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Problem-based learning on trigonometry topic: Independent curriculum teaching module

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Abstract

Background: Students often struggle to understand trigonometry. In this context, problem-based learning emerges as an innovative approach that can enhance students' problem-solving abilities through contextual problem-solving. Therefore, the development of an independent curriculum teaching module based on PBL is necessary to improve the quality of learning.
Aim: The aim of this research is to develop a valid independent curriculum teaching module based on problem-based learning for trigonometry topics.
Method: This research employs the Plomp development model to create the trigonometry teaching module. The module was validated by five experts, consisting of three mathematics experts, one language expert, and one graphic design expert. Validation was conducted using a pre-tested validation sheet. The validation results were analyzed and averaged to determine their alignment with validity criteria.
Result: Based on the validation results, it was found that the developed teaching module as a whole achieved an average score of 3.63, meeting the very valid criteria for each assessed aspect.
Conclusion: The independent curriculum teaching module based on problem-based learning for trigonometry topics is valid for use in mathematics education. This research indicates that the module can enhance the quality of learning and students' mathematical problem-solving skills. Future studies are recommended to test the effectiveness of this module in a broader context and with students of varying ability levels.

INTRODUCTION

Problem solving is the ability to process information related to mathematical concepts to make decisions (Julita, 2018). However, there are still many students who experience difficulties in solving problems, especially in mathematics subjects. If a student's mathematical problem-solving ability is problematic, then the result is that the student has difficulty in solving the problem given, the student cannot solve the problem and determine the answer. This means that problem-solving abilities can be seen as one of the learning processes and outcomes (Davita & Pujiastuti, 2020).

Based on a preliminary study conducted by the researcher through the administration of a mathematical problem-solving test, it was found that students' mathematical problem-solving abilities are still relatively low, particularly in the indicators of solving problems with appropriate strategies and drawing conclusions. This is also similar to previous research by Damayanti & Kartini, (2022) which stated that the mathematical problem solving abilities of high school students were still relatively low, namely only 15.7% of students were able to interpret the results of problem solving. Other research by Ulfa et al., (2022) shows that students who obtain very poor qualifications in determining how to solve problems correctly

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which then has a negative impact on students in determining conclusions from the problems given. Based on interviews conducted with mathematics teachers, it was found that students experience difficulties in applying concepts and strategies to solve everyday problems. Consequently, students' learning outcomes are unsatisfactory, particularly in the topic of trigonometry.

Trigonometry is one of the subjects studied by high school students when studying mathematics (Wardhani & Argaswari, 2022). However, the majority of students consider trigonometry to be a difficult topic (Aminudin et al., 2019). Based on research by Rismen et al., (2020), it is explained that students have difficulty because students sometimes forget and are unsure about the correct formula to use in solving trigonometry problems. Wardhani & Argaswari, (2022) said that one of the causes of errors made by students in solving trigonometry problems is a lack of ability to choose the right solving strategy.

Based on the problems described, a trigonometry learning process is needed that gives students the opportunity to improve their problem-solving abilities. One learning model that can improve students' problem-solving abilities is the problem-based learning model (PBL). The use of the PBL model has been proven to be able to improve students' mathematical problem solving abilities according to the results of research by Siagian et al., (2019) and Oktaviana & Suparman, (2020).

Trigonometry learning is currently still not effective, also due to teachers who are still used as information centers in learning and the lack of variety in teaching materials used so that students have difficulty understanding the learning (Rahmawati et al., 2019). In order to realize a better trigonometry learning process, this can be achieved through the application of an independent curriculum to the teaching materials used in the learning process. The independent curriculum is a new policy from the Ministry of Education and Culture to assist the learning process (Syahril et al., 2023). Based on the results of interviews with mathematics teacher, it was stated that the available teaching materials were old teaching materials and did not use the independent curriculum. Therefore, this study aims to address the aforementioned issues by developing teaching materials in the form of a problem-based learning module, utilizing an independent curriculum on the topic of trigonometry.

Various instructional products developed have proven effective in enhancing the quality of learning (Ainin et al., 2020; Armiati & Hidayati, 2023; Putri et al., 2021; Suanto et al., 2022). One of the methods employed is the use of teaching modules. Studies conducted by Anggraini et al. (2021), Fitriwanti et al. (2023), Putri et al. (2020), and Setiyani et al. (2020) have shown that teaching modules can significantly improve students' learning outcomes, especially on the topic of trigonometry. The implementation of problem-based learning (PBL) in trigonometry teaching materials has also been proven to have a positive impact on classroom learning (Hamdani et al., 2023; Nupus et al., 2022). Additionally, problem-based learning has been shown to enhance students' problem-solving abilities (Putri et al., 2023; Suparman et al., 2021; Yandhari et al., 2019).

Recent research by Syahril et al. (2023) has produced a mathematics teaching module using an independent curriculum that is effective in improving students' problem-solving abilities, but it only focuses on the topic of sequences and series. To fill this gap, this study explores how a mathematics teaching module with an independent curriculum on the topic of trigonometry can influence students' problem-solving abilities. Through this approach, the

study not only expands the discourse on the use of teaching modules in mathematics education but also provides new insights into their impact on mathematical problem-solving skills. Therefore, this research aims to address these issues by designing a valid problem-based learning (PBL) teaching module for trigonometry within an independent curriculum.

METHODS

Design

This research is development research with the aim of producing a trigonometry teaching module to improve students' mathematical problem-solving abilities. This research uses the Plomp development model which focuses on the topic of trigonometry. The research procedures carried out are as shown in Figure 1 below.

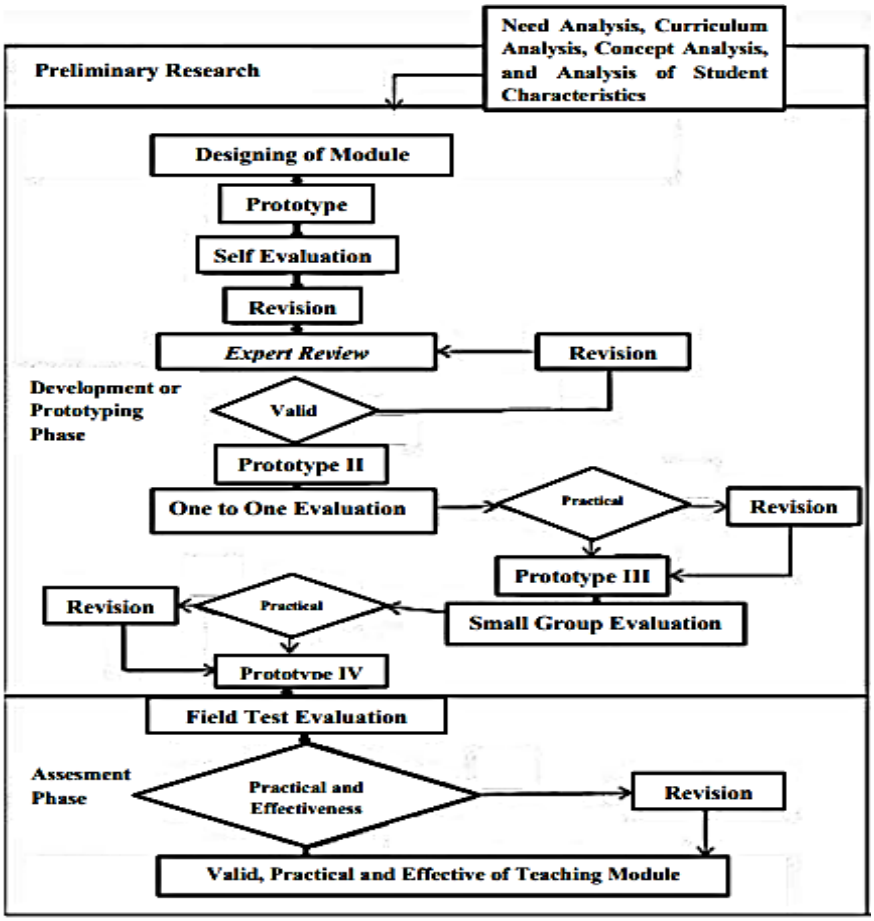


Figure 1. Research Procedure

Participants

This research produces a trigonometry teaching module designed according to indicators of mathematical problem-solving ability. The teaching module was validated by five experts, namely 3 mathematics experts as content validators, 1 language expert as language validator, and 1 design or graphics expert.

Instruments

Teaching modules are validated by experts using previously validated validation sheets. The teaching module consists of 6 meetings that focus on trigonometry material. Teaching modules designed using an independent curriculum and adapted to improve students' mathematical problem-solving abilities.

Data Analysis

The teaching modules that have been designed are then validated by validators, then the average validation results are grouped based on validity criteria modified from the validity criteria by Muliyardi, (2006) which are listed in Table 1 below.

Table 1. Validity Criteria

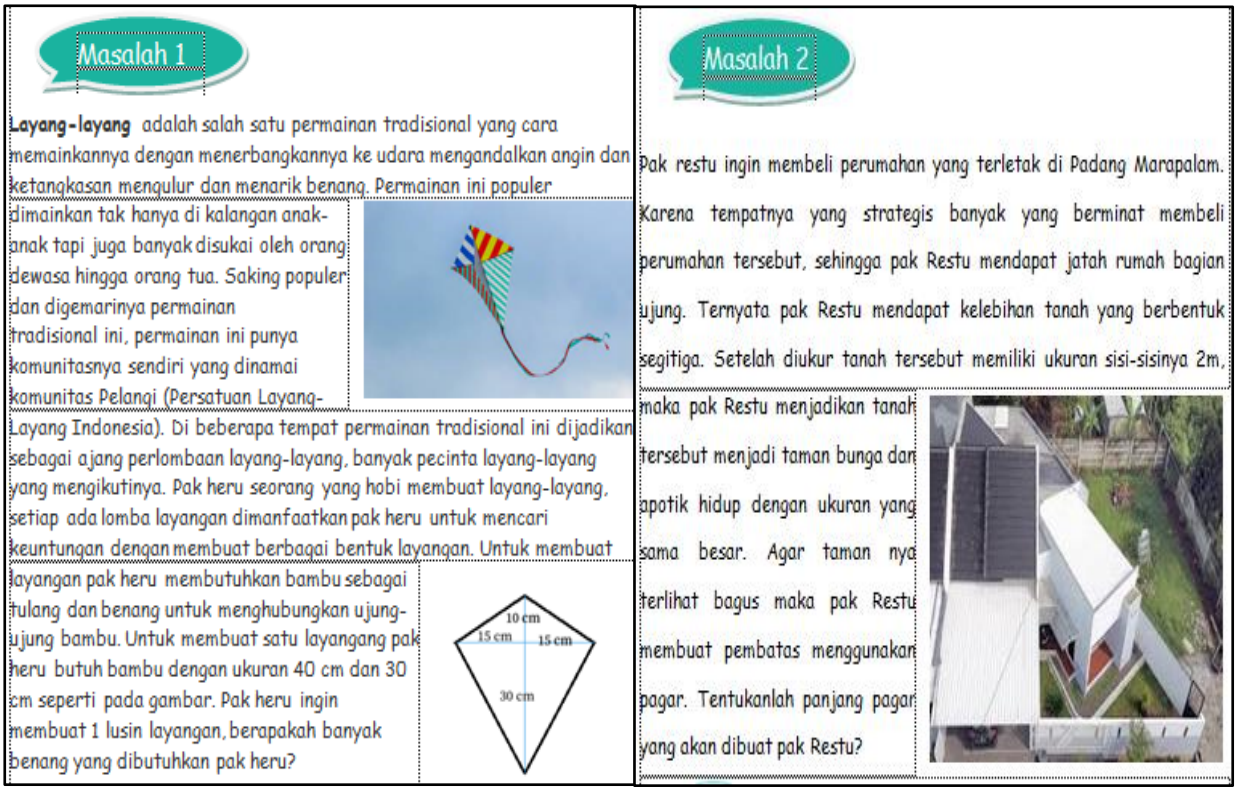
Average	Criteria
$3,4 \leq R \leq 4,0$	Very Valid
$2,8 \leq R < 3,4$	Valid
$2,2 \leq R < 2,8$	Quite valid
$1,6 \leq R < 2,2$	Less Valid
$1,0 \leq R < 1,6$	Invalid

Based on the validity criteria above, it can be seen that the designed teaching module will meet the valid criteria and is good for use if the average validation results obtained by the validator are ≥ 2.8.

RESULTS AND DISCUSSION

This research went through several stages, starting with the initial investigation stage. At this stage, researchers carry out an analysis of the curriculum and concepts used, needs analysis and analysis of student characteristics. This initial investigation stage was carried out and the results obtained were that students needed modules or teaching materials that were effective in helping students to improve students' mathematical problem-solving abilities.

The research continued to the next stage, namely the product design stage. At this product design stage, the researcher designed a product in the form of a Problem Based Learning-based mathematics teaching module that focuses on the topic of trigonometry for class X high school students. In the teaching module there are important components such as initial competencies, core competencies and Pancasila student profiles. In the core competencies there are learning objectives, trigger questions and details of the overall learning activities from each meeting, consisting of preliminary activities, core activities and closing activities. At each meeting, students are given several problems that must be solved by students in groups. The problem presented in this article is one of the problems contained in the designed teaching module, which consists of problem 1 and problem 2 which can be seen in Figure 2 below.



In english

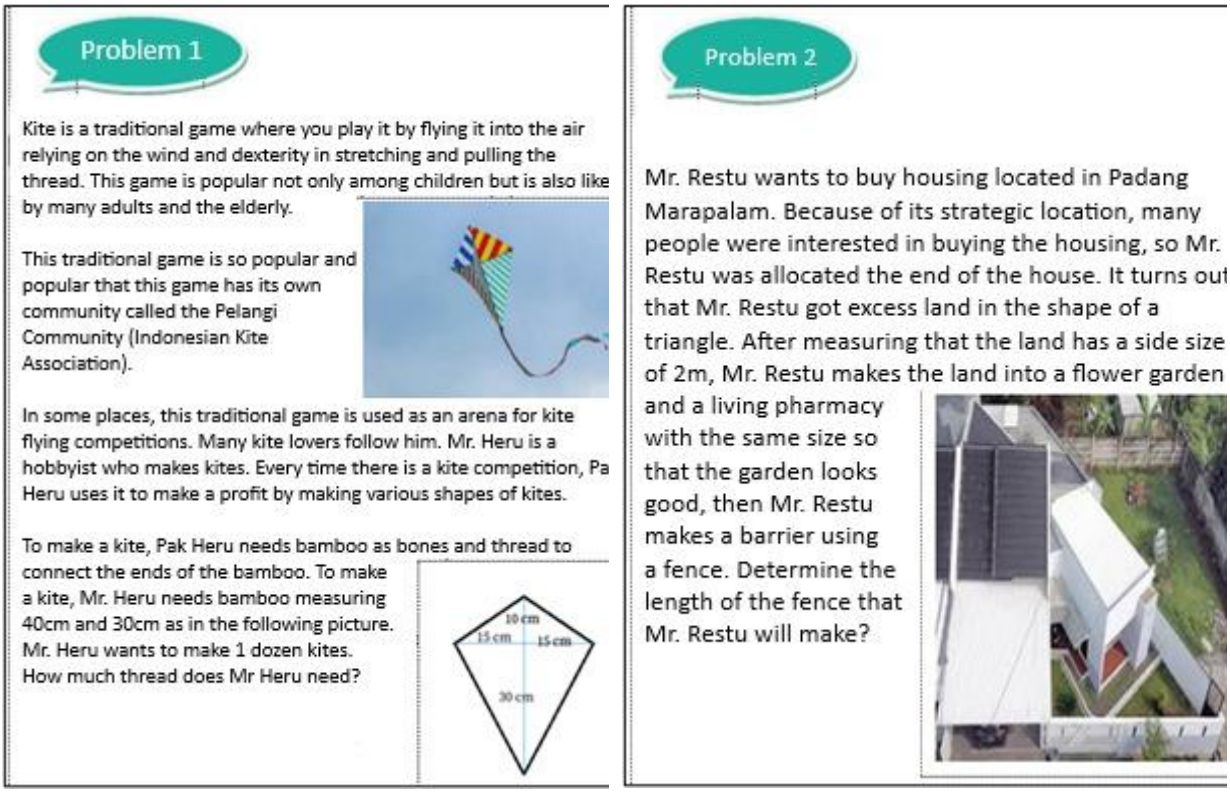


Figure 2. Contextual Problems

After the product has been designed, it is given to a validator consisting of several experts to be validated. Validation is carried out to assess the level of validity of each aspect

stated in the Problem Based Learning teaching module. The validation results by the validators can be seen in table 2 below.

Table 2. Results of Validation Analysis of Problem Based Learning Teaching Modules

No.	Aspects Assessed	Validity Indeks	Category
1	Module Identity	3,67	Very Valid
2	Initial Competency	3,67	Very Valid
3	Pancasila Student Profile	3,67	Very Valid
4	Formulation of Learning Objectives	3,89	Very Valid
5	Selection of Learning Materials	3,33	Valid
6	Selection of Learning Strategies	3,67	Very Valid
7	Selection of Learning Resources	3,83	Very Valid
8	Selection of Learning Media	3,50	Very Valid
9	Steps for Learning Activities	3,39	Valid
10	Evaluation	3,67	Very Valid
11	Language and writing	3,67	Very Valid
	Average Validity Index	**3,63**	**Very Valid**

In table 2, it can be seen that the results of the validation of the teaching module by the validator for aspects of material selection and learning activity steps are in the valid category, while for other aspects they are in the very valid category. Based on the validation results, it can be concluded that the designed Problem Based Learning-based teaching module meets the valid criteria and can be used in learning.

The validation results of the problem-based learning module indicate that this module has an overall very high validity level, with an average validity index of 3.63. This "Very Valid" category reflects that the module is well-designed and meets the necessary quality standards for learning. Key aspects such as module identity, initial competencies, Pancasila student profile, and learning objective formulation all received scores of 3.67 or higher, indicating that the module has a strong foundation in terms of structure and learning goals.

Other aspects rated as highly valid include the selection of learning strategies, learning resources, and instructional media, with scores of 3.67, 3.83, and 3.50, respectively. High validity in these aspects demonstrates that the module provides strategies and resources to support student learning. The PBL strategies employed in this module are designed to encourage students to think critically and work collaboratively to solve problems, which is essential for a deep understanding of trigonometry concepts. The appropriate selection of learning resources and the effective use of instructional media also contribute to a supportive and interactive learning environment.

Although most aspects of the module were rated as highly valid, there are some areas that need improvement, specifically in the selection of learning materials and the structuring of learning activities, which received scores of 3.33 and 3.39, respectively, falling into the "Valid" category. This indicates that while the module is overall valid for use, there is room for enhancement in selecting more relevant materials and structuring the activities more effectively. These improvements will ensure that the module better meets students' learning needs. By addressing these areas, it is expected that the PBL module can be implemented more successfully in various educational contexts, providing greater benefits to both students and teachers.

The implementation of the problem-based learning mathematics module in the classroom has shown positive results in enhancing student engagement and understanding. The learning process organized through this module allows students to learn independently and collaborate with their peers to solve given problems. The module's structure, which includes initial competencies, core competencies, and the Pancasila student profile, ensures that learning starts from a strong foundation and focuses on character development as well as academic skills.

The designed module focuses on student-centered activities, where students are presented with contextual problems that they must solve in groups. In each session, students begin with introductory activities to build context, followed by core activities that require them to think critically and work collaboratively to find solutions. Closing activities are then used for reflection and discussion, helping to reinforce their understanding of the trigonometry concepts learned. This approach not only encourages active student engagement but also develops their collaborative and communication skills. In this module-based learning, the teacher's role shifts from a traditional instructor to a facilitator. Teachers are responsible for guiding discussions, providing constructive feedback, and assisting students when they encounter difficulties in solving problems. In doing so, teachers help create a supportive learning environment and encourage students to become independent and confident learners. This role change also allows teachers to focus more on individual student needs and provide more personalized support.

The validation results indicate that this module is highly valid, with an average validity index of 3.63. Aspects such as the formulation of learning objectives, selection of learning resources, and evaluation received very high scores, indicating that the module is well-designed and aligns with existing educational standards. Although the selection of learning materials and the structuring of learning activities are valid, they still require some improvements. This high validity supports the module's effectiveness in achieving learning objectives, particularly in enhancing students' mathematical problem-solving abilities.

The module has successfully improved students' problem-solving skills, as evidenced by the evaluation results. Through the PBL approach, students are trained to identify, analyze, and find solutions to complex problems (Karan & Brown, 2022; Li et al., 2022). This process not only enhances their understanding of trigonometry concepts but also develops essential critical thinking skills. These results are consistent with previous research, which shows that PBL is effective in improving problem-solving skills and conceptual understanding.

These selected references support the notion that problem-based learning is effective in enhancing problem-solving skills and conceptual understanding. Norman & Schmidt (1992) highlight that students in PBL curricula exhibit improved problem-solving abilities, motivation, self-directed learning, information retention, and integration of knowledge. Similarly, Bilgin et al. (2019) emphasize that PBL promotes a deeper understanding of material and problem-oriented learning, fostering not only basic knowledge acquisition but also real-world problem-solving experiences. By synthesizing these studies, it is evident that PBL can indeed enhance students' problem-solving skills and conceptual comprehension in various educational contexts.

Implication

The implications of this study suggest that a well-designed problem-based learning module can be an effective instructional tool for enhancing the quality of mathematics education in the classroom. This study recommends that schools and educators consider integrating such modules into their curricula to increase student engagement and improve learning outcomes.

Limitation and Suggestion for Further Research

The independent curriculum is a curriculum that has just been implemented in learning, so there are limitations for researchers to implement this curriculum in teaching modules. Another limitation that researchers experienced was time constraints which meant that this research was limited to producing teaching modules that were valid for use. Based on these limitations, future researchers can overcome these limitations. Furthermore, this research only focuses on students' mathematical problem-solving abilities with the topic of trigonometry, so it is hoped that future researchers can develop research that focuses on other mathematical abilities as well as on different mathematical material.

CONCLUSIONS

The conclusion of this study indicates that the problem-based learning mathematics module on the topic of trigonometry for high school students has a very high level of validity, with an average validity index of 3.63. Key aspects such as module identity, initial competencies, Pancasila student profile, formulation of learning objectives, learning strategies, learning resources, instructional media, and evaluation were all rated as highly valid, supporting the module's effectiveness in enhancing students' mathematical problem-solving abilities. Although some aspects, like the selection of learning materials and the structuring of learning activities, received valid scores, improvements in these areas could further enhance the module's effectiveness. Overall, this module has been proven to be valid in supporting the learning process and can be implemented in mathematics education.

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AUTHOR CONTRIBUTIONS STATEMENT

LW and YY made significant contributions to this research. LW was responsible for the research design, development of the learning module, and data analysis. YY played a key role in module validation, manuscript writing, and literature review. Both actively participated in discussing the research results and drafting the conclusions. All authors have read and approved the final version of the manuscript.

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