the scientific argumentation skills of Grade VII-E students at SMP Negeri 11 Jember on the topic of the Solar System. This was evidenced by an increase in the average scientific argumentation score from 1.41 in Cycle I (fair category) to 1.70 in Cycle II (good category). All components of scientific argumentation in Cycle II were categorized as good, with the claim component obtaining the highest average score of 1.75, followed by evidence (1.69) and reasoning (1.67). This improvement occurred after systematic revisions to the structured Student Worksheets, including the addition of separated CER columns, the provision of model argumentation examples at the beginning of the lesson, and the step-by-step arrangement of tasks (scaffolding), which synergistically helped students organize their scientific thinking in a more structured and systematic way.

Theoretically, this study strengthens the empirical foundation regarding the effectiveness of combining the PBL model and CER-based structured LKM within the context of classroom action research. It also confirms that the McNeill & Krajcik (2006) rubric is a valid and operational instrument for assessing junior high school students' scientific argumentation skills. Practically, the Student Worksheets materials that were tested and refined through the two cycles can be directly used by science teachers as a reference in designing learning activities that promote active scientific thinking. These findings also have implications for policymakers to consider integrating the CER framework into curriculum development and science teacher training programs at the junior high school level.

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