

Developing a PBL-Based e-Module for Trigonometry

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Abstract

This research aimed to develop and evaluate the feasibility and effectiveness of an e-module for teaching trigonometry using a Problem-Based Learning (PBL) approach. The study employed the ADDIE model (Analyze, Design, Develop, Implement, and Evaluate) for the e-module development. Data were collected through questionnaires to assess the e-module's feasibility and to gather student feedback. The validators included lecturers and mathematics teachers, and the study involved 28 students from SMA Negeri 5 Kupang. The e-module received high scores from material and media experts, categorizing it as highly suitable for educational use. Students rated the e-module as very interesting. The average test score was 92, indicating the e-module's effectiveness in enhancing students' understanding of trigonometry.

Keywords: E-Module; Problem Based Learning; Trigonometry.

1. Introduction

Mathematics is essential for almost all subjects, making it a vital area of study for students. Learning mathematics is important not only at the school level but also for solving real-world problems. (Fatmawati, 2022). Rachmayani (2014) states that Mathematics is not only the queen but also the servant of all sciences. It serves as the source of scientific knowledge and meets the needs of various disciplines through its development and application. Thus, mathematics can be considered the foundation of all sciences, playing a crucial role in technology and other fields of knowledge.

Technological developments have now permeated the world of Indonesian education. The education sector demands technological advancements to enhance the quality of education, particularly in adapting and improving learning methods. (Budiman, 2017). One of the most important components in life is education. As stated by Safitri (2017), education aims to create a new generation with the right abilities in their respective fields, aligning with advancements in technology and science. Students must learn various subjects during their education, one of which is mathematics. Trigonometry, a branch of mathematics, is particularly related to science and technology.

One of the fields of mathematics is trigonometry, which involves the study of measuring angles and sides of triangles. In high school grade X, trigonometry is one of the most frequently studied subjects. Due to the complexity of some chapters, students often find it challenging to understand subsequent material. According to Putu et al. (2019), advanced mathematics utilizes trigonometry to solve problems across various fields. Data from the 2019 UN High School Show indicate that student proficiency levels were 38.50% for algebra, 36.63% for statistics, 36.54% for geometry, and 24.97% for trigonometry. These figures highlight a significant lack of understanding among students in trigonometry, reflected in

the low percentage of correct answers. This underscores the urgent need for additional teaching materials to enhance comprehension of trigonometric concepts, given the current educational challenges and insufficient supporting resources.

During an interview with a grade X mathematics teacher at SMAN 5 Kupang, it was revealed that despite employing modern teaching methods, students exhibit low engagement in the classroom, posing challenges for teachers. The primary instructional resource used by mathematics teachers is textbook packages that often feature unclear language and overly complex material. Moreover, teachers have yet to develop supplementary teaching materials that effectively motivate and capture students' interest in learning mathematics.

Technology is increasingly viewed as engaging and facilitating learning. According to Divayana, Suyasa, Ariawan, Mahendra, and Sugiharni (2019), traditional textbooks can sometimes fail to capture student interest, lacking interactive learning media that enhance motivation. Such teaching materials also serve as valuable references for educators (Hutama, 2017), applicable across all subjects, including mathematics, known for its complexity. Electronic-based teaching materials enhance student engagement by making learning more interactive and enjoyable. To prevent student disengagement, trigonometric concepts are often contextualized within everyday life to enhance comprehension. Combining printed modules with electronic media—referred to as electronic modules or e-modules—further facilitates student learning.

Electronic modules, a type of teaching material systematically aligned with the curriculum and accessed via electronic devices like Android, computers, or laptops, are discussed by Santosa & Santyadiputra (2017). The Flip PDF Professional application offers an intuitive and visually appealing platform for creating engaging e-modules for trigonometry education. It supports both online and offline access, although its use currently requires paid subscriptions, limiting offline access to smartphones or tablets. Effective teaching methods, such as Problem-Based Learning (PBL), should complement these materials to cater to students' educational needs.

Problem-Based Learning (PBL) is an educational approach that involves tackling real-life, open-ended problems to enhance students' problem-solving abilities and foster critical thinking skills. Purnomo, Santosa, and Tentama (2019) note that PBL not only deepens students' understanding of the material but also promotes long-term retention. Teachers facilitate students in independently identifying and addressing sustainable problems, aiming to cultivate a greater enthusiasm for learning and empowering students to devise effective solutions (Qudwatullathifah, Suyitno, & Ridlo, 2020).

Based on the aforementioned challenges of limited teaching materials and conceptual understanding, researchers propose an alternative solution through the development of e-modules. The primary research question is: How can the process of developing e-modules using a Problem-Based Learning (PBL) approach for trigonometric material be both feasible and effective? This study aims to develop and evaluate e-modules employing a PBL approach for trigonometric education, focusing on feasibility and effectiveness as assessed through student feedback. The goal is to create e-modules that enhance student engagement by contextualizing trigonometric concepts within daily life scenarios, thereby facilitating comprehension and preventing student disengagement.

2. Method

This research follows a Research and Development (R&D) approach using the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation (Personal, 2016). The first stage involves analyzing teaching materials through needs analysis and material analysis. The second stage focuses on designing the e-module based on the findings from the analysis stage. In the third stage, the e-modules are developed and undergo validation to assess their feasibility. The validation process employs an assessment scale ranging from 1) strongly disagree to 5) strongly agree to determine the suitability of the trigonometric e-modules. The fourth stage, Implementation, involves utilizing the developed e-modules to evaluate their impact on learning quality

(Widyastuti & Susiana, 2019). The testing phase took place at SMA Negeri 5 Kupang City, involving 28 students from class X of Senior High School.

Validation of the e-modules involves assessment by teaching material experts and content specialists to ensure feasibility. Data collection employs feasibility, attractiveness, and effectiveness analysis techniques. Feasibility is assessed using validation sheets tailored to the e-modules. The research was conducted on Thursday, May 4, 2023, with practicality assessed through student questionnaires. Post-treatment, students were evaluated to gauge the effectiveness of the e-module. Continuous evaluation of each stage is crucial to align designs and materials with student needs (Aldoobie, 2015). The fifth stage, Evaluation, refines the product through feasibility, practicality, and effectiveness tests. Feasibility is gauged using validation instruments measuring both media and content suitability. Practicality is assessed via student response questionnaires, while effectiveness tests measure students' grasp of trigonometric concepts.

To analyze quantitative data from the questionnaires used by validators and respondents related to PBL-based e-modules, the following percentage formula can be utilized:

2.1. Eligibility Analysis

To measure the feasibility of the Problem-Based Learning (PBL) flat-built e-module, the researcher used the following percentage formula to analyze quantitative data gathered during the validity test:

$$\text{Percentage} = \frac{\text{Total Score Obtained}}{\text{The Highest Score}} \times 100\%$$

Table 1 Eligibility Assessment Criteria

It	Percentage	Category	Information
1.	$x \geq 76\%$	Proper	Excellent
2.	$51\% \leq x \leq 75\%$	Proper	Good
3.	$26\% \leq x \leq 50\%$	Not eligible	Less
4.	$x \leq 25\%$	Not eligible	Very Less

2.2. Attractiveness Analysis

To calculate the average score of aspects based on questionnaire responses for attractiveness analysis, the researcher used the following formula:

$$\text{Average Score of each Aspect} = \frac{\text{The Total Score of Each Aspect}}{\text{The Number of Items in Each Aspect}}$$

Table 2 Attractiveness Criteria

It	Percentage	Category
1.	$x \geq 76\%$	Very interesting
2.	$51\% \leq x \leq 75\%$	Pull
3.	$26\% \leq x \leq 50\%$	Less Interesting
4.	$x \leq 25\%$	Not Interesting

Source: Sugiyono. 2012

2.3. Effectiveness Analysis

To analyze the effectiveness of the Problem-Based Learning (PBL) flat-building e-module based on student learning outcomes, you can calculate the average test score using the following formula:

$$\text{Average Score} = \frac{\text{Students' Total Score}}{\text{Number of Students}}$$

Individual student learning outcomes are considered successful if students achieve the Learning Goals Criteria (KKTP) score, which is set at > 80 by SMA Negeri 5 Kupang. Similarly, the trigonometric e-module using a Problem-Based Learning approach is deemed effective if the average student learning score meets or exceeds this minimum KKTP score of 80.

3. Results and Discussion

The process of developing trigonometry e-modules with the Problem-Based Learning (PBL) approach typically involves the following five stages:

a. Analyze Stage

During the analysis stage, interviews with teachers and students revealed that students rely solely on school-distributed handbooks for learning mathematics, indicating a need for additional learning resources to enhance their understanding. Given that all students possess and regularly use gadgets, developing an E-Module is deemed appropriate as it can be accessed conveniently through these devices. The E-Module is designed with a Problem-Based Learning (PBL) approach, aiming to cultivate students' problem-solving skills and critical thinking abilities. This approach encourages students to tackle real-world problems, thereby promoting quick and thoughtful decision-making.

b. Design Stage

During the design stage, the following activities are carried out using Microsoft Word 2007, I Love PDF, and Flip PDF Professional apk. At this stage, a blueprint of the e-module will be developed using the PBL approach, which consists of several steps, namely: 1). Orientation of students to the problem, 2). Organizing students to learn, 3). Guiding individual or group investigations, 4). Connecting and presenting the results, 5). Analyzing and evaluating the problem-solving process.

c. Development stage

At this stage, they make products and develop learning tools according to the results at the design stage. In addition, to test whether this e-module is feasible to use, this e-module is first validated by two validators related to the material and media.

The results of the two material expert validators obtained an average percentage of 90.00% in the feasible category with very good information. And for the validation of the two validators, media experts got an average percentage of 93.33% in the feasible category with very good information. As for the material expert validator 1, a score of 89.28% was obtained which was in the feasible category with a "very good" description, for the material expert validator 2 a score of 90.71% was obtained which was included in the feasible category with a "very good" description, then an average of 90% of the two validators were obtained which was included in the feasible category with a "very good" description. So that the trigonometric e-module is ready to be used as a teaching material.

d. Implementation Stage

Once the e-module is deemed suitable for use, it proceeds to implementation at SMA Negeri 5 Kupang City, involving 28 students in class X. The implementation follows the structured steps of PBL, beginning with the presentation of real-world problems that resonate with students' daily lives for observation. An example of problem presentation within the e-module is illustrated in Figure 1.

Masalah Awal
Orientasi

Petunjuk : perhatikan dan jawablah permasalahan dibawah dengan berdiskusi bersama teman sekelas!

Soal : Ical ingin mengukur lebar sebuah sungai tanpa menyebrang. Ia melakukan teknik pengukuran sebagai berikut:
 Ical berdiri dititik A dan mengukur sudut ke titik C diseborang sungai sebesar 50° . Kemudian ia melangkah Sejauh 300 meter dan berdiri dititik B. dari titik B ia Mengukur sudut C sebesar 30° . Coba bantu Ical menghitung lebar sungai tersebut! Perhatikan gambar disamping

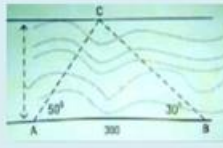


Figure 1. Examples of Problems Presented

After presenting students with a problem and allowing them to observe it, the next stage is organizing students into groups to facilitate collaborative learning. Several groups are formed to encourage idea-sharing and collective problem-solving. During this stage, the teacher provides guidance to each group, fostering the use of student-generated ideas to address the problem. This collaborative process encompasses the third and fourth steps of PBL. An example of how students are organized into groups to facilitate learning is illustrated in Figure 2.



Figure 2. Organizing Students to Learn

In the final stage of PBL, students present their solutions to the problem they have worked on. This presentation allows for collective analysis and evaluation, involving both other student groups and teachers. Together, they assess the effectiveness of the solutions and discuss different approaches taken to solve the problem. An example of this stage is depicted in Figure 3.



Figure 3. Students Present Answers to the Initial Problems Presented

At this stage, a questionnaire was distributed to students to evaluate the practicality of the e-module, gathering their feedback and responses. The results of the student response questionnaire are detailed in Table 4.

Table 4. Student Response Results

It	Student Respondents	Score	Percentage
1.	S1	124	99,2
2.	S2	122	97,6
3.	S3	116	92,8
4.	S4	124	99,2
5.	S5	124	99,2
6.	S6	116	92,8
7.	S7	124	99,2
8.	S8	124	99,2
9.	S9	124	99,2
10.	S10	98	78,4
11.	S11	124	99,2
12.	S12	124	99,2
13.	S13	124	99,2
14.	S14	94	75,2
15.	S15	72	57,6
16.	S16	124	99,2
17.	S17	121	96,8
18.	S18	120	96
19.	S19	115	92
20.	S20	106	84,8
21.	S21	124	99,2
22.	S22	99	79,2
23.	S23	117	93,6
24.	S24	121	96,8
25.	S25	124	99,2
26.	S26	124	99,2
27.	S27	106	84,8
28.	S28	114	91,2
	Sum	3249	2599,2
	Average Percentage		92,8%

According to Table 4, the average student response indicates a satisfaction rate of 92.8%, suggesting that students find the e-module highly engaging and interesting.

e. Evaluation Stage

During the evaluation stage, a learning outcome test was administered to students at SMA Negeri 5 Kupang who had engaged with the trigonometric e-module using the PBL approach (Problem-Based Learning). The results of this test are detailed in Table 5.

Table 5. Results of Student Formative Test Scores

It	Student	Value	Information
1.	S1	100	Complete
2.	S2	100	Complete
3.	S3	100	Complete
4.	S4	100	Complete
5.	S5	91	Complete
6.	S6	66	Incomplete
7.	S7	100	Complete
8.	S8	100	Complete

It	Student	Value	Information
9.	S9	100	Complete
10.	S10	91	Complete
11.	S11	90	Complete
12.	S12	100	Complete
13.	S13	100	Complete
14.	S14	100	Complete
15.	S15	100	Complete
16.	S16	66	Incomplete
17.	S17	100	Complete
18.	S18	66	Incomplete
19.	S19	100	Complete
20.	S20	100	Complete
21.	S21	100	Complete
22.	S22	91	Complete
23.	S23	100	Complete
24.	S24	91	Complete
25.	S25	66	Incomplete
26.	S26	83	Complete
27.	S27	83	Complete
28.	S28	96	Complete
Sum		2580	85,71%
Average		92	

According to Table 5, the average score of the test results is 92, achieving a completion percentage of 85.71%. Based on these results, the effectiveness of the trigonometric e-modules with the PBL approach falls within the "effective" category.

4. Conclusion

In this study, the feasibility of the problem-based learning (PBL) trigonometric e-module was evaluated based on three criteria: feasibility, attractiveness, and effectiveness. The validation questionnaire administered to material validators yielded an average score of 90%, categorized as "feasible" with very good feedback. Similarly, the validation questionnaire for media validators received an average score of 93.33%. Furthermore, the student response questionnaire indicated high attraction with a score of 92.8%, categorized as "very interesting" across all questions. Regarding effectiveness, students at SMA Negeri 5 Kupang achieved an average score of 92 in the learning outcome test, surpassing the KKM score (>80) and falling within the "effective" category. Based on these findings, it can be concluded that the development of the PBL-based e-module on trigonometric material for Class X students at SMA Negeri 5 Kupang is feasible and suitable for use.

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