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Development of Problem Based Learning Physics Teaching Modules to Improve the Argumentation Skills of Students at SMA Negeri 2 Makassar

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Abstract: This research is a type of Research and Development (R&D) research with a 4D model development method. The 4D stages include: defining, designing, developing, and disseminating. This research and development aim to design and analyze a physics teaching module based on Problem Based Learning that is valid, practical, and effective and can improve students' argumentation skills. The number of validators who provided an assessment of the validity of the module content was 3 validators, the number of teachers who provided an assessment of practicality was 10 physics teachers, and the physics teaching module based on Problem Based Learning that had been developed was tested on 36 students of class X.9 of SMA Negeri 2 Makassar. The instruments used in this study included validation of the open physics module, teacher response questionnaires, and validated argumentation ability tests. The results of the study indicate that the physics teaching module based on Problem Based Learning is in the valid category with an average Aiken's V value of 0.79, practicality with a percentage of teacher responses of 89% is in the very practical category, and effectiveness with an average N-Gain of 0.62 is in the moderate category. Based on these results, the physics teaching module based on Problem Based Learning as a whole is considered valid, very practical, and quite effective for use in the physics learning process.

Keywords: Argumentation skills; Problem-based learning; Teaching module

Introduction

Education has a major role in ensuring the survival of a nation and state, because education is a vehicle for improving and developing the quality of human resources. The key role of education is not only limited to providing information, but also in forming quality and productive human resources. Human resources are expected to be able to adapt to change. In the context of the 21st century, education is directed at four main pillars, namely learning to know, learning to do, learning to be, and learning to live together, and prioritizing a student-centered learning approach (Banarsari et al., 2023)

The curriculum is an important part of the education system because it is the main reference in the learning process. The curriculum is not only a formal document, but also functions as a tool that helps educators design and implement a quality learning process (Andari, 2022). In response to the impact of the COVID-19 pandemic which caused learning loss in students, the government through the Ministry of Education, Culture, Research and Technology has innovated by implementing the Merdeka Curriculum (Maulida, 2022). This curriculum is designed to meet the demands of the times, emphasize flexible and contextual learning, and form independent and character-based students (Nurhamida & Andromeda, 2023).

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One of the main differences in the Independent Curriculum is the use of teaching modules instead of the Learning Implementation Plan. Teaching modules are learning tools designed to achieve learning outcomes by considering the needs and characteristics of students. The preparation of teaching modules is part of the teacher's pedagogical competence because it requires creativity and innovation in designing effective and efficient learning (Maulida, 2022).

Learning outcomes refer to the skills that students acquire as a result of the learning process and can be observed through the learner's performance (Hsieh & Maritz, 2023; Nurmahasih & Jumadi, 2023). In the Merdeka Curriculum, learning outcomes can be achieved if the learning process aligns with the Learning Achievements (Capaian Pembelajaran, CP). Learning Achievements (CP) are the competencies that students must attain at each phase (Nurmahasih & Jumadi, 2023; Saputri et al., 2023; Wahyuni et al., 2024).

Adapting to the demands of the independent learning curriculum, it is important for students to have science process skills and reasoning skills, namely argumentation (Triananda et al., 2025). Argumentation skills are very important for students to master because first, students will gradually learn to solve problems through the process of mastering argumentation skills. Second, students can build social activities through activities to explain, criticize and modify arguments. Third, it is easier and bolder for students to express their ideas because they are based on supporting evidence. Fourth, it is easier for students to understand concepts and reasoning, because evidence to support claims must be found independently by students. Fifth, argumentation skills help students connect facts, procedures, concepts, and solutions that are interrelated from argumentation skills.

One of the hopes is that the higher a person's argumentative ability, the better their ability to provide reasons for solutions or answers to the problems given (Fatmawati et al., 2018). So, from this reason, the ability to argue is very necessary for students. Argumentation also plays an important role in physics learning activities, because through the argumentation process, students who study physics will also have the opportunity to defend or refute existing ideas when practicing scientific methods. Argumentation is the process of strengthening claims through critical thinking analysis based on evidence and logical reasons (Irvan & Admoko, 2020).

According to Sujanem et al. (2018) the educational process in the 21st century prioritizes the development of critical thinking skills or abilities. Argumentation skills are included in one of the indicators of critical thinking skills that are prioritized in the 21st century. The same thing was expressed by Rahman (2018) that argumentation can facilitate several 21st century competencies, including critical thinking competencies, besides that argumentation can also develop communication competencies. Some important reasons for implementing argumentation in learning are: (1) scientists use argumentation in developing and improving their scientific knowledge; (2) society uses argumentation in scientific debates; and (3) students in learning need argumentation to strengthen their understanding.

Physics is first formally introduced to students at the junior high school level and often provides an initial impression that shapes long-term views of the subject. Many consider physics difficult and less relevant to everyday life, even though physics actually aims to develop a scientific mindset to understand natural phenomena, not just solve mathematical equations. This gap between conceptual goals and mathematical approaches can hinder the learning process, including in terms of developing problem-solving skills. In addition, difficulties in understanding physics material can affect students' argumentative abilities, because mastery of concepts greatly supports these abilities (Allen et al., 2025).

Previous research results found that students' argumentative abilities still tend to be low. Mubarok et al. (2016) stated that argumentative abilities in physics learning are still low because learning has not directed students to actively participate in the learning process. According to Mahardika et al. (2015), students' skills in providing arguments in the learning process are considered very low because argumentative skills are rarely practiced. The same thing was expressed by Ishaq et al. (2022) that the lack of students' argumentative abilities was due to the less than optimal answers given by students due to several factors including a lack of understanding of physics concepts and unfamiliar question forms.

One of the learning models recommended in the Merdeka Curriculum is Problem Based Learning (PBL), which focuses on solving problems relevant to real life. This model is considered effective in training students' critical thinking and argumentation skills because it requires them to discuss and defend solutions to the problems given (Kumala et al., 2017).

The PBL model is considered effective in improving students' 21st century skills (Nilyani & Ratnawulan, 2023). Problem-based learning aims to provide real problems to students, so that they learn collaboratively in groups, search for and collect relevant information, process data, and solve the problems given. Through this process, problem-based learning not only develops critical thinking and problem-solving skills but also fosters scientific argumentation skills. Collaboration in groups allows students to exchange knowledge, build new knowledge from other people's ideas, and practice evidence-based reasoning and strong decision-making (Tsai, 2018).

The results of observations at SMA Negeri 2 Makassar indicate that, first, this school has implemented an independent curriculum in physics learning. Second, in the physics learning process, the teaching modules used in the learning process are still simple, the learning syntax has not been described in detail for each teacher and student activity, the reading materials used use open packages provided by the Ministry of Education and Culture, this is because teachers experience obstacles in developing teaching modules such as limited time, energy and lack of creativity. Teachers also sometimes use teaching modules provided by the Ministry of Education and Culture which have not fully adapted to the needs and characteristics of students in each region with different characteristics, such as the culture of the learning environment, the completeness of learning resources, and other learning variables that affect learning outcomes including the ability to argue.

The ability to argue in physics learning has an important role for students. First, students will gradually learn to solve physics problems through the process of mastering argumentation skills that include determining claims, collecting data/facts that support claims, providing justifications that connect data/facts with claims. Second, students can dig deeper into physics concepts in the problem-solving process accompanied by data/facts and justifications. Third, students become more courageous in expressing ideas based on supporting evidence and providing rebuttals to claims of a problem that are not quite right. This encourages discussions to be more active in the physics learning process. However, based on the results of the interview, in the physics learning process at SMA Negeri 2 Makassar, students' argumentation skills have not been trained.

Argumentation skills are very important in physics learning because they help students solve problems through compilation of claims, data support, and justification. In addition, students can understand physics concepts more deeply and become more confident in expressing ideas and refuting inappropriate claims. This encourages more active discussions in the physics learning process. However, based on the interview results, in the physics learning process at SMA Negeri 2 Makassar, students' argumentative skills have not been trained. This causes students to tend to be passive when discussing during the learning process. In fact, when the teacher asks students to express ideas or answer questions, they often choose to remain silent because they are afraid of giving the wrong answer. In addition, assessments to measure argumentative skills have never been developed at the school.

In developing a Problem Based Learning (PBL)-based teaching module, expert assessment is needed to assess the feasibility of the module. According to Nieveen in Sari (2021), a good learning product must meet three main criteria: validity, practicality, and effectiveness. A module is declared suitable for use if it meets these three aspects. Valid means legitimate and cannot be disputed, practical means easy and efficient, while effective refers to achieving goals in a timely manner. Based on this, the researcher conducted a study entitled "Development of a Physics Teaching Module Based on Problem Based Learning to Improve Argumentation Skills of Students at SMA Negeri 2 Makassar."

Physics learning is often considered difficult by students, even though some have high intelligence in fun programming. This perception gap is a challenge for teachers in designing interesting and easy-to-understand learning. One solution that can be done is the development of a user-friendly learning module. (Afdalia et al., 2020). Abstract physics requires time and learning media that support understanding of its concepts. Physics modules can be teaching materials that help students learn independently and lighten the teacher's workload (Bahri et al., 2017). Module development is very important in improving the quality of learning, especially at the secondary school level, if it is adapted to the needs of teachers and students (Mustafa et al., 2020). The quality of the module is evaluated based on aspects of validity, practicality, and effectiveness.

Validity, according to KBBI, is a true nature based on evidence, logic, or is legitimate. This term comes from the word valid, which means relevant and justifiable (Douglas & Purzer, 2015). Validity relates to the extent to which a test actually measures what it should measure (Zahfa et al., 2025). In assessment, it is important to ensure that the test measures the right thing and is suitable for use in decision making. Validity indicates the accuracy and precision of the measuring instrument in carrying out its function (Sudaryono et al., 2019). In teaching modules, validity is assessed through aspects of the appropriateness of content, presentation, language, and graphics (Nursyahitna et al., 2024).

Practicality, according to KBBI, means something that is based on practice, easy to use, fun, and efficient. The practicality test is carried out after the product is declared valid to assess whether the module can be understood and is of interest to instructors and students (Dahal et al., 2023). Practicality criteria include clarity of content, timeliness, and benefits of the module, and are determined by teacher responses and their application in learning (Zakirman et al., 2022). While effectiveness is a measure of success in the learning process, which shows the extent to which the experience and results of the intervention are in accordance with the objectives that have been set. An activity is declared effective if it is able to achieve the expected goals (Febriyanti et al., 2018).

Method

Type of Research

This research is a Research and Development that refers to the 4-D development model developed by Thiagarajan, namely Define, Design, Development, and Dissemination.

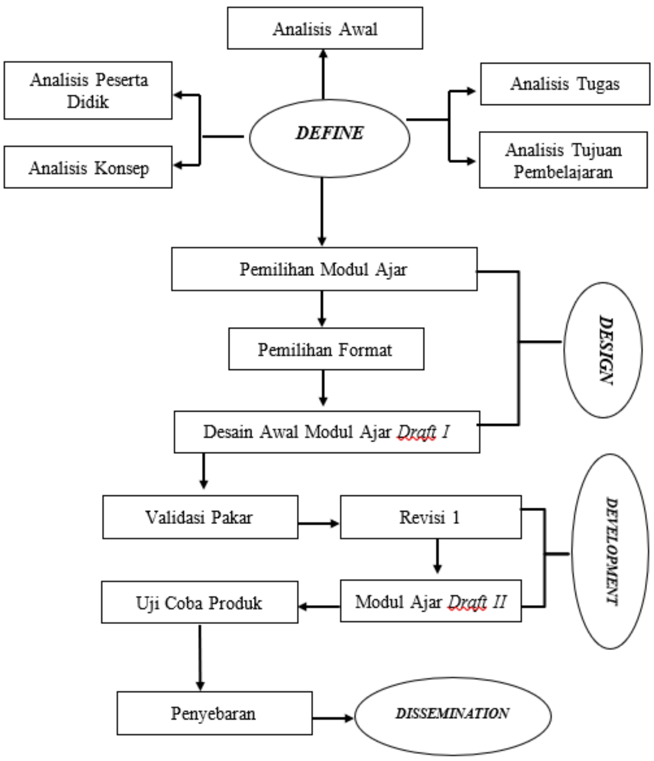


Figure 1. 4D model development procedure

Define Stage

The first stage carried out was the definition stage, namely the determination of learning requirements, which aims to determine and define the needs in the learning process and collect various information related to the development of the physics teaching module based on Problem Based Learning. The define stage includes several analyzes, namely initial analysis, student analysis, task analysis, concept analysis, and learning objective analysis.

In the initial analysis stage at SMA Negeri 2 Makassar, a number of fundamental problems were found in the physics learning process. Although the school has implemented the Independent Curriculum, teachers experience obstacles in developing teaching modules that are in accordance with the characteristics and needs of students. The modules used are still simple, do not contain detailed learning syntax, and depend on textbooks from the Ministry of Education and Culture that are less contextual and do not pay attention to current phenomena. Teachers also face limitations in time, energy, and creativity in compiling innovative and relevant teaching materials.

In addition, learning tends to focus on question-and-answer techniques and has not provided space for students to develop their argumentative skills. Argumentative skills that include conveying claims, presenting supporting data, providing justification, and rebuttals have not been trained systematically so that students tend to be passive and lack confidence when discussing. Assessments to measure this ability are also not yet available. Therefore, it is necessary to develop a Problem Based Learning (PBL)-based teaching module that is able to facilitate students to learn actively, independently, and collaboratively through contextual problem solving, and can be accessed with the support of technological devices that are already available in schools.

Analysis of grade X students of SMA Negeri 2 Makassar shows that they are in the age range of 15-18 years, which according to Jean Piaget's cognitive development theory is included in the formal operational stage. At this stage, students are generally able to think abstractly, use logic in problem solving, and are able to plan and understand argument structures. In terms of learning styles, students show diversity, with a dominant kinesthetic learning style (39%), followed by visual (36%), and auditory (25%). This diversity of learning styles requires the application of a varied and interactive learning approach. Therefore, learning tools are needed such as Problem Based Learning (PBL)-based teaching modules that can accommodate students' needs through visual presentation in reading materials, physical activities in LKPD, and discussion and presentation methods that are in line with the cognitive characteristics and learning styles of students.

Task analysis is carried out to identify the main activities that must be carried out by students based on the learning outcomes (CP) of the Independent Curriculum in phase E. The tasks previously designed by the teacher include observing learning videos about the phenomena of climate change and global warming, followed by recording important facts and answering analytical questions. The concepts discussed in the material on climate change and global warming are the greenhouse effect, causes and impacts of global warming, facts about climate change, and efforts to control climate change. The objectives of this learning are that through literacy and discussion students are able to analyze the phenomenon of the greenhouse effect; through literacy and discussion students are able to analyze the causes and impacts of global warming; through literacy and discussion students are able to understand the phenomenon of climate change; through literacy and discussion students are able to evaluate alternative solutions to climate change and global warming in everyday life.

Design Stage

After identifying the problem in the definition stage, the next step is the design stage. The design stage aims to create an open module based on Problem Based Learning that can be used in physics learning. This stage includes the selection of learning modules and materials, selection of learning module formats, and development of initial learning module designs.

Develop Stage

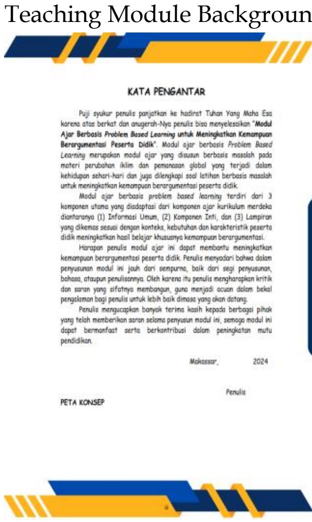
This development stage aims to produce a physics teaching module based on Problem Based Learning. At this stage, the validity of the instruments used in the study, design revisions and trials are carried out. At the content validity stage, the validity of the teaching module, the validity of the teacher response questionnaire sheet, and the validity of the physics argumentation ability test instrument for students are carried out. Based on the results of the assessment, corrections and suggestions from experts, improvements are then made to the PBL-based physics teaching module. After conducting the validity of the teaching module content based on expert assessments, the revision results are obtained which are used to revise the PBL-based physics teaching module, as in the table 1.

After the revision of the teaching module, a limited product trial was conducted to determine the results of the application of the PBL-based physics teaching module in classroom learning and to determine the increase in students' argumentation skills after using the PBL-based physics teaching module.

Dissemination Stage

After going through a limited trial, the next stage is the dissemination of the physics teaching module. In this study, the dissemination was carried out on a limited basis to physics teachers at SMA Negeri 2 Makassar, SMA Negeri 3 Makassar, and SMA Negeri 8 Makassar. The purpose of this stage is to promote and obtain assessments from physics practitioners/teachers in order to determine the level of practicality of the PBL-based physics teaching module. The assessment was carried out using a validated questionnaire instrument, involving 4 physics teachers from SMA Negeri 2 Makassar, 3 teachers from SMA Negeri 3 Makassar, and 3 teachers from SMA Negeri 8 Makassar.

Table 1. Results of the Revision of the PBL-Based Physics Teaching Module

Before Revision	After Revision
Cover	
	
Teaching Module Background and Text Type	
	
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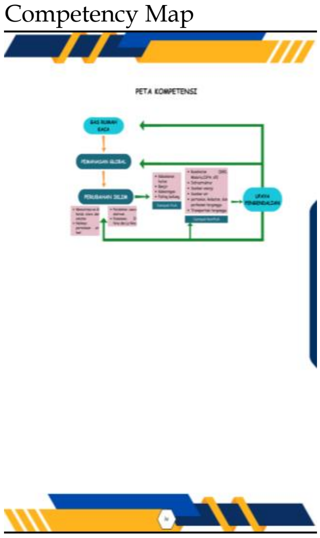
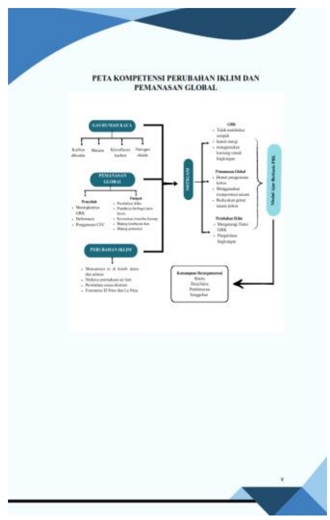
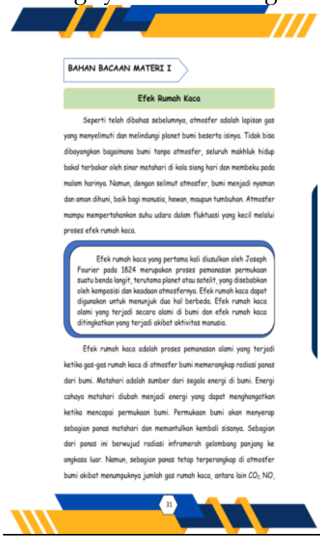
	

Before Revision	After Revision
Adding syntax to reading materials	
	

Trial subjects

The trial subjects in the study were students of class X.9 MIPA at SMA Negeri 2 Makassar in the 2024/2025 Academic Year. The product trial was conducted on 36 students of class X.9. The research trial design used the One-group pretest-posttest design model as shown in the following figure:

O_1	X	O_2

Figure 2. One-group pretest-posttest design model

Data Analysis

Analysis of Teaching Module Validity Data

To determine the validity relevance of the teaching module as assessed by three experts, the content validity coefficient (Aiken's V) was used. The Aiken's V formula is employed to calculate the content validity coefficient based on the assessment results from each expert regarding an item, using the equation 1, proposed:

$$V = \frac{\sum s}{n\,(c-1)} \quad (1)$$

Explanation

V: index of rater agreement on the validity of an item

s: The score assigned by each rater minus the lowest score in the category used (s = r – Io, where r is the rater's category score and Io is the lowest score assigned)

n: number of raters

c: number of categories selected by the raters

The criteria for Aiken's V test indicate that if V ≥ 0.4, then the index of expert agreement is considered valid (Retnawati, 2016).

Analysis of Practitioner Response

The practicality analysis is based on data obtained through a questionnaire filled out by practitioners/teachers. Practitioners' assessment of the physics teaching module based on Problem Based Learning stated in the questionnaire sheet was analyzed using equation 2.

$$PRS = \frac{\sum A}{\sum B} \times 100\% \quad (2)$$

Calculating the percentage of practitioner assessment for each statement with the criteria determined through the scaling procedure produces figures at the measurement level as follows:

Table 2. Practitioner Assessment Score Criteria (Riduwan, 2015)

Percentage (%)	Criteria
80-100	Very Practical
61-80	Practical
41-60	Quite Practical
21-40	Not Practical
0-20	Very Not Practical

Analysis of the Effectiveness of Teaching Modules

The effectiveness of the PBL-based physics teaching module can be seen from the students' argumentation ability scores after the module usage trial. The developed teaching module can be said to be effective if there is an increase in students' argumentation ability. To determine the increase in students' argumentation ability, an analysis of the pretest-posttest data was carried out using the following N-Gain percentage formula:

$$N - Gain = \frac{skor\ posttest - pretest}{skor\ maksimum - pretest} \quad (3)$$

The gain index interpretation criteria can be seen in Table 3 below:

Table 3. Normalized Gain Criteria (Meltzer, 2002)

Limits	Category
$g \geq 0.7$	High
$0.3 \leq g < 0.7$	Medium
$g < 0.3$	Low

Result and Discussion

Results of Content Validity of Physics Teaching Module Based on Problem Based Learning with Aiken's V Index

The physics teaching module based on Problem Based Learning developed in this study was validated by three experts to assess its validity before conducting a limited trial. Aspects assessed in the validation process include the appropriateness of the content, appropriateness of the presentation, appropriateness of the language, and appropriateness of the graphics of the teaching module. The results of the test scores for the analysis of the validity coefficient of the expert agreement index with the Aiken's V index are presented in Table 4 below:

Table 4. Validity Analysis Test of PBL-Based Physics Teaching Module with Aiken's V Index

Aspect	Total score item validity	V	Category
Content suitability	10.67	0.76	Valid
Presentation suitability	5.67	0.81	Valid
Language suitability	9.67	0.81	Valid
Graphics suitability	7	0.78	Valid
Average		0.79	Valid

Source: processed primary data (2025)

Based on the research results, data analysis has been conducted on the validity of the content of the PBL-based physics teaching module assessed by three experts. Aspects assessed in the validation process include the feasibility of the content, the feasibility of the presentation, the feasibility of the language, and the feasibility of the graphics of the teaching module. The content validity of the teaching module was analyzed using the Aiken's V expert agreement index test, with the criterion that an instrument is declared valid if the Aiken's V coefficient is greater than 0.4. Based on the results of the validity analysis as shown in Table 4, an average Aiken's V coefficient of 0.79 was obtained, which indicates that the PBL-based Physics teaching module is included in the valid category and is worthy of being continued to the trial stage.

The results of this study are in line with the results of previous studies. Santoso et al. (2022) showed that research instruments such as handouts and LKPD used in physics learning with the PBL-Online model to improve the scientific argumentation skills of high school students were in the valid category while the pretest posttest sheets showed that they were in the very valid category so that they were declared suitable for use for research. Nuraliza et al. (2023) in their research also stated that the content validity of the PBL-based physics module on the material of optical instruments and global warming for high school physics learning was in the very valid category, so it was suitable for teachers to use in the learning process.

The same thing in the study conducted by Rizaldi et al. (2023) stated that the validation of the PBL-based High School Physics Practical E-Module was in the very valid category. These results indicate that the E-Module can be tested. Meanwhile, Nabila (2024) stated that the PBL-based physics teaching module received a very good assessment from material and media experts, so it was declared suitable for use as a learning resource.

Teachers' responses to the Physics Teaching Module Based on Problem Based Learning

Teachers' responses to the physics teaching module based on Problem Based Learning were obtained through filling out a questionnaire by physics subject teachers. This assessment questionnaire was filled out by 4 physics teachers from SMA Negeri 2 Makassar, 3 physics teachers from SMA Negeri 3 Makassar, and 3 physics teachers from SMA Negeri 8 Makassar. The teacher response questionnaire consisted of 19 statement items related to the scope of the teaching module content, the suitability of the teaching module in measuring argumentation skills, the advantages of the teaching module, and the practicality of the developed teaching module. Teachers' responses to the practicality of the PBL-based physics teaching module developed can be seen in Table 5 below:

Table 5. Practitioner Assessment Results of PBL-Based Physics Teaching Modules

Assessment Aspects	∑A	∑B	PRS %	Criteria
Coverage of Teaching Module Content	111	120	93	Very Practical
Suitability of Teaching Module in Measuring Argumentation Ability	167	200	84	Very Practical
Advantages of Teaching Module	213	240	89	Very Practical
Practicality of Teaching Module	180	200	90	Very Practical
Average			89	Very Practical

Source: processed primary data (2025)

Practitioners in this study were high school physics teachers in Makassar, totaling 10 physics teachers. The practicality of the PBL-based physics teaching module was analyzed based on the results of teacher responses shown in Table 5. The teacher response questionnaire consisted of 19 statement items related to the ease of use of the PBL-based physics teaching module that had been developed. The aspects assessed in the teacher response questionnaire sheet included (1) aspects of the scope of the teaching module content, (2) aspects of the suitability of the teaching module in measuring argumentation ability, (3) aspects of the excellence of the teaching module and (4) aspects of the practicality of the teaching module.

According to KBBI, practicality refers to ease of use or practical application. According to Zikra et al. (2025), regarding the practicality of E-LKPD differentiated learning styles on global warming material phase E of SMA which shows that teaching devices can be considered practical if practitioners state that the teaching devices are theoretically feasible to use in learning, and the level of application shows good results in the field. Based on the analysis of data from the teacher response questionnaire in Table 5 a percentage of 89% was obtained which was in the very practical category. This shows that the developed teaching module can help teachers in the physics learning process and provide convenience to train students' argumentation skills in learning.

Teachers gave feedback that the PBL-based physics teaching module developed was interesting for students to use and suitable for use in learning, especially in efforts to improve argumentation skills. This is supported by learning activities designed in the module that provide opportunities for students to discuss, explore problems, and express opinions, which are in line with the characteristics of the PBL model. However, practitioners also provide suggestions that the material presented be increased with content that is more relevant to everyday life and uses factual data to make it easier for students to understand.

The results of this study are in line with the results of previous research conducted by Waruwu et al. (2024) who developed a PBL-assisted physics e-module to improve student learning achievement, where the results showed that the practicality of the e-module was in the very practical category, meaning that the PBL-assisted physics e-module can be used by teachers in the learning process.

Effectiveness of Physics Teaching Modules Based on Problem Based Learning

The effectiveness of the Problem Based Learning-based physics teaching module can be seen based on the increase in students' argumentative abilities derived from the test results of class X.9 students of SMA Negeri 2 Makassar. The argumentative ability test was given before learning (pretest) in the form of 4 essay questions and given after learning (posttest).

The argumentative ability test (pretest) was used to measure students' initial abilities before participating in learning activities on the material of climate change and global warming, while the argumentative ability test (posttest) was used to see how the argumentative ability was after using the PBL-based physics teaching module. The results of the analysis of students' argumentative ability tests before (pretest) and after (posttest) being given the PBL-based physics teaching module can be seen in Table 6.

Table 6. Results of Analysis of Argumentation Ability Test Scores of 36 Students

Parameter	Pretest	Posttest
Maximum Ideal Score	44	44
Minimum Ideal Score	0	0
Maximum Empirical Score	22	38
Minimum Empirical Score	4	21
Average Score	11.72	31.53

Source: processed primary data (2025)

Based on Table 6. above, it is obtained a picture of the increase in students' argumentation skills as reviewed from the data on pretest and posttest scores on 36 students. The average score of students for the pretest was 11.72 while the average score of students for the posttest was 31.53.

The improvement of students' physics argumentation skills based on the pretest and posttest is completely presented in the form of a bar chart in Figure 3. Based on Figure 3, the scores obtained by students after following the learning process using the Problem Based Learning-based physics teaching module increased.

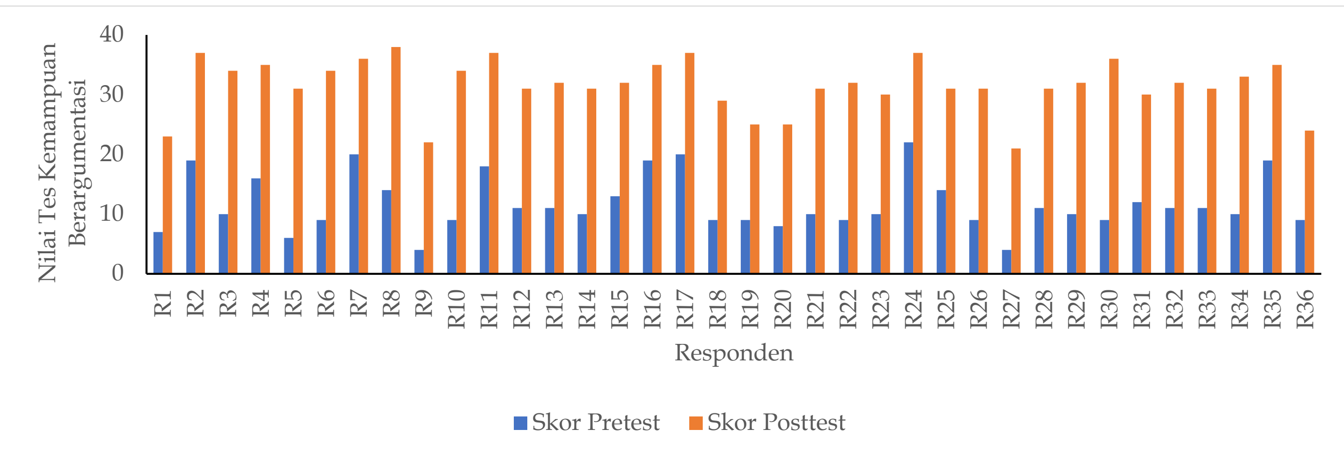


Figure 3. Pretest and posttest scores of students' argumentation skills

The effectiveness of the developed PBL-based physics teaching module can be seen through the pretest and posttest scores of the argumentation skills of class X.9 students of SMA Negeri 2 Makassar. The results of the analysis of the effectiveness of the use of PBL-based physics teaching modules analyzed using the N-Gain formula can be seen in Table 7.

Table 7. Normalized Gain (N-Gain) Analysis of Physics Argumentation Ability of Class X.9 Students of SMA Negeri 2 Makassar

Limits	Category	Average N-Gain
$g \geq 0.7$	High	
$0.3 \leq g < 0.7$	Medium	0.62
$g < 0.3$	Low	

Source: processed primary data (2025)

The results of the argumentative ability test obtained from the pretest and posttest were analyzed using the N-Gain formula so that an average N-Gain of 0.62 was obtained in the moderate category ($0.3 \leq g < 0.7$), which indicates that there was an increase in argumentative ability from pretest to posttest at a fairly significant level. This proves that physics learning using PBL-based teaching modules can improve students' argumentative abilities. This is in line with previous research conducted by Pratama et al. (2021) which stated that problem-based practical learning has proven to be very effective in improving argumentation skills, as indicated by the average N-gain value of the pretest and posttest of 0.80 (high category).

The results of the research and development of physics teaching modules based on Problem Based Learning show that the module meets the criteria of being valid, very practical and quite effective in improving the argumentation skills of students at SMA Negeri 2 Makassar. The improvement of students' argumentation skills cannot be separated from the role of the PBL model which is integrated in the development of teaching modules. The PBL model provides space for students to be actively involved in the learning process, especially through group discussion activities that trigger the exchange of ideas and clarification of concepts or facts. This activity trains students in building and defending arguments, and responding to other people's arguments constructively. This active involvement also forms an important foundation in the development of students' argumentation skills.

This is in line with the research results of Santoso et al. (2022) who stated that through the syntax of the PBL model, it can encourage students to be more actively involved during learning to express their arguments. Likewise, Pratiwi et al. (2019) found that there was a relationship between the application of problem-based learning (PBL) and increased argumentation skills in learning, with a correlation coefficient of 0.639. This indicates that there is a very good relationship between the application of problem-based learning and the development of argumentation skills in problem-based learning.

The results of this study are also in line with the research of Lentika et al. (2022) who developed a PBL-based physics LKPD on Newton's Gravity material. The study showed that the teaching materials developed had a high level of validity, were very practical to use, and were effective in improving students' scientific argumentation skills, with an average N-Gain of 0.7342 so that it was declared suitable for use in learning. The results of this study are also in line with the research of Muspiroh et al. (2024) in their study entitled "Improving Students' Scientific Argumentation Skills Through Problem-Based Learning (PBL)", an N-gain of 0.53 was obtained in the experimental class in the moderate category. Student learning activities with the application of PBL require students to be more active in learning so that they have a positive influence on learning success.

Conclusion

Based on the results of the research and discussion that have been conducted, it can be concluded that the physics teaching module based on Problem Based Learning is in the valid category with an average Aiken's V value of 0.79, practicality with a percentage of teacher responses of 89% is in the very practical category, and effectiveness with an average N-Gain of 0.62 is in the moderate category. Based on these results, the physics teaching module based on Problem Based Learning as a whole is considered valid, very practical, and quite effective for use in the physics learning process.

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Authors Contribution

O.B.M.: Conceptualization, methodology, writing original draft preparation, formal analysis, investigation, visualization, writing—review and editing. J. & K.A.: Validation, supervision, and resources. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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