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Development of problem-based learning module on fundamentals of mechanical engineering

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Abstract

This study aims to develop a teaching module based on Problem Based Learning (PBL) in the subject of Fundamentals of Mechanical Engineering for class X students of SMK Dhuafa Padang. This research uses the Research and Development (R&D) method with the DDD-E development model which includes four stages: Decide, Design, Develop, and Evaluate. The developed module aims to increase students' engagement in learning as well as their ability to solve problems through a problem-based approach. The developed module was validated by three experts, namely material, media, and language experts. The validation results showed a very good level of validity, with the percentage of validation as follows: material aspect of 98.33%, media aspect of 91.76%, and language aspect of 92.5%, which indicates this module is very valid and feasible to use. In addition, the practicality test was conducted by class X students, and the results showed that this module was very practical with a practicality score of 88.21%. In conclusion, this Problem-Based Learning-based teaching module is effective and practical to use in learning Fundamentals of Mechanical Engineering, and can increase students' active participation and their problem-solving skills. This module is expected to be a useful reference in the development of vocational learning that is more relevant to the needs of the industrial world.

Keywords : Teaching module, Problem Based Learning, Fundamentals of Mechanical Engineering, module development, DDD-E.

Introduction

Education plays a vital role in the development of a country, because the progress of a country depends on the intelligence of its people. According to Law No.20 of 2003 on the National Education System, education is aimed at developing students' abilities, fostering character, and instilling positive values to create a generation that contributes to the progress of the nation and educates the community. Education in Indonesia is experiencing rapid development in response to the demands of globalization and technological development. One aspect of education that is crucial in preparing the younger generation to face these challenges is Vocational High Schools (SMK). SMK has a strategic role in preparing students to be ready to enter the world of work by equipping them with practical skills and knowledge.

One of the subjects in the SMK curriculum, especially in Mechanical Engineering, is “Fundamentals of Mechanical Engineering”. A good understanding of these fundamentals is the foundation for students to master further skills in mechanical engineering. However, challenges arise when conventional teaching methods that tend to be teacher-centered are unable to optimize students' learning potential. Teaching modules are tools that support learning in the Merdeka Curriculum, and their development is considered effective for improving the quality of education, so that it can encourage better learning for students (Manalu, et, al., 2022). The module-based learning approach contributes positively to student learning outcomes. Modules not only help structure learning but also facilitate in-depth understanding of concepts, (Smith, J., & Johnson, A., 2021).

The use of modules as a tool in learning is proven to increase the effectiveness and efficiency of the learning process. Thus, educators must have the skills to develop teaching modules that will serve as a guide in carrying out learning effectively. (Sari, et, al., 2020).
The development of teaching modules in the independent curriculum is carried out as a form of interactive education implementation, motivating students and providing opportunities for students to be creative and learn independently according to their development (Ningrum, 2022). The teaching module developed must meet the criteria that are attractive to students, namely by using clear, simple, and easy to understand language, so that this learning tool can make it easier for students to be more effective (Syamsurizal, 2020). Based on this, a learning model is needed that is able to help students to solve problems, especially in Basic Mechanical Engineering subjects, all of which are only focused on mastering the material, so the appropriate learning model is the PBL learning model.
PBL is to develop their knowledge to find solutions in learning activities. (Nisak, 2017). By utilizing the context of real-world problems, PBL encourages students to actively seek solutions and deepen their understanding. The application of PBL can increase student engagement, develop problem-solving skills, and prepare them to face challenges in the real world. The integration of PBL in vocational education shows that PBL is effective in improving students' engagement and their problem-solving ability in vocational education environments, (Kim, Y., & Lee, S., 2018). Therefore, the development of a PBL-based module for the subject of Fundamentals of Mechanical Engineering at SMK Dhuafa Padang is expected to improve students' understanding and their practical skills in dealing with technical problems. With the background description, this research focuses on developing a PBL-based module as an innovation in learning Fundamentals of Mechanical Engineering at SMK Dhuafa Padang. This research is expected to impact the quality of vocational education and help students develop critical thinking skills, as well as better prepare them to face the demands of the world of work in mechanical engineering.

Methods

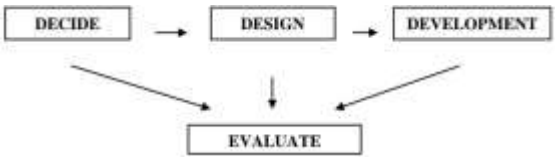
Type of research

This research is a type of Research and Development (R&D), which according to Nana Syaodih (2005) is a process of developing new products or improving existing products scientifically. Budiyono (2017) adds that the R&D method produces products in a particular field along with effective by-products. This research uses the DDD-E model (Decide, Design, Develop, Evaluate) and involves material and language experts in evaluating the practicality of the product. Ivers and Barron (1989) in developing products in the form of teaching modules.

Model Development

This research applies the DDD-E (Decide, Design, Develop, Evaluate) development model. This model consists of three main stages, namely Decide, which focuses on determining objectives and materials, Design, which involves structuring teaching materials, and Develop, which deals with the production of teaching materials. In addition, there is an Evaluation stage used in the development stage.

Fugure 1. DDD-E Development Model



Data Collection Technique

Observation, validity test by material, media, and language experts, and practicality test are the data collection methods in this study involving all students of class X TP SMK Dhuafa Padang.

Data Analysis Technique

The data analysis stage is used descriptively by classifying the results into two categories: Quantitative Data and Qualitative Data. Module feasibility analysis was carried out based on

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questionnaires filled out by material and media experts, language, and practicality tests by students. This analysis technique aims to assess the feasibility level of the module from various perspectives. The reference for analyzing the validity and practicality of teaching modules is shown in table 1.

Table 1. Criteria for assessment aspects

Keterangan	**Skor**
SS (Sangat Setuju)	5
S (Setuju)	4
CS (Cukup Setuju)	3
TS (Tidak Setuju)	2
STS (Sangat Tidak Setuju)	1

After the data is obtained, the data is converted into numerical form, then the average score of each data derived from the validation of material experts, media, language, and user or student responses that have been collected is calculated. The formula used to calculate this average was then applied to each component of the assessment. xi = X/Y x 100%
After the average score in percentage is obtained, it is then converted into qualification criteria for validity and practicality. In making this conversion, it will refer to Kusuma (2018: 67) which is shown in Table 2. for validity criteria and table 3. for practicality criteria.

Table 2. Validity criteria

Persentase	**Qualification**	**Eligibility Criteria**
84% < xi ≤ 100%	Very Valid	No Revision
68% < xi ≤ 84%	Valid	No Revision
52% < xi ≤ 68%	Moderately Valid	Needs Revision
36% < xi ≤ 52%	Less Valid	Revised
20% < xi ≤ 36%	Very Poorly Valid.	Revision

Table 3. Practicality criteria

Persentase	**Qualification**	**Eligibility Criteria**
84% < xi ≤ 100%	Very Practical	No Revision
68% < xi ≤ 84%	Practical	No Revision
52% < xi ≤ 68%	Practical Enough	Needs Revision
36% < xi ≤ 52%	Less Practical	Revised
20% < xi ≤ 36%	Very Less Practical	Revision

Finding and Discussion

Finding

This research and development produces PBL-based teaching module products for Basic Mechanical Engineering subjects. The product in the form of teaching materials for this module is made using Microsoft word which then designs the template using the Canva application. The DDD-E model was used in making this module. The DDD-E model has 4 stages as follows: decide, design, develop, evaluate.

Research data

Product Results

Once the data was collected, it was converted into numbers and the average score for each category was calculated, including validation from material, media, and language experts, as well as responses from users or students. The formula used to calculate this average was applied to all elements of the assessment.

Validity Test

After developing the teaching module, the author proceeded to the validation stage, which included three aspects to be evaluated by the validator: material, media, and language. The validator fills in the teaching module feasibility validation sheet, which consists of a sheet for material experts in PBL-based Basic Mechanical Engineering subjects, a sheet for media experts, and a sheet for language experts. The author collects research data as well as criticism and suggestions from validators through questionnaires that have been tested for validity. The data obtained from each validation sheet was processed using Microsoft Excel.

Table 4. Percentage of material validation results

Number of Items	Total Score	Maximum Score	Percentage
12	59	60	98,33%

From the summary of table 4. it is known that the percentage of material validation is 98.33% from all aspects. The assessment was carried out by 1 teacher of Basic Mechanical Engineering material at SMK Dhuafa Padang.

Data on Validation Results by Media Experts

Table 5. Percentage of media validation results

number of items	score	Maksimum score	Percentage
17	78	85	91,76%

From the summary of table 5. it is known that the percentage of material validation is 91.76% from all aspects. This media expert teaching module assessment was carried out by one FT lecturer at Padang State University, namely Dr. Bulkia Rahim, S.Pd., M.Pd. T.

Data on the Results of Validation by Linguists

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Table. 6 Percentage of language validation results

Number of items	score	Maksimum score	Percentage
8	37	40	92,5%

From the summary of table 6. above, it is known that the percentage of material validation is 92.5% from all aspects. The assessment of this language expert teaching module was carried out by 1 lecturer in Mechanical Engineering at Padang State University, namely Dr. Rizky Ema Wulansari, S.Pd., M.Pd. T.

Practicality Test
Data on the results of the practicality test with respondents of all X TP class students of SMK Dhuafa were obtained by collecting questionnaires that had been filled in on google form.

Table 7. Percentage of test results

Number of respondens	Number of items	Percentage
17	15	88,21%

Discussion
This research follows the stages of the development procedure to produce a quality Problem Based Learning-based module in the Fundamentals of Mechanical Engineering class X subject. Each stage of development is carried out according to procedures and gradually and at each stage is maximally completed. Based on the results of product development that researchers conducted, the average results of module development at the material validation stage were 98.33% very valid category, media validation of 91.76% very valid category, language validation of 92.5% very valid category, and practicality test results of 88.22% very practical category.
Based on the results of the analysis of the three aspects of validity assessment, the data obtained in the form of a bar chart graph showing the percentage level in the aspects of material, media, and language assessment can be seen in Figure 2.

Figure 2. Graph of validation scores

The first step used in this research is to collect data to determine the material used in the teaching module and adapted to the ATP from the Ministry of Education and Culture and analyze the latest curriculum, namely the independent curriculum. The teaching modules developed were then validated by expert validators of material, media, and language, which aims to determine the validity value of the teaching modules that have been developed.
In line with the implementation of research by Zebua et. al. in 2023 on the Development of Indonesian Language Modules with PBL. The study is a research and development study that uses

the ADDIE model which consists of five stages, namely the analysis (analysis), design (design), development (development), implementation (implemitation), and evaluation (evaluation) stages. The development model used is a procedural development model, which is a descriptive model, outlining the steps that must be followed to produce the product. The results showed that the Indonesian language module with the PBL approach was categorized as very good and effective as well as very practical and feasible to use as learning media.
In contrast to the research that the researchers are currently doing with the discussion of the development of Problem Based Learning-based modules in the Fundamentals of Mechanical Engineering class X SMK Dhuafa Padang. The difference in previous research is that the development that researchers are currently doing uses the DDD-E development model by Ivers and Barron, which only has 4 stages, namely Decide, Design, Development, and Evaluate.
The difference between previous research and current research can explain the position of each research and current research can be a renewal, especially in the world of education. The current research can be a refinement of similar previous research if there are deficiencies in previous research. The current research is expected to be able to be an improvement for further research.

Conclusion

The product of the development of teaching modules based on (PBL) in Basic Mechanical Engineering subjects at SMK Dhuafa Padang has been successfully developed. The design of this module with the stages of the DDD-E model (Decide, Design, Develop, Evaluate) and through consultation with the supervisor to produce a module that suits the needs of students.
This teaching module media, material, language experts have validated, the validation results show that this module is very valid for use, with the percentage of validity as follows: 98.33% for material aspects, 91.76% for media aspects, and 92.5% for language aspects. This indicates that this module is suitable for use in learning.
From the results of the practicality test, this module obtained a score of 88.21%, which is included in the very practical category. This means that this module is not only valid from a scientific point of view, but also practical to be applied in the learning process in the classroom.

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Declaration

Author contribution

Qhairunnisa as a researcher and data collector for the facility relationship. Prof. Dr. Ambiyar, M.Pd. is a provider of direction and methods in research; Drs. Nelvi Erizon, M.Pd. Evaluating research methods, Dr. Ir. Mulianti, MT. data analysis and evaluating Background of the Problem.

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Conflict interest

The author states that there was no conflict when conducting the research.

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