Development of Trigonometry Course Module Based on Problem Solving

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Abstrak

Pemecahan masalah adalah salah satu kemampuan yang sangat penting untuk dimiliki oleh mahasiswa. Salah satu upaya untuk mengembangkan kemampuan pemecahan masalah mahasiswa adalah dengan melakukan pembelajaran menggunakan modul yang didesain untuk meningkatkan kemampuan pemecahan masalah. Tujuan penelitian ini adalah untuk mengembangkan modul mata kuliah trigonometri dengan kualitas baik yang memenuhi kriteria valid, praktis, dan efektif. Jenis penelitian yang dilakukan adalah penelitian pengembangan model Borg & Gall. Model Borg & Gall terdiri dari fase potensi dan masalah, pengumpulan data, desain produk, validasi desain, ujicoba pemakaian, revisi produk, ujicoba produk, revisi desain, revisi produk, dan produksi masal. Subjek penelitian ini adalah mahasiswa semester I Program Studi Pendidikan Matematika Universitas Tidar. Data dianalisis berdasarkan tingkat kevalidan, kepraktisan, dan keefektifan modul. Hasil penelitian menunjukkan modul termasuk pada kategori valid dan kategori praktis. Aspek keefektifan berdasarkan hasil *posttest* dengan soal pemecahan masalah dikatakan efektif. Hasil pengembangan dalam penelitian ini adalah produk modul mata kuliah trigonometri berbasis pemecahan masalah yang valid, praktis, dan efektif digunakan untuk mahasiswa pendidikan matematika. Kontribusi dari penelitian ini adalah modul dapat digunakan dalam perkuliahan trigonometri.

Keyword: Modul, pemecahan masalah, trigonometri.

Abstract

Problem-solving is one of the most important skills for students to have. One of the efforts to develop students' problem-solving skills is to conduct learning using modules designed to improve problem-solving abilities. The purpose of this research is to develop a good quality trigonometry course module that meets the criteria of being valid, practical, and effective. The type of research conducted is research on the development of the Borg & Gall model. The Borg & Gall model consists of potential and problem phases, data collection, product design, design validation, usage trials, product revisions, product trials, design revisions, product revisions, and mass production. The subjects of this study were the first semester students of the Mathematics Education Study Program, Tidar University. Data were analyzed based on the level of validity, practicality, and effectiveness of the module. The results showed that the module was included in the valid category and the practical category. The aspect of effectiveness based on the results of the posttest with problem-solving questions is said to be effective. The result of the development in this research is the product of a trigonometry course module based on problem solving that is valid, practical, and effectively used for mathematics education students. The contribution of this research is that the module can be used in trigonometry lectures.

Keyword: Module, problem-solving, trigonometry.

INTRODUCTION

Mathematics learning is an interactive process involving students, lecturers, and learning resources within a learning environment to construct mathematical concepts and principles through self-directed internalization (guided direction). The primary goal of mathematics learning is to develop students' ability to think logically, critically, and systematically in solving problems (Abayeva et al., 2024; Popova et al., 2022). However, in practice, many students still rely on memorizing formulas without deeply understanding the underlying concepts (Altıntaş & İlgün, 2017; Guner, 2020). This is because mathematics is abstract and requires conceptual understanding (Andamon & Tan, 2018; Yuliandari & Anggraini, 2021). The mathematics learning process applied so far has not been optimal. One influencing factor is the teaching method, which does not provide enough opportunities for students to explore concepts in depth. Additionally, the available learning

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materials are still limited, making it difficult to support a comprehensive understanding (Prabowo et al., 2022).

Learning materials are a set of systematically arranged content, either in written or non-written form, designed to facilitate students' learning processes. Learning materials serve as a collection of instructional tools that include learning content, methods, and assessments, structured in an engaging and systematic manner to achieve the expected competencies (Hendriana et al., 2019). These materials assist lecturers in preparing learning activities and guiding students both in the classroom and during independent study at home (Kusuma & Apriyanto, 2018). The presence of learning materials plays a crucial role for both lecturers and students. For lecturers, well-organized and comprehensive learning materials enhance the effectiveness of the teaching process. Without adequate materials, lecturers may face difficulties in delivering content optimally (Firmansyah et al., 2021). Meanwhile, for students, learning materials serve as a primary guide for understanding concepts and completing assignments (Mutmainah et al., 2019). The absence of proper learning materials can lead to difficulties in the learning process, hindering comprehension and the achievement of optimal learning outcomes.

Daily classroom learning practices still face challenges, as the learning materials used do not fully support a student-centered approach. Well-structured, student-centered learning materials have a positive impact on learning practices (Czajka & McConnell, 2019; Marlena et al., 2022). Students often struggle to comprehend the sentences in the learning materials (textbooks) provided. Therefore, it is crucial for lecturers to develop instructional materials to ensure more effective and efficient learning that remains aligned with the intended competencies. The selection and development of learning materials are entirely entrusted to lecturers as professional educators. One type of learning material that lecturers can develop according to students' characteristics is printed learning modules (Rufii, 2015). Asyhar (2012) states that print-based media is the oldest and most widely used medium due to its practicality, minimal equipment requirements, affordability, and accessibility. One of the main advantages of modules is their self-instructional nature, which enables students to learn independently without relying solely on lecturers as the primary source of knowledge. Thus, lecturers are encouraged to develop modules that meet students' needs.

The modules developed by lecturers are also expected to enhance students' abilities, particularly problem-solving skills (Nurmeidina et al., 2021; Xueting & Ismail, 2024). One of the key competencies emphasized in the curriculum is problem-solving ability (Cumhur & Tezer, 2020; Khalid et al., 2020; Piñeiro et al., 2022; Wong & Yip, 2023). Problem-solving has long been a major focus in mathematics education research. Over the past 30 years, studies have shown that problem-solving provides students with more opportunities to tackle mathematical challenges and improve their understanding and learning outcomes (Felmer et al., 2016; Säfström et al., 2024). Problem-solving is the process of applying previously acquired knowledge to new, unfamiliar situations (Getenet, 2024; Polya, 1985). It is the ability to generate different solutions to a problem based on experience (Tasgin & Dilek, 2023). Problem-solving is regarded as an application of concepts and skills, often requiring the combination of multiple concepts and techniques in a novel situation (Hudaibiah et al., 2024). This skill is highly significant for students and their future, as it helps them expand their mathematical understanding and develop the ability to address real-life challenges (Căprioară, 2015; Gurat, 2018).

Trigonometry is one of the compulsory courses in the Mathematics Education Study Program at Universitas Tidar. This course serves as a fundamental subject and a prerequisite for enrolling in advanced mathematics courses in subsequent semesters. This indicates that trigonometry is a crucial subject that all students must master. The material requires students to think carefully and meticulously. Some of the topics covered in the trigonometry course include angles and angle measurements, trigonometric ratios, sum and difference formulas, double-angle formulas, sum and difference of identical trigonometric functions, trigonometric identities, sine and cosine rules, triangle area, graphs of trigonometric functions, trigonometric equations, and inverse trigonometric functions.

The development of a trigonometry course module based on problem solving offers the potential to enhance students' learning outcomes by enabling them to master theoretical trigonometry concepts and apply them to relevant problems that support mathematics education at the secondary level. Based on this rationale, the researcher is interested in developing a trigonometry course module based on problem solving for students in the Mathematics Education Study Program at Universitas Tidar.

METHOD

This study is a Research and Development (RnD). RnD is a research method used to produce a specific product and test its effectiveness (Sugiyono, 2013). The module developed in this study is a trigonometry course module based on problem solving. The research was conducted on first-semester students of the Mathematics Education Study Program at Universitas Tidar, located at Jalan Kapten Suparman 39, Magelang. The development model used is the Borg & Gall model (Sugiyono, 2013), which is a process designed to develop and validate educational products. The research and development steps include: (1) identifying potential and problems, (2) data collection, (3) product design, (4) design validation, (5) usability testing, (6) product revision, (7) product testing, (8) design revision, (9) final product revision, and (10) mass production.

To obtain a high-quality prototype, the developed product needs to undergo quality testing based on three aspects: validity, practicality, and effectiveness. The validity assessment is obtained from validators with doctoral degrees in mathematics education. The practicality assessment is derived from students' feedback after learning with the trigonometry course module. The effectiveness assessment is based on students' learning outcomes in solving problem-solving questions related to trigonometry after using the module.

Data collection techniques include validation sheets, questionnaires, and test instruments. The validation sheet is used to measure the validity of the course module and the test instruments developed by the researcher. The questionnaire is used for validators and students to assess the developed course module. The test instrument is used to gather data on the effectiveness of the developed course module.

Validation data analysis is obtained from questionnaires related to content/material feasibility, presentation suitability, and language appropriateness. The validator's assessment scores are then averaged and converted to determine whether the developed course module is valid and feasible for use. A course module is considered valid if the validator provides a minimum rating of "feasible with revision" and an average score that meets at least the "good" criteria. The interval values for determining validity levels are presented in Table 1.

Table 1. Criteria for Validity Levels

No	Range	Category
1	$X > 84$	Very good
2	$68 < X \leq 84$	Good
3	$52 < X \leq 68$	Fair
4	$36 < X \leq 52$	Poor
5	$X \leq 36$	Very poor

Practicality analysis is assessed based on students' evaluations. There are 14 statements in the practicality questionnaire, with a maximum total score of 56. The practicality aspect is determined from the total score obtained by students, with the assessment criteria presented in Table 2.

Table 2. Practicality Assessment Criteria

No	Category	Score
1	Strongly agree	4
2	Agree	3
3	Disagree	2
4	Strongly disagree	1

The total score obtained by students from the practicality questionnaire is then categorized based on the criteria presented in Table 3.

Table 3. Practicality Level Criteria

No	Range	Criteria
1	$X > 47{,}6$	Very good
2	$39{,}2 < X \leq 47{,}6$	Good
3	$30{,}8 < X \leq 39{,}2$	Fair
4	$22{,}4 < X \leq 30{,}8$	Poor
5	$X \leq 22{,}4$	Very poor

In this study, the problem-solving-based trigonometry course module is considered practical if at least 75% of students achieve a minimum criterion of Good.

The analysis of problem-solving test data is conducted using an assessment rubric. The data analysis technique for effectiveness level is determined based on students' post-test results in the trigonometry course. In this study, a student is considered individually proficient if they achieve a minimum score of 75, and class-wide proficiency is achieved if at least 80% of students meet this criterion (Kemp et al., 1994).

RESULT AND DISCUSSION

This research is a development study that employs the Borg & Gall model, which consists of ten stages: (1) potential and problems, (2) data collection, (3) product design, (4) design validation, (5) usage trial, (6) product revision, (7) product testing, (8) design revision, (9) product revision, and (10) mass production.

Potential and Problems

The problem identified in this study is the absence of a trigonometry course module specifically designed to help students gain a deeper understanding of trigonometric concepts. Existing learning modules tend to focus on delivering information to readers without encouraging students to construct their own knowledge. Meanwhile, according to constructivism in mathematics learning, a good conceptual understanding is achieved when students actively build their knowledge through exploration and reflection (Ampadu & Danso, 2018).

Additionally, the available instructional materials generally emphasize procedural aspects, such as formulas and calculation techniques, without fostering the development of mathematical problem-solving skills. According to Tambunan (2019), problem-solving is the core of effective mathematics learning, as it allows students to develop more flexible thinking strategies when facing various situations. However, in several trigonometry textbooks, students are not yet facilitated to enhance their mathematical problem-solving abilities.

Previous studies have highlighted that a major challenge in learning trigonometry is students' difficulty in understanding fundamental trigonometric concepts, such as angle relationships, trigonometric functions, and their applications in real-life problem-solving (Nabie et al., 2018; Omer, 2015). Therefore, it is necessary to develop a module that not only presents information but also provides opportunities for students to explore, identify patterns, and apply concepts in various problem-solving contexts.

Data Collection

After identifying potential and problems, the next step is data collection to gather information regarding students' needs for a trigonometry learning module. Data collection was conducted through interviews with students enrolled in the trigonometry course. Based on the interview results, it was found that students faced difficulties in understanding trigonometric concepts because the instructional materials presented were often abstract and less engaging. Additionally, students expressed a desire for a learning module that not only contains theoretical explanations but also provides example problems, exercises, and systematic as well as applicable solution guidelines. The module is expected to attract students' interest and motivate them to learn trigonometry through this resource.

According to Pulukadang et al. (2020), a well-designed module can enhance students' learning motivation, especially when it is developed based on their needs and characteristics. This aligns with previous studies (Andayani & Pratama, 2022; As'ari, 2019), which state that learning using modules that incorporate contextual problems and problem-solving-based exercises can improve students' understanding.

Product Design

The design stage involves the development of the module. This stage focuses on determining the specifications of the developed product, including competency achievement indicators, instructional materials, learning objectives, and problem-solving-based questions. The steps for designing the module are as follows:

1. Introduction Section, this section includes the front cover (outer cover), inner cover, course overview, user guidelines, and competency map.

2. Module Content Section, this section consists of material explanations, example problems, exercises with solution guidelines, and formative tests with answer keys, all of which are aligned with problem-solving-based questions.
3. Closing Section, this section contains the bibliography and back cover.

Design Validation

The validation process was conducted by two validators to ensure that the developed module meets the established quality standards. The validation results are presented in Table 4 below.

Table 4. Module Validation Results

Validator Score		Average	Criteria
I	II		
89	87	88	Sangat Baik

Based on Table 4, the validation results indicate that the module achieved an average score of 88, classified as "Very Good." The validators provided an assessment with the criterion of "suitable for use with revisions," meaning the module is considered valid for learning purposes. Validation is a crucial step in module development to ensure content accuracy, clarity of presentation, and relevance to students' needs (Gurnot Roman, 2016). The module's success in meeting validation standards demonstrates that its content aligns with effective instructional design principles.

Product Trial

This stage involves a limited product trial, conducting an initial field test on the product design to assess its practicality. The limited field trial was conducted with 76 students from the Mathematics Education Study Program at Universitas Tidar. Based on the questionnaire responses from these 76 students, the data in Table 5 were obtained.

Table 5. Practicality Test Results

No	Criteria	Number of Students
1	Very good	30
2	Good	45
3	Fair	1
4	Poor	0
5	Very poor	0

Based on Table 5, a total of 75 students (96.68%) rated the module at least "Good," indicating that the module is practical for use. According to Hendratno et al. (2022), a learning product is considered practical if it is easy to use by users and aligns with learning needs. These practicality results show that students can easily understand the presented material and follow the instructions provided in the module.

Product Revision

Based on the validation results from the validators and the limited product trial, various inputs and suggestions were gathered to improve the quality of the developed trigonometry module. These suggestions covered aspects such as content, language, presentation, and alignment of materials with the intended learning objectives. Consequently, revisions were made to the module based on the validation and limited trial results. The purpose of these revisions is to ensure that the module meets students' needs, is easy to understand, and is effective in enhancing problem-solving skills in trigonometry learning.

Product Trial

After successfully testing the product, the trigonometry course module was further tested on a larger scale. In this study, the module was tested on first-semester students of the Mathematics Education Study Program at Universitas Tidar to assess its effectiveness. At this stage, an effectiveness test was conducted by administering a problem-solving-based trigonometry posttest to students. The effectiveness test results are presented in Table 6.

Table 6. Effectiveness Test Results

Score Range	Number of Students	Percentage (%)
95 − 100	55	41,98
90 − < 95	6	4,58
85 − < 90	24	18,32
80 − < 85	1	0,76
75 − < 80	22	16,79
< 75	23	17,56

Based on the effectiveness test results, 108 out of 131 students (82.44%) achieved a minimum score of 75, indicating that the module is categorized as effective for learning purposes. These findings suggest that using the trigonometry module can enhance students' mathematical problem-solving skills. This study's findings align with previous research. Anisah & Lastuti (2018) revealed that students' mathematical problem-solving abilities improved after using learning modules in the learning process. The module helps students become accustomed to problem-solving and encourages them to think at a higher cognitive level. Furthermore, research by Bulu & Nahak (2020) indicated that the implementation of instructional materials contributes to improving students' mathematical problem-solving skills. Similarly, Oktaviana & Susiaty (2020) stated that mathematics textbooks developed for coursework can be used effectively by both mathematics education and pure mathematics students to enhance their problem-solving abilities.

Design Revision

Following the product trial results, students provided various suggestions and feedback for improving the design of the trigonometry course module. These suggestions included aspects of visual appearance, layout, readability, and material presentation to make the content easier to understand and more engaging. Therefore, in this phase, the researcher refined the module design by adjusting the necessary elements based on the obtained feedback. This revision aims to enhance readability, user comfort, and the module's appeal to support students' learning effectiveness. A well-designed module can increase students' motivation to learn and help them understand complex mathematical concepts (Setiyani et al., 2020).

Product Revision

In addition to design improvements, several suggestions were provided regarding the module content, such as clarity of the material and question presentation. These revisions aim to ensure that the module can be optimally used by students, thereby improving their mathematical problem-solving skills. According to Novitasari et al. (2024), a well-designed learning module should be able to adapt to students' needs and support deep conceptual understanding.

Mass Production

Once the trigonometry module was validated, deemed practical, and proven effective, the final stage involved mass production. This step ensures that the module can be used by a larger number of students in various learning contexts. The module's success in passing a series of validation, practicality, and effectiveness tests demonstrates its suitability for widespread use in trigonometry learning. Thus, this research makes a tangible contribution to the development of innovative learning modules and supports efforts to improve the quality of trigonometry education at the higher education level.

CONCLUSION

The results of this development research have produced a trigonometry course module based on problem solving that is valid, practical, and effective for use. The validity aspect indicates that the module falls into the valid category. The practicality aspect shows that the module is categorized as practical. The effectiveness aspect, based on post-test results using problem-solving questions, confirms that the module is effective. The development of this trigonometry course module based on problem solving provides a valid, practical, and effective learning resource for mathematics education students.

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