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Development of Science Learning Module Based on Ethno-STEM Integrated PBL to Improve Critical Thinking Skills of Junior High School Students

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Abstract

This research aims to produce a valid, practical, and effective science learning module. The developed science learning module is based on the problem-based learning approach. It integrates Ethno-STEM into the topic of temperature and heat to improve the critical thinking skills of junior high school students. This research uses a modified 4D development model consisting of 3 stages (Define, Design, and Develop). The results of developing this science learning module were tested on a small group of 10 students and a class test of 25 class VII students at SMP Negeri 15 Banjarmasin. The data analysis technique employed is a descriptive analysis technique, which includes validity and practicality analyses using percentages, while effectiveness analysis utilizes N-gain. The research results showed that the developed science learning module received a validity score of 82%, a practicality score of 94%, and an effectiveness score of 0.82. Based on the scores obtained, the developed science learning module is highly valid, practical, and effective when used in science learning to enhance the critical thinking skills of junior high school students.

1. INTRODUCTION

Science learning is not only oriented towards understanding concepts, principles, theories, and natural laws, but also enables students to master learning through scientific methods, thus producing products and processes, and developing various thinking skills, such as critical thinking (Hidayati et al., 2021). This critical thinking is a skill every individual must possess in the 21st century (Wati et al., 2024). Individuals who think critically spontaneously ask concrete questions, organize relevant information, put forward logical arguments based on the information, and draw reliable conclusions (Pratama et al., 2024).

Low critical thinking skills are often attributed to students' lack of training in interpreting, analyzing, and solving problems. The presentation of material that is primarily cognitive in nature,

without addressing actual problems, leads to the underdevelopment of skills and the failure to develop students' ideas (Yampap & Bay, 2020). Furthermore, the implementation of inappropriate learning models can contribute to a lack of critical thinking skills (Yashiroh, 2024). However, in reality, many educators still teach without considering students' abilities and employ monotonous teaching (Perangin-Angin, 2020).

Based on observations of educators at SMP Negeri 15 Banjarmasin, the teaching materials used by educators are still limited in variety, and learning remains conventional. This results in less effective learning and a lack of critical thinking skills in students. The lack of critical thinking skills among students is evident in their low academic scores on daily tests, which average 60. The issue of low critical thinking scores among students must be addressed because it is one of the essential skills required in the 21st century. Efforts that can be made to overcome this problem include using controlled open materials that stimulate critical thinking skills, and then connecting the subject matter with real-world problems that exist around them.

Open materials refer to learning materials, methods, and evaluations that are structured to achieve specific learning objectives. Teaching materials are naturally tailored to students' learning needs. For example, if a teacher wants to learn about nature and the animals that live there, they can direct students to a zoo. However, in reality, educators still tend to use conventional teaching materials, such as worksheets. Research based on Asmi et al. (2024) explained that the results of interviews with four educators in different locations relied solely on conventional methods and textbooks from schools.

Based on interviews with students during the Teaching Assistant program at SMP Negeri 15 Banjarmasin, students demonstrated a limited understanding of science. They found it difficult to understand. They tended to be less interested in science lessons. Students consider science learning boring because teachers often present material and then expect them to understand it immediately, without providing sufficient time for reflection. Learning in this way will undoubtedly be boring for students, who often find that they lack interest, struggle to understand, and find it challenging to learn, often finding it boring as well.

Problem-based learning is a learning process that focuses students on a specific problem before beginning the lesson. Problem-based learning certainly encourages students to be more active. This is based on research by Najoan et al. (2023) and Sulistiana (2022), which explains that problem-based learning presents real-world problems, making learning more engaging, increasing students' curiosity, and improving problem-solving skills. Therefore, developments that involve students more actively and present real-world problems during the learning process, namely problem-based learning, are needed.

The use of problem-based learning (PBL) science learning modules in this study will be developed on the topic of temperature and heat by integrating Ethno-STEM. Students require teaching materials that enhance their scientific process skills in the 21st century (Salsabilla & Setiaji, 2023). Based on this, teaching materials on temperature and heat are needed to make them easily understood by students. The addition of ethnoscience can create a learning environment by combining cultures that are beneficial to life, so students are more enthusiastic and interested in science learning (Mardianti et al., 2020). Through STEM, students can become critical thinkers and problem solvers. Therefore, Ethno-STEM will make learning more meaningful and help students understand STEM concepts (Asmaningrum et al., 2022).

Research on the development of problem-based learning science learning modules has previously been conducted by several researchers, including: 1) Sary et al. (2023) on the development of a problem-based learning module on the interaction of living things with the environment; 2) Al Farizi et al. (2023) on the development of a problem-based learning module to improve students' metacognitive knowledge on temperature and heat; 3) Turahmah (2022) on the development of a problem-based learning (PBL) science learning module to improve students' critical thinking skills on the human respiratory system in junior high school. Although the development of problem-based learning science learning modules has been conducted, there are differences between these studies and the current research, namely, the integration of Ethno-STEM.

The purpose of this research is to develop a valid, practical, and effective ethno-STEM integrated learning module on the topic of temperature and heat to enhance students' critical thinking skills. This research is expected to inspire more diverse and engaging learning designs and methods.

Furthermore, this research aims to enhance students' understanding of ethnoscience and STEM concepts, while also increasing their interest and motivation in learning these subjects.

2. METHOD

This research is a developmental study with three expert validators, 10 seventh-grade students as small-group trial subjects, and 25 seventh-grade students from SMP Negeri 15 Banjarmasin as class test subjects. The development model used in this study is a modified 4D development model consisting of three development stages: Define, Design, and Develop (Imran et al., 2021). A brief outline of the stages in this science learning module development research is presented in Figure 1.

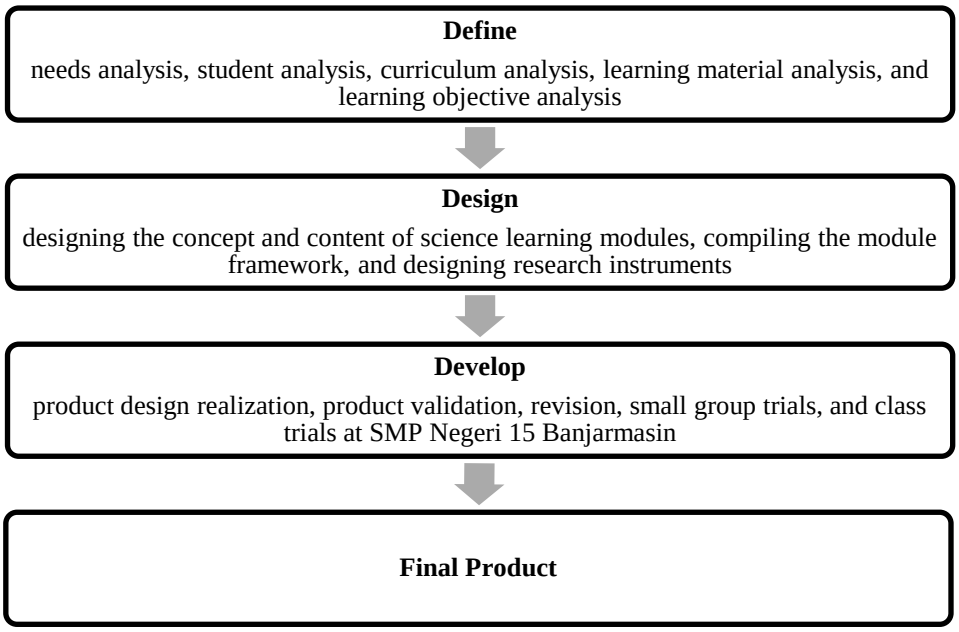

Figure 1. Research stage flow

The first stage of this model involves conducting a needs analysis for new product development, which includes needs analysis, student analysis, curriculum analysis, learning material analysis, and learning objective analysis. The second stage involves designing the concept and content of the science learning module, as well as the research instruments, including validation sheets, practicality questionnaires, and test questions, to be used in testing the developed science learning module product. The third stage is the realization stage, where the previously created product design is transformed into a science learning module product ready for testing and implementation. At this stage, a validation test is conducted with the validator to obtain a validity score, as well as comments and suggestions, which serve as material for product improvement. The science learning module is then tested with small groups to determine whether it meets the practical aspects of the product. Additionally, a trial was conducted in the class, involving a total of 25 seventh-grade students, to assess their response to the practicality and effectiveness of the science learning module based on problem-based learning integrated with Ethno-STEM that was developed.

The data analysis techniques employed in this study included both qualitative and quantitative descriptive analyses. Qualitative descriptive analysis was employed to process the data, which consisted of comments and suggestions from the validator. Quantitative descriptive analysis was employed to process data obtained from the validation questionnaire, student response questionnaire, and test instruments, which were presented in the form of scores.

The validity data of the science learning module was calculated using percentages. The practical value of the science learning module was assessed by calculating the scores from the students' responses to the questionnaire. The effectiveness of the science learning module, based on Ethno-STEM integrated problem-based learning, was reviewed using the results of the pretest and posttest. The improvement in students' critical thinking skills was determined by calculating the pretest and posttest scores using the normalized gain equation, also known as the (N-gain) equation.

3. RESULTS AND DISCUSSION

a. Define

The first stage of this development involved identifying problems in science learning and student needs. The analysis conducted in this initial development stage is as follows.

1) Needs Analysis

The needs analysis began with observations of educators during the implementation of Teaching Assistance at SMP Negeri 15 Banjarmasin. Observations revealed that educators tended to use conventional teaching materials. Classroom learning was still teacher-centered, resulting in students being less active in their own learning. This resulted in low critical thinking skills.

Focusing on student interaction. Problem-based learning is a learning process that develops students' abilities to identify and solve problems independently. This learning model encourages students to be active and improve their critical skills. Integrating ethnoscience and STEM in science learning can improve context-based understanding and critical thinking skills. Fionita & Wulandari (2024) explained that students' critical thinking skills improved when using Batik Sidoarjo's ethnoscience-integrated teaching materials compared to those using textbooks. Dywan & Airlanda (2020) also explained that students' critical thinking skills improved when learning with STEM-integrated teaching materials compared to learning without STEM integration. Therefore, Ethno-STEM integration is necessary to trigger critical thinking skills.

Data from the analysis conducted at the research site indicate that the school does not yet have a science learning module that integrates problem-based learning with Ethno-STEM. Based on the results of this analysis, the researcher proposes an alternative solution to address the low student activity and limited teaching materials, namely the development of teaching materials in the form of a science learning module based on problem-based learning integrated with Ethno-STEM

2) Students Analysis

The researchers analyzed students' characteristics regarding science subjects through interviews conducted during the Teaching Assistant program. The interviews revealed that students perceived science as a complex subject to understand. This lack of understanding of science subjects resulted in low learning outcomes, including poor critical thinking skills.

3) Curriculum Analysis

This researcher conducted a curriculum analysis related to the subject matter being presented. Researchers discussed the curriculum used with educators before developing the science learning module. The curriculum used was the Independent Curriculum.

4) Analysis of Learning Materials

At this stage, the researcher is also able to carry out analysis related to identifying the components of the material to be presented. The material used in the science learning module is based on problem-based learning, integrated with Ethno-STEM, which is on temperature and heat. This material was chosen because it closely relates to the Ethno-STEM concept, which is integrated into students' daily lives.

5) Analysis of Learning Objectives

Researchers conducted an analysis related to the formulation of learning objectives as a reference for developing science learning modules. Learning objectives facilitate educators in selecting and compiling teaching materials, conducting more focused learning activities, and facilitating assessments

b. Design

The second stage of this development involves designing the product to be developed, specifically integrating problem-based learning modules into Ethno-STEM. This stage begins with designing the concept and content of the required science learning module. This science learning module is designed for seventh-grade students. The design begins with preparing the seventh-grade Natural Science textbook. Then, the design and search for various images and backgrounds. At this stage, the validation sheet, practicality questionnaire, and test questions are also designed.

c. Develop

1) Validity of Science Learning Module

The result of this development research is a problem-based science learning module with temperature and heat material for seventh-grade junior high school students, which includes Ethno-STEM integration. This science learning module has been reviewed by two validators, who are lecturers in the Science Education Study Program at Lambung Mangkurat University, and one validator from a science teacher at SMP Negeri 15 Banjarmasin. The results of the validity calculation for the science learning module, based on the assessment of three validators, are presented in Table 1.

Table 1. Result of the validity of the science learning module

No	Assessment Aspect	Validator			Percentage of Aspect Score	Criteria
		I	II	III		
1	Presentation Format Suitability	69	68	74	83.73%	Very Valid
2	Content Eligibility	58	56	63	81.94%	Very Valid
3	Language	27	27	32	79.62%	Valid
	Amount	154	151	169		
	Overall Score		**474**		**82%**	**Very Valid**

The validators' assessment of the science learning module was not limited to just validity scores; they also provided comments and suggestions. These comments and suggestions will serve as a reference for future improvements—the comments and suggestions from the three validators are presented in Table 2.

Table 2. Validator comments and suggestions on the science learning module

No	Comments and Suggestions	Repair
1	Provide critical thinking questions at the end of the sub-material so that students get used to thinking critically	Adding critical thinking questions at the end of the temperature and heat sub-topic
2	Increase the level of critical thinking skills in students	Adding questions during discussion activities

The validity test of the Ethno-STEM, which integrated problem-based learning and the science learning module, was conducted by three validators: two lecturers from the Science Education Study Program at Lambung Mangkurat University and one science teacher from SMP Negeri 15 Banjarmasin. A teaching material can be considered valid if the validity test results obtained align with the specified criteria (Weriyanti et al., 2020). Based on the results of the validity test calculation in Table 1, the developed science learning module obtained a score of 82% with very valid criteria. There are three aspects assessed, namely the feasibility of the presentation format, the feasibility of the content, and the linguistic aspect.

The first aspect assessed by the validator was the feasibility of the presentation format. The feasibility of the presentation format in this science learning module received a validity score of 83.73% with a very valid criterion. This indicates that the format for compiling the developed science learning module is in accordance with problem-based learning in activities. The presentation, based on the module he developed, is both appropriate and attractive to users. This is in accordance with research conducted by Lorenza et al. (2024), which suggests that the combination of appropriate text and images can more effectively capture the interest and understanding of students, thereby facilitating effective teaching. Sukma & Diyana (2024) also explained that a good validity value in the feasibility of the presentation aspect indicates that the developed teaching material is interesting.

The second aspect assessed by the validator was the content feasibility aspect. The content feasibility aspect of this science learning module received a validity score of 81.94%, indicating a very valid result. This indicates that the content of the science learning module developed is in accordance with the Independent Curriculum, based on the appropriateness of the material in the learning, the objectives, and the flow of learning objectives. Furthermore, this also demonstrates that the integration of Ethno-STEM presented in this science learning module aligns with the concept of temperature and heat, as presented in the materials. Based on her research, Irma (2022) explains that the suitability between teaching materials and the content of learning materials, such as examples or practice questions, must be considered for more efficient learning to achieve learning objectives.

Zaputra et al. (2021) also explained that valid content feasibility indicates that the module is in accordance with the needs of students, the accuracy of the material concepts, and the material is presented clearly and systematically to help students understand. The relationship of material examples to existing conditions in the environment helps increase knowledge.

The third aspect assessed by the validator is the linguistic aspect. The linguistic aspect of this science learning module received a validity score of 79.62% with valid criteria. This indicates that the sentences used are clear and in accordance with the understanding of junior high school students. A teaching material must have good and clear linguistic aspects; the use of good language will make it easier for students to understand he learning material. This is based on research by Yani & Mulia (2023), which explains that the use of communicative language in this open material will affect the success of learning. Students will more easily understand the teaching material if it uses clear and simple language.

The validity test results obtained from the three validators met the same criteria as previous research. First, Sary et al.'s (2023) study the development of a PBL; this learning module is also based on interactions with living things and their environment, achieving a validity of 91%, categorized as very valid. The similarity between these studies and the previous one lies in the development model used, namely the 4D model, while the difference lies in the topic covered in the material. Second, Al Farizi et al.'s (2023) research on the development of problem-based learning modules to improve the students' metacognitive knowledge on temperature and heat material obtained a validity of 88.10% from language experts, 83.91% from learning design experts, 85.26% from media experts, and 91.07% from material experts, with a very reasonable category. The similarity between this research and the research conducted lies in the topic of the material discussed, namely, temperature and heat.

In contrast, the difference lies in the development model used and the research objectives achieved. Third, Turahmah's (2022) research on the development of a problem-based learning (PBL) science learning module to improve students' critical thinking skills on the human respiratory system in junior high schools obtained a material expert validity of 92%, a media expert validity of 82.5%, and a language expert validity of 86.7% with a very feasible category. This study aligns with the researcher's objective, which was to enhance critical thinking skills, although the differences lie in the topic, the material presented, and the development model employed. Based on the results of the validity test obtained and supported by several previous research studies, it is evident that the science learning module based on Ethno-STEM incorporates problem-based learning. This learning is efficient and can be applied in real-world situations.

2) Practicality of Small Group Testing

The validated science learning module was then revised based on the comments and suggestions provided by the three validators. The revised science learning module was then subjected to a limited trial with a small group of 10 students from class VII D of SMP Negeri 15 Banjarmasin. This trial determines the practicality of the module for science learners, as reflected in the students' responses to the questions. The results of the trial of the practicality of the science learning module in the small group test are in Table 3.

Table 3. Practical results in small group tests

No	Assessment Aspect	Amount	Percentage of Aspect Score	Criteria
1	User Ease	251	89.64%	Very Practical
2	Benefit	280	87.50%	Very Practical
3	Time Efficiency	186	93.00%	Very Practical
Overall Score		**717**	**90%**	**Very Practical**

In addition to obtaining practicality scores for the science learning modules based on student response questionnaires, the developed science learning modules also received comments and suggestions from students. These comments and suggestions are presented in Table 4.

Table 4. Students' comments and suggestions on small group tests

No	Comments and Suggestions
1	The module is unique; there are Soto Banjar and Sasirangan
2	Lessons are easier to understand with modules

3) Pretest and Posttest Small Group Test

In addition to distributing the response questionnaire, a critical thinking test instrument was also administered during the small group testing phase, serving as both a pretest and posttest to determine whether the critical thinking questions used were appropriate for the junior high school level. The test instrument was also distributed to 10 students in class VII D of SMP Negeri 15 Banjarmasin. The results based the pretest and posttest are the small group testing are shown in Table 5.

Table 5. Pretest and posttest results of small group tests

Average Pretest Score	Average Posttest Score	Average N-gain Score	Criteria
47	84	0.70	High

Based on the pretest and posttest results in Table 5, there was an increase in scores before and after using the science learning module. This indicates that the test instrument questions were suitable for junior high school students, meaning they were neither too easy nor too difficult for these students. These questions can generate valid information.

4) Practicality of Class/ Field Testing

Science learning in a module developed in small groups has met efficient criteria. There are no suggestions or improvements from students. The science learning module that was developed was tested in class with 25 students from Class VII E of SMP Negeri 15 Banjarmasin to determine its practicality and effectiveness, based on the calculation of student responses to the questionnaire scores in Table 6.

Table 6. Results of the practicality of the science learning module

No	Assessment Aspect	Amount	Percentage of Aspect Score	Criteria
1	User Ease	654	93.42%	Very Practical
2	Benefit	753	94.12%	Very Practical
3	Time Efficiency	475	95.00%	Very Practical
Overall Score		**1,882**	**94%**	**Very Practical**

In addition to obtaining practicality scores for the science learning modules based on student response questionnaires, the developed science learning modules also received comments and suggestions from students. These comments and suggestions are presented in Table 7.

Table 7. Students' comments and suggestions on class tests

No	Comments and Suggestions
1	Learning becomes more fun and easier to understand
2	Lessons are easier to remember because there are examples
3	I like learning using the science learning module, and suggest that the module can be further developed
4	The material on temperature and heat is easier to remember because you observe it directly
5	Practical lessons are inspiring and add new knowledge
6	Learning with modules is more interesting

The validated and improved science learning module was then tested on students. This trial aimed to determine the results of the science learning module. The initial stage was a limited trial involving a small group of 10 students from Class VII D of SMP Negeri 15 Banjarmasin. The results of the small group test showed that the developed science learning module received a favorable category with a score of 90%. The next stage after the small group test was to administer a class test to class VII E of SMP Negeri 15 Banjarmasin, which consisted of 25 students. The student response questionnaire consisted of three aspects: user convenience, benefits, and time efficiency.

The first aspect of this practicality questionnaire is user-friendliness. Based on student responses, the user-friendliness aspect received a score of 93.42%, which is categorized as very practical. This suggests that the developed science learning module has enabled students to understand the subject matter more easily. Consistent research conducted by Apriani et al. (2021) demonstrated that students' understanding of the material improves when using coherently structured learning materials, thereby achieving learning objectives.

The second aspect of this practicality questionnaire is its usefulness. Based on the student response questionnaire, this aspect of usefulness received a score of 94.12%, indicating it is convenient. This indicates that the developed science learning module has attracted students by connecting material and concepts to everyday life. Connecting material with everyday life can train students' critical thinking skills. According to research conducted by Mahmudah & Chamami (2025), students will gain a deeper understanding through learning that connects material to real-life experiences, thereby developing critical thinking skills.

The third aspect of this practicality questionnaire is the time efficiency aspect. Based on the student response questionnaire, this aspect of time efficiency received a score of 95% with the criterion of being very practical. This indicates that the developed science learning module is easy to learn and understand during the learning process, and is easy to remember because students observe directly. This aligns with positive comments from students who find the material easier to remember due to its direct observation. This is based on Budiastra & Wicaksono (2023), which explains that understanding the concept of science material is obtained from practical learning, where students touch, observe, measure, and carry out direct proof, making the learning easier to remember.

Based on the three aspects of the student response questionnaire, the developed science learning module received a score of 94%, with the criteria of being very practical. This suggests that the science learning module, integrated into problem-based learning related to Ethno-STEM, is practical for students, offering user-friendliness, benefits, and time efficiency

5) Effectiveness of Class/ Field Table 7. Students' Tests

The effectiveness of the developed science learning module can be based on the results of the N-gain score calculation for the students' pretest and posttest. The results of the calculation on the effectiveness of the science learning module, integrated with Ethno-STEM as a problem-based learning approach, improving students' critical thinking, are presented in Table 8.

Table 8. Results of the effectiveness of the science learning module

Average Pretest Score	Average Posttest Score	Average N-gain Score	Criteria
37.6	89.2	0.82	High

The results of the critical thinking test for 25 students, presented by the critical thinking indicator, are shown in Table 9.

Table 9. Critical thinking test results per indicator

No	Critical Thinking Indicators	Question No	Pretest	Posttest	N-gain score	Average N-gain score
1	Provide a simple explanation	1	12	60	0.54	0.65
		3	12	80	0.77	
2	Build basic skills	4	20	92	0.90	
		5	16	80	0.76	0.84
		6	68	96	0.80	
3	Conclude	2	44	92	0.57	0.89
		10	48	96	0.92	
4	Provide further explanation	7	68	100	1.00	0.97
		9	20	96	0.95	
5	Set strategy and tactics	8	68	100	1.00	1.00

The effectiveness of the science learning module, based on problem-based learning integrated with Ethno-STEM, in improving students' critical thinking skills is reviewed based on the results of calculating the pretest and posttest scores of critical thinking questions completed by students using the N-gain calculation. The calculation of the effectiveness of this science learning module is in Table 8. The results of critical thinking test questions answered by students before learning using the science learning module (pretest) yielded an average score of 37.6. In contrast, the results based on critical thinking test questions answered by students after learning using the science learning module (posttest) yielded an average score of 89.2.

This science learning module integrates ethnoscience and STEM, which can help improve students' critical thinking skills. According to the research conducted by Fionita & Wulandari (2024), which found that students' critical thinking skills increased when Batik Sidoarjo ethnoscience teaching materials were integrated, compared to using textbooks. Dywan & Airlanda (2020) also explained that students' critical thinking skills increased when they learned with STEM-integrated teaching materials compared to those who learned without STEM integration.

The indicator providing simple explanations is the lowest. Based on the type of questions given, students are still not trained when conducting daily interviews related to ethno-STEM. This objective relates to local wisdom, which can train students' critical thinking skills. Consistent with research conducted by Shafira & Suratsih (2024), which explains that students' critical thinking skills can be trained by getting used to formulating and answering questions that require explanations related to everyday life using a problem-based learning model. The indicator for building basic skills was the fourth highest. This improvement was supported by problem-based learning, which connects the concept of interpreting experimental data into graphs, thus training critical thinking skills.

The conclusion indicator was the third highest. This improvement was supported by the activity of interpreting data into conclusions in the first and second discussion sessions, thus practicing students' science process skills. This aligns with research conducted by Santiawati et al. (2022), which explains that concluding is part of the science process skills, obtained through a series of activities presenting data from investigations, including making predictions, drawing conclusions, and formulating hypotheses based on the data obtained.

The indicator providing further explanation was the second highest. This improvement was supported by a more in-depth explanation of the concepts of temperature and heat, connecting them to local wisdom. The research is based on A'yun et al. (2025), which demonstrated that strong critical thinking skills allow students to elaborate on a concept in depth and analyze a problem.

The indicator for managing strategies and tactics was the highest. This improvement was supported by the teacher's provision of guiding questions in the first lesson, which involved students measuring the temperature difference between hot and cold water. This aligns with research conducted by Bilkisda & Sudibyo (2021), which showed that junior high school students are at the formal operational cognitive development stage, capable of abstract reasoning and possessing strong memory, as well as strategic thinking in developing strategies.

4. CONCLUSION

Based on the results of research and development carried out, the science learning module, which integrates problem-based learning with Ethno-STEM on temperature and heat materials, is suitable for use to improve the critical thinking skills of junior high school students. The science learning module developed: 1) Very valid based on a validity score of 82%, 2) Very practical based on a practicality score from class/ field trials of 94%, 3) Very effective based on a critical thinking N-gain score of 0.82 with a high category. The researcher provides suggestions for further research to develop teaching materials by creating learning modules based on problem-based learning, integrated with Ethno-STEM, to enhance students' abilities in the 21st century.

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