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Creating Problem Based Learning E-Modul for Teaching Heat and Heat Transfer in Grade XI Physics

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Abstrak

Bahan ajar merupakan komponen penting dalam proses pembelajaran. Bahan ajar memberikan arahan kepada guru dalam menentukan langkah-langkah pembelajaran dan membantu menciptakan lingkungan belajar aktif. Lingkungan ini dapat menggeser peran guru dari yang awalnya menggunakan metode ceramah menjadi lebih banyak menggunakan metode diskusi. Salah satu bahan ajar yang digunakan adalah modul. Modul harus dikembangkan sesuai dengan kebutuhan kurikulum dan perkembangan zaman, modul konvensional telah berkembang menjadi modul elektronik. Dalam pengembangan e-modul, perlu diperhatikan kesesuaian isi dan model yang digunakan dengan tuntutan abad 21. Salah satu model pembelajaran yang sesuai dengan kurikulum dan tuntutan abad 21 adalah model pembelajaran berbasis masalah. Penelitian ini bertujuan untuk menghasilkan e-modul yang valid dan praktis. Penelitian ini menggunakan metodologi Penelitian dan Pengembangan (R&D) dengan model pengembangan ADDIE. Hasil uji validitas e-modul menunjukkan skor rata-rata sebesar 0,87 yang masuk dalam kategori valid. Uji praktikalitas yang dilakukan terhadap guru menghasilkan skor 92,08%, sedangkan uji praktikalitas yang dilakukan terhadap siswa menghasilkan skor 91,14%, keduanya menunjukkan kategori praktis.

Kata kunci : *E-Modul, Pembelajaran Berbasis Masalah, Kalor dan Perpindahan Kalor*

Abstract

Educational materials are essential components in the learning process. Teaching materials provide direction to teachers in determining learning steps and help create an active learning environment. This environment can shift the teacher's role from primarily using lecture methods to incorporating discussion methods. One of the teaching materials used is modules. Modules must be developed according to curriculum needs and current trends; conventional modules have evolved into electronic modules. In the development of e-modules, it is crucial to consider the suitability of the content and the model used to meet the demands of the 21st century. One learning model that aligns with the curriculum and 21st-century demands is the problem-based learning model. This research aims to produce e-modules that are both valid and practical. The study used a Research and Development (R&D) methodology and employed the ADDIE development model. The results of the validity test of the e-module showed an average score of 0.87, falling into the valid category. The practicality test conducted with teachers resulted in a score of 92.08%, while the practicality test conducted with students yielded a score of 91.14%, both indicating a practical category.

Keywords : *E-Module, Problem-Based Learning, Heat and Heat Transfer*

INTRODUCTION

The progress of technological knowledge in the 21st century is increasing because of the many advanced technologies that can assist human work. Technological advancements have impacted the field of education, particularly in the development of instructional materials and teaching media. One example is physics education. Physics education is a subject that discusses natural phenomena and events related to them. Physics education teaches students to understand concepts and principles, which helps in developing their confidence. Therefore, in physics

education, the renovation of teaching materials is necessary so that students can better improve their achievements in learning (Maritsa dkk., 2021).

Teaching materials are a form of learning support that can help teachers implement various learning models. Instructional materials developed independently, while considering the conditions and behaviors of students, can significantly contribute to the success of the learning process. These adjustments make learning more effective and tailored to students' needs. Teaching materials can encourage teachers to adopt newer models, thereby reducing their reliance on traditional lecture methods(Fajri, 2018). The lecture method is a teaching approach that often involves minimal student interaction, which can make learning monotonous and result in lower student performance (Magdalena dkk., 2020). One type of teaching resource required in the independent curriculum is a module.

Modules are one type of teaching material that presents learning content in a specific model, thereby making learning more varied. Modules help guide teachers and provide steps for implementing learning, enabling a shift from traditional lecture methods to more innovative learning models. As time has progressed, modules have also evolved. Initially, printed modules were widely used, but they have largely been replaced by electronic modules or e-modules . The disadvantage of printed modules is that they have not kept pace with technological advancements, limiting their presentation to static images (Dewi dkk., 2015) . Additionally, excessive use of paper contributes to environmental damage. Printed modules, which can be bulky, also incur costs for students, making them less efficient for learning (Zhang, 2017) .

E-modules are among the instructional resources that must be developed in accordance with the applicable curriculum. The current curriculum in effect is the independent curriculum, which provides students with the flexibility to hone their abilities and maximize their potential. The independent curriculum aligns with 21st-century education goals, aiming to produce students who are researchers, problem solvers, and who exhibit creativity and critical thinking (Hudha dkk., 2017). E-modules are essential for realizing the goals of both the independent and 21st-century curricula (Akhmadi, 2023). To address the complex and dynamic challenges of the 21st century, appropriate and effective learning models are needed. One of the most suitable approaches is the Problem-Based Learning (PBL) model, which motivates students to confront and solve real-world problems. This model enhances students' problem-solving skills and encourages greater engagement in the learning process.

The PBL model is a highly effective educational approach for enhancing students' abilities to analyze and solve various problems. In the PBL model, students are tasked with analyzing and addressing problems that arise in their immediate environment. This approach not only facilitates a deeper understanding of the issues they encounter but also encourages their active involvement in the educational process(Hartatik, 2023). Students engage in more in-depth and practical experiences, which strengthens their critical analysis skills and problem-solving capabilities. The use of PBL modules can be particularly beneficial for students and schools that have traditionally relied on printed books from previous curricula. Therefore, implementing the PBL model within the independent curriculum can offer educators direct, hands-on experiences.

E-modules represent an innovative advancement in educational materials, providing a modern approach to the learning process (Jayanti & Pertiwi, 2023). To maximize their effectiveness, e-modules should be specifically developed by teachers, considering the unique characteristics of students and the teaching methods to be employed. This tailored development ensures that e-modules meet the needs of students and align with the educational strategies used in the classroom. E-modules are prepared before the material is introduced, allowing students to familiarize themselves with the content prior to class discussions. This preparation enables students to learn independently and gain a general understanding of the material.

The contextual presentation of e-modules helps educators use them more effectively. The problems presented in e-modules reflect real-life situations in students' environments and are illustrated through images, videos, and animations. E-modules can be accessed via computers and smartphones, enhancing the educational experience and allowing learning to occur anywhere (Gede Agus Saka Prasetya dkk., 2017). The interactive nature of e-modules encourages students

to be more actively involved in the classroom, fostering two-way interactions that enhance their ability to analyze issues related to the learning materials.

However, the reality observed in the field does not reflect ideal conditions. To gather data, researchers distributed questionnaires to students, conducted interviews with physics teachers, and made direct observations in the classroom. In this study, the researcher examined the tendencies in the learning models used by teachers. It was found that teachers still predominantly use lecture and presentation methods to explain learning materials. Teacher activities remain traditional, with teachers explaining lessons using lectures while students passively listen. Students are not given the opportunity to express their opinions or engage in discussions, which restricts their understanding of physics to only basic concepts.

The second issue identified is the low level of awareness among teachers regarding the development of their own teaching materials. As a result, the teaching materials at schools still follow the old curriculum. Teachers continue to use printed books from the previous curriculum as their primary learning materials. Interviews with physics teachers revealed that they have limited time and capability to design new teaching materials, leading them to rely on outdated printed books.

The third problem is the monotonous nature of the teaching materials, which are often limited to pictures. Because the materials are based on printed books, students show reduced interest in learning. Printed books are perceived as difficult and cumbersome, leading students to rely solely on teacher explanations without engaging in independent study. This issue becomes apparent during classroom observations, where the use of only printed materials creates a monotonous learning environment with minimal interaction between teachers and students. Students often do not know what will be covered in the lesson and have not attempted to understand the material beforehand.

The fourth problem relates to students' learning outcomes in physics. Assessment results reveal that some students do not fully understand the physics material. The average score was 56.25, which falls into the low category. This data suggests that students face challenges in studying physics.

The fifth problem concerns heat and heat transfer. A questionnaire administered to students indicated that heat and heat transfer are perceived as difficult topics. Additionally, interviews with physics teachers revealed that there are no teaching materials, such as modules, available for these topics. Teachers have been unable to create instructional materials due to time constraints and a lack of proficiency in designing engaging materials using available applications. Consequently, teaching materials for these topics are not yet available at schools, and students continue to rely on outdated printed books.

The gap between ideal and real conditions highlights significant issues. This situation points to a research problem. Given these challenges, the researcher is interested in developing PBL-based teaching materials for heat and heat transfer. One essential teaching resource that aligns with the current curriculum is the e-module. E-modules can enhance students' enthusiasm for learning both in the classroom and independently. They are more interactive, easy to view or load videos, and include evaluations that support independent learning. Effective e-modules should be engaging and incorporate images and videos to captivate students' interest.

Electronic teaching materials provide students with opportunities to access content on heat and heat transfer while adhering to the PBL model. PBL-based e-modules can facilitate educators in presenting material and make it easier for students to understand the content. Developing PBL-based e-modules is crucial for student-centered learning, promoting active participation, and enhancing students' critical thinking and problem-solving skills.

METHOD

This research uses the Research and Development (R&D) method, which emphasizes the creation of new products and the improvement of existing products. This approach allows researchers to develop learning products based on needs analysis and field observations. This research follows the ADDIE (Analyze, Design, Develop, Implement, Evaluate) model, which is a structured framework that facilitates continuous evaluation and revision, ensuring that the resulting

e-modules have high validity. The aim of this study is to create a PBL-based e-module for physics learning, with a focus on the topic of heat and heat transfer, for grade XI Phase F students.

This research was conducted at the Faculty of Mathematics and Natural Sciences, Padang State University, during the process of product linking and valorization. After that, the research continued at UNP Development High School to test the practicality of the product. This e-module was chosen because it has gone through a development and validation process. After the validation stage, this e-module was tested to assess its practicality through trials involving physics teachers and students at the UNP SMA Development Laboratory. This research applies the ADDIE model, which is divided into five stages.

A. Analysis Stage

The analysis stage includes needs analysis, problem identification, and goal formulation. Needs analysis was conducted through observation, interviews with physics teachers, and distribution of questionnaires to students. This process included:

1. Analysis of Student Characteristics: This assesses the level of development and cognitive abilities of students based on experience, background, interests, talents, initial abilities, learning outcomes, as well as personality and behavioral differences. The results of this analysis are used as a basis for designing appropriate learning.
2. Module Needs Analysis: This is used to gain an overview of existing facts, alternative solutions, and student characteristics to help select the media to be developed.
3. Curriculum Analysis: This aims to review performance indicators and learning objectives that apply in schools. The curriculum analysis is carried out to examine the curriculum used and to consider it in the development of teaching materials.
4. Material Analysis: This examines the curriculum used at school to identify the content included in the module and adjusts it to the competencies that students need to acquire in the field of heat and heat transfer.

B. Design

The next step in this process is the design phase, which involves the creation and structuring of e-modules. This includes determining learning indicators, defining learning objectives, and organizing e-module materials. At this stage, the e-module is prepared in alignment with the criteria of the Ministry of National Education (2010), using a logical and accurate framework for teaching materials. This design, based on previous research, resulted in an e-module based on the Problem-Based Learning (PBL) model. The design structure of the e-module, in accordance with the guidelines of the Ministry of National Education (2010), includes elements such as the cover, introduction, and content (title, e-module instructions, learning outcomes, learning objectives, materials, worksheets that align with the problem-based learning model, exercise questions, glossary, and references). At this stage, researchers collect and edit content from references using Word, Canva, and Heyzine.

C. Development

After the e-module's initial design has been completed, the development stage focuses on applying the design to produce e-modules based on the PBL model, which is aligned with the material, learning outcomes, and goals to be achieved. At this point, the researcher presents the product to experts for evaluation. This research involved five lecturers from the UNP Department of Physics as validators, who provided feedback and recommendations used by researchers to improve the product. Evaluation at this stage involves analyzing data from product assessments provided by validators. The purpose of this evaluation is to determine the validity of the e-module based on the problem-based learning model. Taking into account the suggestions and comments of experts, as well as the analysis of product revision data by researchers, it is expected to develop a suitable product ready for further testing.

D. Implementation

At this stage, a small-scale trial was conducted to assess the practicality of the e-module. Two teachers and 28 students participated, providing evaluations, feedback, and suggestions about the e-module. The assessment involved physics teachers and students evaluating the e-module’s practicality, including two physics teachers and 28 students from the UNP Development Laboratory High School. Initially, the researcher provided detailed

instructions on the effective use of the e-module, ensuring that all participants understood its functions and features. Then, various features of the e-module that facilitate students in the learning process were introduced, such as the assignment collection feature, which aids teachers, among several other features that enhance the use of e-modules.

After the testing phase, the researcher guided participants on how to fill out the questionnaire provided, which was designed to collect detailed feedback on various aspects of the e-module. Teachers and students were asked to critically evaluate the e-modules, focusing especially on the module's alignment with the PBL model. Their feedback, including numerical assessments and qualitative suggestions, is crucial for the next stage of evaluation. During this evaluation stage, the researcher carefully analyzed the data collected from the participants' assessments. This analysis aims to determine the overall practicality and effectiveness of the e-module, as well as to identify areas that need improvement. The insights gained from teachers and students are invaluable in refining the e-modules, ensuring they are suitable for use in education and meet the desired learning objectives.

E. Evaluation

Evaluation conducted at each step in the ADDIE development model is an important process that aims to identify and minimize errors in product development. At each stage of development, evaluation is carefully conducted to uncover any weaknesses that may exist in the process, allowing the researcher to make necessary improvements. This process involves structured data analysis, starting from the needs analysis stage where data is collected through interviews and observations to understand user needs and the learning context. After that, at the development stage, product validity results are evaluated to ensure that the product is considered valid. Finally, at the implementation stage, practicality data is collected to assess the extent to which the product can be applied in a real learning environment. Each of these data analysis stages provides important insights that are used to continuously improve and refine the product, making it an optimal learning resource ready for use in various educational contexts.

RESULTS AND DISCUSSION

The first stage in this process is the analysis stage, which ensures that the development of educational products is based on real needs in the field. This needs analysis aims to gather in-depth information about the various problems that arise in physics learning, as well as identify the root causes. These problems can be related to various aspects, ranging from teaching and learning activities to the effectiveness of the teaching materials used. By understanding these problems, the specific needs required to support and improve the learning process can be accurately identified. The process of collecting information is done through three methods: direct observation during learning activities, interviews with physics teachers, and questionnaires distributed to students.

Direct observation of the learning process provides researchers with a deep understanding of how learning activities are implemented in the field. Furthermore, it gives the researcher the opportunity to gauge the degree to which students understand, absorb, and apply the learning materials. Thus, the researcher can collect information regarding teaching methods and how students respond to learning materials. Meanwhile, interviews with educators and grade XI students at the UNP Development Laboratory High School provide a deeper perspective on the challenges they face every day, as well as needs that may not be met by existing teaching materials or methods.

Through the data obtained, the needs analysis is able to provide a clear picture of the condition of physics learning in grade XI and to provide a strong basis for developing more effective and relevant solutions. The results of this analysis stage will be the foundation for the next development steps, ensuring that the products produced are truly in line with the needs of students and educators in the field.

The second stage is the product design stage, which focuses on refining and adjusting the initial e-module design. A PBL model is used in this e-module, designed to make the learning experience more dynamic and engaging. This model allows for a more active approach to learning.

Additionally, the framework of this e-module adheres to the 2010 regulations from the Ministry of National Education. This guarantees that the module not only follows established best practices but also meets the quality standards required to support an effective learning process. Some of the main components contained in this e-module include: 1) Title, which provides clear identification of the topic, 2) Learning outcomes, which set out what students are expected to achieve after using the e-module, 3) Learning objectives, which detail the specific objectives to be achieved in each sub-learning material, 4) Teaching materials, which include material to be learned, 5) Practice questions, which are designed to test students' understanding of the material, 6) Evaluation, which aims to evaluate the achievement of predetermined competencies, and 7) References, which provide sources for the e-module.

Furthermore, researchers adjusted the structure of the e-module to fit the applicable curriculum and the PBL model. This model follows the five main steps: 1) Orientation to the problem, 2) Organizing learners, 3) Guiding investigations, 4) Presenting results, and 5) Analyzing and evaluating the problem-solving process. This product design stage is then evaluated through a continuous improvement process until the product reaches the expected quality. In this study, the designed e-module resulted in four learning activities divided into sub-chapters for each meeting. The e-module that has been designed is compiled in accordance with the Ministry of Education's 2010 guidelines. After the product design was completed, researchers conducted an initial validity test of the e-module to ensure that the developed product met the expected standards and was ready for further testing stages.

The third stage is the product validation stage. At this point, the developed product is reviewed and approved by experts. The results given by experts become a standard in determining the feasibility of the e-modules used and serve as a guideline for revising the products. All suggestions from validators are used to create e-modules that are appropriate for use. Testing the validity of e-modules based on the PBL model aims to assess the validity of the products that have been designed and to obtain comments and suggestions from experts for improvements. This process begins with the assessment of the validation sheet by the supervisor, ensuring that the assessment instrument used is in accordance with established standards. Before the validation sheet was applied, the researcher compiled the relevant instrument theory to ensure alignment with the instrument used in the product evaluation. During the first month, the validation sheet was used to evaluate various aspects of the e-module, covering aspects such as material content, instructional design, visual elements, the software utilized, and the implementation of the PBL model.

The validation process of this e-module lasted for about 1.5 months and involved five experts with special expertise in physics education and teaching. During this period, the experts provided suggestions on the developed e-modules. This assessment covered various aspects of the e-module, such as material substance, learning design, visual communication, software used, as well as the application of the PBL model. The feedback provided by the experts was used to refine and improve the product to meet the set standards.

The results of the experts' assessment show that this e-module meets the required academic standards and is declared suitable for use in grade XI physics learning, especially on heat and heat transfer materials. Thus, this e-module is expected to achieve the desired educational objectives, namely improving students' understanding of the material taught and facilitating a better and more interactive learning experience. This thorough validation process is an important step in ensuring that the final product is a quality learning resource that is suitable for use.

The evaluation of the e-module's validity was carried out by dividing it into five primary components. These components are: the substance of the material, which includes its content and quality; the learning design, which is concerned with the organization and presentation of the material; the visual communication, which involves the graphical elements and overall visual layout; the software used, to verify that the technological aspects function properly; and the application of the PBL model, which evaluates how effective this e-module is in use. In the substance component of the material, the assessment is carried out based on four indicators: accuracy, completeness, relevance, and suitability of the material. The assessment results for

these indicators are 0.83, 0.87, 0.84, and 0.89, all of which are classified as valid categories. These figures show that the material presented in the e-modules has met the expected academic standards and relevance to the learning context.

The first component, content feasibility, includes four indicators. The results describing the substantial aspects of the material in the e-module using the PBL model are detailed in Figure 1. This figure illustrates the evaluation of each content feasibility indicator and provides an overview of the quality of the material presented in the e-module.

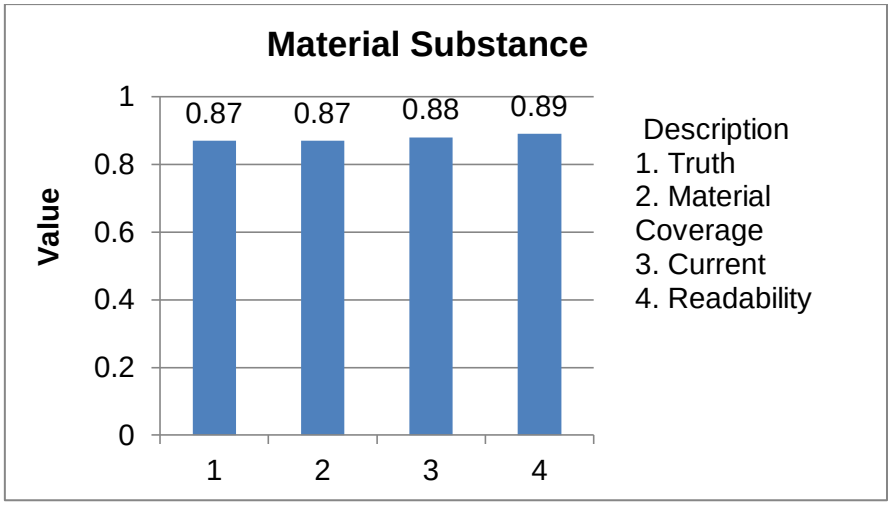

Fig 1. Validation Graph on the Material Substance Component

The second component, the learning design assessment aspect, includes six indicators. The results illustrating the learning design component in the PBL model-based e-module are shown in Figure 2. This figure provides a detailed description of how each indicator related to the learning design was assessed.

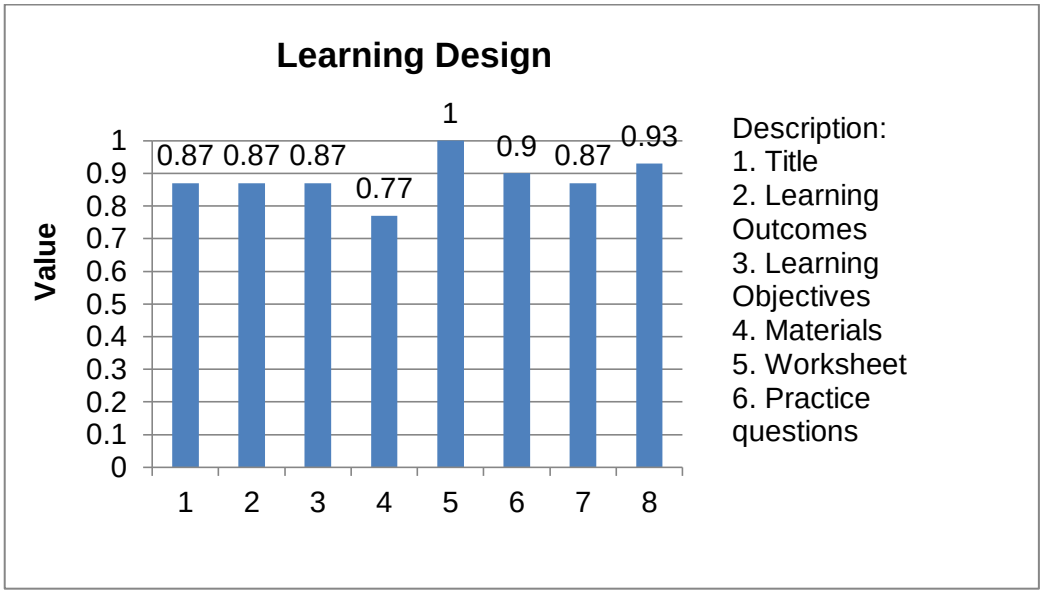

Fig 2. Validation Graph on the Learning Design Component

The third component, the visual appearance aspect, includes six indicators. The results describing the visual communication component in the PBL-based e-module are shown in Figure 3. This figure provides a detailed description of the results for each indicator related to the visual appearance component.

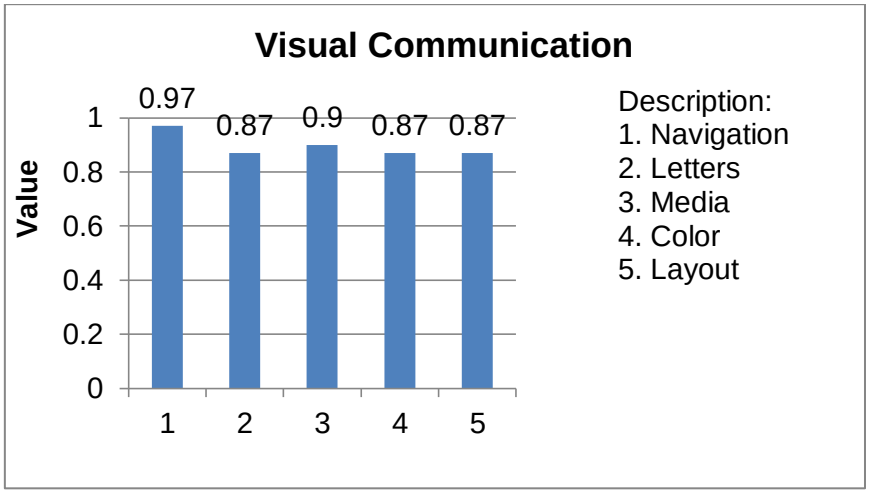

Fig 3. Validation Graph on Visual Communication Component

The fourth component involves the assessment of the software or devices used**.** The evaluation results for this aspect in the PBL-based e-module show an average value of 0.89. This value indicates that the software or device component is categorized as valid, meaning it meets the required standards.

The fifth component focuses on assessing the PBL model aspect and consists of five different indicators**.** The results for this component in the e-module are shown in Figure 4. The figure provides a comprehensive overview of how each indicator related to the PBL model was assessed, offering insights into the extent of the model's integration and implementation in the e-module.

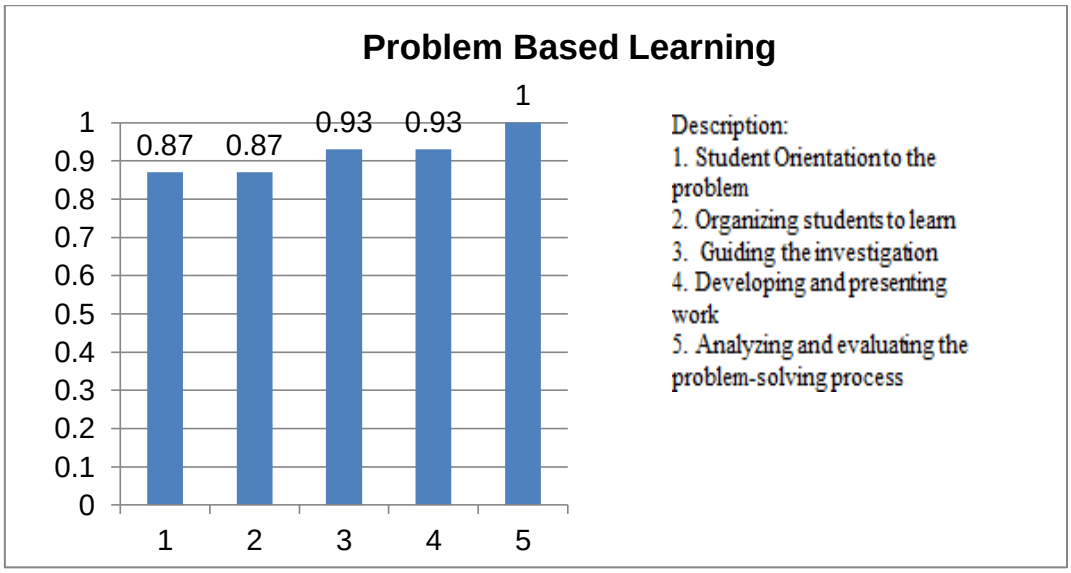

Fig 4. Validation on PBL Model components

The average value obtained from each component of the assessment of the PBL-based e-module for physics learning on heat and heat transfer in Grade XI Phase F SMA/MA is calculated from the analysis of the six components of the validity assessment. The assessment is conducted by experts in physics education and learning material development. This process aims to evaluate the validity of the materials used. **Table 1 displays the average results of the assessment.** This table provides an overview of the evaluation conducted by professionals in the field, showing how well the e-module meets the expected validity criteria for use in the learning process.

Table 1. Validity Value Table

	Komponen Validitas	Rata-Rata Nilai V	Kategori
1	Material Substance	0,87	Valid
2	Learning Design	0,88	Valid
3	Visual Communication	0,89	Valid
4	Software dan devices	0,90	Valid
5	PBL Model	0,92	Valid
	Average	**0,89**	**Valid**

At this stage, improvements are made based on the validation results and feedback from the validators. This evaluation is crucial to ensure that the product meets the established standards. Comments from the validators serve as the basis for further improvements. The goal of this evaluation is to refine the e-module, focusing on heat and heat transfer material, to ensure it meets validity criteria and is ready for practicality testing. The validation of e-modules adopting the PBL model yielded various recommendations and inputs from the validators. This feedback will be used to revise and enhance the module to ensure it complies with academic standards and is effective in a learning context, providing optimal benefits for its users.

The product implementation stage is crucial in the development of e-modules, as it assesses the practicality and user-friendliness of the module. During this stage, practicality assessment sheets are distributed to teachers and students who will use the e-modules in their educational activities. This testing aims to evaluate how user-friendly the e-module is in a classroom setting and how effectively it supports the learning process. Before distributing the assessment sheets, the researcher validated them with the supervisor to receive suggestions and input, ensuring that the assessment sheets effectively measure the practicality of the e-module.

This practicality test was conducted at the UNP High School Development Laboratory, involving 28 Grade XI students and two physics teachers who had studied heat and heat transfer material. Prior to the test, the researcher provided detailed briefings to teachers and students on how to use the e-module, including navigation, use of available features, and task completion through the module. Researchers also demonstrated key features of the e-module, such as assignment submission, access to teaching materials, and utilization of evaluation tools. This was done to ensure users fully understand how to use the e-module, so the results of this practicality test accurately reflect the e-module's effectiveness in supporting learning. The results of the practicality assessment for teachers and students are presented in the table below.

Table 2. Practicality Results by Teachers

No	Practicality Component	Average Score	Category
1	Easy of use	89,77%	Very practical
2	Attractiveness	94,64%	Very practical
3	Efficiency	92,86%	Very practical
4	PBL model	92,50%	Very practical
	Average	92,08	Very practical

Table 3. Practicality Results by Student

No	Practicality Component	Average Score	Category
1	Easy of use	9148%	Very practical
2	Attractiveness	91,20%	Very practical
3	Efficiency	90,56%	Very practical
	Average	91,14%	Very practical

The results of the practicality test conducted by students showed that the developed e-module was found to be highly practical for use. The average value of 91.14% obtained from this practicality test indicates that the e-module supports the learning process effectively and is user-friendly for students in daily learning contexts. The analysis of the practicality values reflects that the e-module meets the expected needs, suggesting that this module can be applied effectively in teaching and learning activities and provides significant benefits for its users.

CONCLUSION

According to the results, the e-module developed with the PBL model for heat and heat transfer has been validated with an average score of 0.87 from experts. In terms of usability, physics teachers rated it very practical with an average score of 92.08%, while students rated it at an average of 91.14%. This indicates that the e-module is both effective and user-friendly in the learning process. However, since this research involved only a small-scale test, further studies are recommended to assess its effectiveness more comprehensively. Researchers hope that this module's development will extend beyond heat and heat transfer to cover all class XI materials in the independent curriculum.

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