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THE DEVELOPMENT OF GOOGLE SITES-ASSISTED PROBLEM BASED LEARNING MODEL TO ENHANCE STUDENTS' MATHEMATICAL PROBLEM SOLVING AND SELF-CONCEPT ON JUNIOR HIGH SCHOOL

Dadang Anugrah Pangestu[1], Euis Eti Rohaeti[2], Harry Dwi Putra[3]
[1]IKIP Siliwangi, Jl. Terusan Jend. Sudirman, Cimahi, Indonesia.
dadangpangestu889@gmail.com
[2]IKIP Siliwangi, Jl. Terusan Jend. Sudirman, Cimahi, Indonesia.
e2rht@ikipsiliwangi.ac.id
[3]IKIP Siliwangi, Jl. Terusan Jend. Sudirman, Cimahi, Indonesia.
harrydp@ikipsiliwangi.ac.id

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ABSTRACT

Mathematics learning requires students to develop not only conceptual knowledge but also mathematical problem-solving skills and positive self-concept. However, junior high school students often experience difficulties in solving contextual problems, particularly those involving the Pythagorean Theorem. This study aimed to develop a Google Sites-assisted Problem-Based Learning (PBL) model to enhance junior high school students' mathematical problem-solving skills and self-concept in learning the Pythagorean Theorem. This study employed a Research and Development (R&D) approach using the Borg and Gall development model, consisting of ten stages: research and information collecting, planning, preliminary product development, preliminary field testing, main product revision, main field testing, operational product revision, operational field testing, final product revision, and dissemination and implementation. The developed product integrated PBL syntax with Google Sites to provide contextual problems, digital learning resources, collaborative activities, worksheets, and assessments. Preliminary field testing involved 10 students, while the main and operational field testing involved 20 students. Data were collected through validation instruments, mathematical problem-solving tests, self-concept questionnaires, and student performance assessments. The results showed that the preliminary field trial produced an average self-concept score of 84%, categorized as high. In the revised operational trial, the experimental group obtained a mean score of 63, while the control group obtained 70.5. The effectiveness test produced a mean N-Gain score of 0.4603 or 46.03%, categorized as moderate. Thus, the developed Google Sites-assisted PBL model demonstrated sufficient effectiveness and potential as an alternative mathematics learning resource for supporting students' learning outcomes, problem-solving skills, and positive self-concept.

Corresponding Author:

Dadang Anugrah Pangestu,
Department of Mathematics Education,
Institut Keguruan dan Ilmu Pendidikan Siliwangi,
Jl. Terusan Jend. Sudirman, Cimahi, Indonesia
Email: dadangpangestu889@gmail.com

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INTRODUCTION

Education is one of the key factors in preparing future generations to compete in an increasingly globalized world. It plays a vital role in human development by fostering not only cognitive growth but also affective aspects, such as attitudes and values, as well as psychomotor skills. Through education, individuals acquire the knowledge, competencies, and character needed to adapt to social changes and contribute meaningfully to society (Winata et al., 2022). In the learning process, students are required to study a variety of subjects as part of their educational curriculum. Among these subjects, mathematics is often considered one of the least preferred by students due to its perceived difficulty and complexity. According to Kholil & Zulfiani, (2020) Many students perceive mathematics as a difficult and uninteresting subject, which often leads to a lack of interest and enthusiasm toward learning it. As a result, mathematics is frequently viewed as a subject to be avoided rather than embraced. Despite these perceptions, mathematics is one of the most widely applied disciplines and plays a crucial role in everyday life, supporting individuals in solving problems and making informed decisions in various situations.

Mathematics is a fundamental discipline that plays an essential role in education. According to Permatasari (2021) mathematics serves as a means of developing logical, systematic, critical, objective, and rational thinking skills. These competencies enable students to understand and apply fundamental mathematical concepts in their daily lives. Furthermore, a deeper understanding of mathematical concepts is necessary for individuals to perform everyday activities in a more organized and efficient manner (Tampubolon et al., 2019). One of the key competencies that supports this understanding is mathematical problem-solving ability.

Mathematical problem-solving ability is an essential and fundamental competency in mathematics learning. Problem-solving is considered a basic skill that plays a crucial role in helping students understand and apply mathematical concepts effectively (Mariam et al., 2019). According to Palera et al (2020) students' mathematical problem-solving ability involves the capacity to think strategically about how to solve problems and to process mathematical information in a meaningful way. Therefore, the development of problem-solving skills is an important objective of mathematics education, as it enables students to address both academic and real-life challenges systematically and effectively.

Despite its importance, Indonesian students' mathematical problem-solving ability remains relatively low. Evidence of this can be seen in the results of the Programme for International Student Assessment (PISA) 2016, in which Indonesia ranked 64th out of 72 participating countries, achieving a score of 397, considerably below the PISA benchmark score of 500 (Arafani et al., 2019). This condition indicates that many students still face difficulties in solving mathematical problems effectively. Furthermore, inadequate problem-solving skills may contribute to lower human resource quality, as the ability to analyze and resolve problems is essential for academic and professional success (Hidayat et al., 2022). Therefore, improving students' mathematical problem-solving ability has become an important priority in mathematics education. Many students still experienced difficulties in completing the various stages of the problem-solving process. Mathematical problem-solving ability is an important competency that every student should develop, as it plays a significant role in their capacity to address challenges encountered in everyday life Roza (2022). Several common errors were identified among students, including difficulties in understanding problem statements, the use of inappropriate solution procedures, and mistakes in mathematical calculations. These difficulties may be attributed to students' limited understanding of effective problem-solving strategies, their lack of experience in dealing with complex real-world problems, and their low interest in learning mathematics (Sahri et al., 2023). Consequently, appropriate instructional

interventions are needed to help students strengthen their mathematical problem-solving skills and improve their overall learning outcomes.

Mathematical problem-solving ability needs to be enhanced because it plays a crucial role in improving students' learning outcomes. In addition to cognitive factors, psychological factors also contribute significantly to an individual's success in completing academic tasks. One of the most important psychological factors is self-concept. A well-developed self-concept enables students to approach learning tasks with confidence and persistence, whereas a poor self-concept may hinder their ability to perform effectively (Hamdani et al., 2019). Self-concept dapat mempengaruhi motivasi berprestasi seseorang dikarenakan konsep diri merupakan bagaimana seseorang menilai dirinya Self-concept is closely related to students' achievement motivation because it reflects how individuals perceive and evaluate themselves (Sidik & Gandi, 2021). These self-perceptions influence the level of motivation, effort, and determination that students invest in achieving their academic goals. Therefore, fostering a positive self-concept is essential for supporting students' academic performance and encouraging them to engage more actively in the learning process.

According to Susilawati et al (2020) self-concept is an important attribute that every student should possess, as it helps foster confidence, courage, perseverance, and commitment in learning mathematics. Students with a positive self-concept tend to be more willing to engage in mathematical tasks and persist when faced with challenges. However, in many schools, students' mathematical self-concept remains relatively low, which can negatively affect both their learning motivation and academic achievement. Low levels of self-confidence and negative perceptions of one's mathematical ability often lead students to give up more easily when confronted with difficult problems. In addition, many students experience anxiety about failure, fear of not progressing academically, and concern about making mistakes in front of their peers or teachers. Such fears can undermine students' confidence and reduce their willingness to participate actively in mathematics learning (Valerina & Abadi, 2023). Therefore, fostering a positive self-concept is essential for supporting students' engagement, persistence, and success in mathematics education.

To address these challenges, it is essential to implement an instructional approach that not only strengthens students' mathematical problem-solving skills but also fosters a more positive self-concept. One instructional model that has shown considerable promise in achieving these objectives is Problem-Based Learning (PBL). As explained by (Firdaus et al., 2021) Problem-Based Learning (PBL) is a student-centered learning approach that utilizes authentic problems encountered in everyday life as the starting point of the learning process. Through this approach, students are encouraged to develop critical thinking, improve their problem-solving abilities, and construct their own understanding of mathematical concepts. Within the Problem-Based Learning (PBL) framework, learners are actively engaged in investigating real-world problems that require meaningful solutions. Rather than relying solely on teacher explanations, students work collaboratively to analyze situations, discuss alternative strategies, and formulate appropriate solutions based on evidence and logical reasoning. This active involvement not only enhances higher-order thinking skills, including critical, analytical, and creative thinking, but also increases students' confidence in their own abilities. As students successfully overcome learning challenges through exploration and collaboration, they gradually develop a stronger and more positive self-concept, which ultimately supports better learning outcomes in mathematics.

One of the main challenges in implementing Problem-Based Learning (PBL) in schools is maintaining students' active participation while creating an engaging, interactive, and enjoyable learning environment. For this reason, the integration of appropriate educational technology is essential to ensure that the learning process remains aligned with instructional objectives and

supports meaningful student engagement. One digital platform with considerable potential for supporting Problem-Based Learning (PBL) is Google Sites. Google Sites is a web-based platform that enables teachers to develop simple educational websites containing various learning resources, instructional activities, and multimedia content in a single integrated environment. By organizing learning materials through Google Sites, teachers can present content in a more structured, attractive, and accessible format, thereby enhancing the effectiveness of classroom instruction. According to (Afrianto et al, 2022) Google Sites is a service provided by Google that offers website-like features, allowing users to create and manage digital learning content with relative ease. Similarly (Tifani, 2021) reported that Google Sites enables teachers to distribute learning materials that students can access anytime and anywhere, promoting greater flexibility in the learning process. Furthermore (Febrian et al., 2024) emphasized that Google Sites is highly flexible, user-friendly, and can be implemented without requiring expensive computer network infrastructure, making it a practical option for technology-supported instruction in schools. The integration of Problem-Based Learning with Google Sites is expected to provide students with authentic, technology-enhanced learning experiences that encourage active participation, collaboration, and independent inquiry. Through this learning environment, students are anticipated not only to improve their mathematical problem-solving skills but also to develop a stronger and more positive self-concept as they gain confidence from successfully engaging in meaningful and collaborative learning activities.

Several mathematics topics require greater instructional attention due to the limited use of innovative teaching strategies during the learning process, which often results in students experiencing difficulties in understanding the concepts. One of these topics is the Pythagorean Theorem, a fundamental concept that many students find challenging to master. Student responses to Pythagorean Theorem problems demonstrate a wide range of errors, reflecting differences in conceptual understanding and problem-solving ability. According to (Pangestu & Kadarisma, 2021) the most common difficulties include misconceptions about the fundamental principles of the Pythagorean Theorem, incorrect interpretation of problem statements, computational errors during mathematical operations, and mistakes caused by answering questions hastily without carefully analyzing the given information.

A preliminary study conducted by Pangestu & Kadarisma, (2021) at a junior high school in West Bandung Regency identified several common errors made by students when solving Pythagorean Theorem problems. These errors included: (1) misconceptions regarding the fundamental concepts of the Pythagorean Theorem, (2) misinterpretation of the meaning of the problem, (3) inaccuracies in performing mathematical calculations, and (4) mistakes resulting from answering questions too hastily. These findings suggest that many students encounter difficulties not only in understanding the underlying concepts but also in applying appropriate problem-solving strategies. Similar findings were reported by (Rina & Bernard, 2021) who found that students frequently experience difficulties due to: (1) insufficient mastery of the prerequisite concepts related to the Pythagorean Theorem, (2) incorrect application of the Pythagorean formula, (3) lack of accuracy in computations and the use of inappropriate solution procedures, (4) failure to construct an appropriate mathematical model, and (5) limited understanding of how to simplify square root expressions. These recurring difficulties indicate that students' challenges extend beyond conceptual understanding to procedural and representational aspects of mathematical problem solving. Furthermore (Resliana & Nurmeidina, 2020) classified the primary sources of students' errors into three categories: conceptual errors, procedural errors, and computational errors. Together, these findings highlight the need for instructional approaches that not only strengthen students' conceptual

understanding but also improve their procedural fluency and computational accuracy in solving Pythagorean Theorem problems.

Based on the problems identified above, this study developed and implemented a Problem-Based Learning (PBL) model supported by Google Sites to enhance junior high school students' mathematical problem-solving skills and self-concept. The integration of a student-centered instructional model with a digital learning platform is expected to create a more engaging and meaningful learning environment, enabling students with different levels of prior knowledge to participate actively and improve their learning outcomes. By providing authentic problem-solving experiences supported by accessible digital resources, the proposed learning model aims to strengthen both students' cognitive competencies and their confidence in learning mathematics.

Accordingly, this study is entitled "Development of a Google Sites-Assisted Problem-Based Learning Model to Enhance Junior High School Students' Mathematical Problem-Solving Skills and Self-Concept." The primary objective of this research is to develop and evaluate an innovative learning model that integrates Problem-Based Learning with Google Sites as a technology-enhanced instructional medium. In doing so, the study seeks to contribute to the advancement of mathematics education by offering an instructional innovation that aligns with current developments in science, technology, and digital learning while addressing students' cognitive and affective learning needs.

METHOD

This study employed a Research and Development (R&D) methodology to develop and validate an instructional product intended to improve students' mathematical problem-solving skills and self-concept. Research and Development is widely recognized as a systematic approach for designing, producing, and evaluating educational products to ensure their quality, practicality, and effectiveness. According to Fransisca & Putri (2019) the R&D method is used to develop specific products and evaluate their effectiveness through a series of validation and testing procedures. Similarly Anindya (2023) stated that R&D focuses on generating innovative products rather than testing existing theories. In addition (Andarsyah & Fadilla, 2020) described R&D as a development framework aimed at designing, validating, and refining educational products or applications before their implementation in real learning environments. Within the field of education, Research and Development plays an important role in producing innovative instructional designs, learning models, teaching materials, and digital learning media that respond to students' learning needs and technological advancements. Beyond the development process itself, educational products should also be evaluated in terms of their validity, practicality, and effectiveness to ensure that they contribute meaningfully to the teaching and learning process. Accordingly, this study developed a Google Sites-assisted Problem-Based Learning (PBL) model for teaching the Pythagorean Theorem at the junior high school level. The developed product integrates the principles of Problem-Based Learning with a web-based learning platform to provide students with interactive learning resources, authentic problem-solving activities, and opportunities for collaborative learning. The development process followed the Borg and Gall Research and Development model, which consists of a series of systematic stages, from needs analysis and product design to expert validation, field testing, product revision, and final implementation. The stages of the development procedure are illustrated in Figure 1.

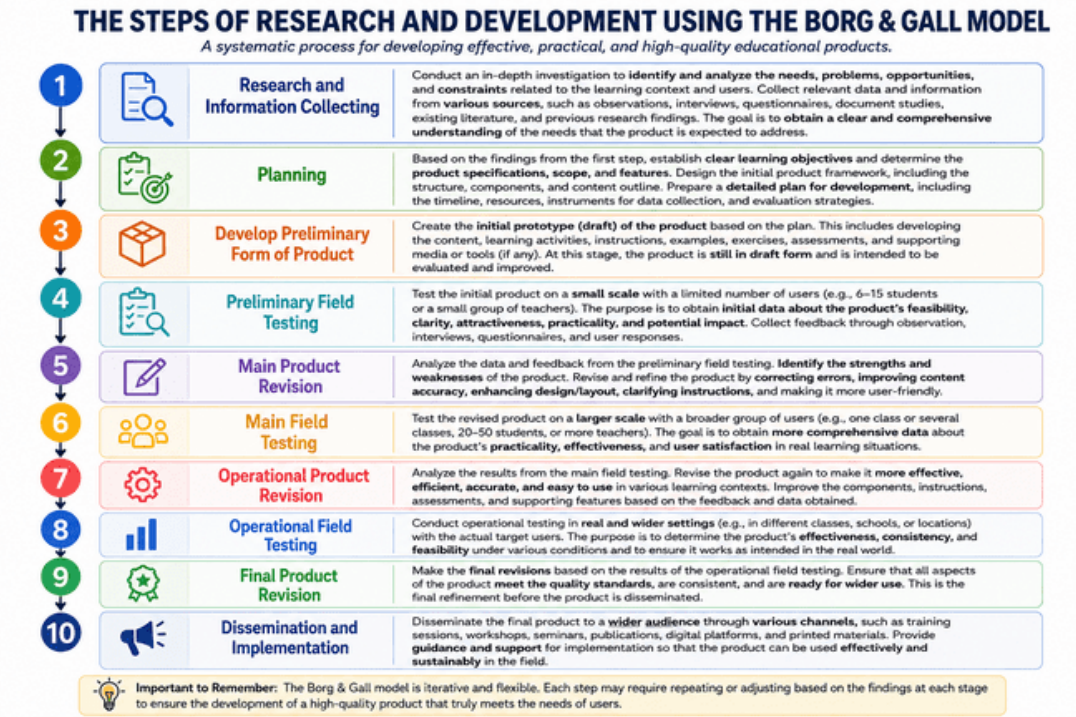

Figure 1. Borg and Gall R&D Model Stages

RESULTS AND DISCUSSION

Results

This study employed a Research and Development (R&D) approach based on the Borg and Gall development model. The model consists of ten stages: (1) research and information collecting, (2) planning, (3) developing a preliminary form of the product, (4) preliminary field testing, (5) main product revision, (6) main field testing, (7) operational product revision, (8) operational field testing, (9) final product revision, and (10) dissemination and implementation. Each stage was conducted systematically to produce a product that met the required quality criteria and was appropriate for use in the learning process.

Research and Information Collecting

A needs analysis was conducted to identify the problems encountered by junior high school students in mathematics learning, particularly in relation to mathematical problem-solving skills and self-concept. The analysis was based on the existing literature and preliminary findings concerning students' difficulties in learning mathematics and solving Pythagorean Theorem problems. The findings indicate that the problems encountered by students are not limited to their cognitive abilities but also involve affective aspects that influence their engagement and persistence in mathematics learning.

From the cognitive perspective, students continue to experience difficulties in solving mathematical problems, particularly those involving the Pythagorean Theorem. These difficulties include misconceptions about the underlying concepts, difficulties in interpreting problem statements, inappropriate use of mathematical formulas, errors in mathematical calculations, difficulties in constructing mathematical models, and limited ability to apply appropriate problem-solving procedures. These findings indicate that students need learning experiences that provide opportunities to understand mathematical concepts meaningfully and apply them to contextual and authentic problems rather than merely memorizing formulas and procedures.

From the affective perspective, students' self-concept in mathematics also requires attention. Students who perceive mathematics as difficult may demonstrate low confidence in their mathematical abilities, hesitate to ask questions or express their opinions, and tend to give up when encountering challenging problems. Negative perceptions of mathematical ability may consequently reduce students' motivation, participation, and persistence during the learning process. Therefore, mathematics instruction needs to provide learning experiences that allow students to actively participate, experience success in solving problems, and develop greater confidence in their own mathematical abilities.

The needs analysis also indicates that conventional learning practices may not adequately accommodate students' need for active, collaborative, contextual, and technology-supported learning experiences. Problem-Based Learning (PBL) provides an appropriate instructional framework because it engages students in authentic problems, encourages collaboration and discussion, and facilitates the development of higher-order thinking and problem-solving skills. However, the implementation of PBL also requires appropriate learning resources and media to maintain students' engagement and provide accessible learning materials.

In this context, the integration of Google Sites into the PBL model represents a potential solution to address the identified needs. Google Sites can provide an accessible digital learning environment in which learning materials, problem scenarios, multimedia resources, activities, and supporting information can be organized systematically. Its integration with PBL is expected to facilitate students' active involvement in identifying, analyzing, and solving authentic mathematical problems while providing opportunities for independent and collaborative learning.

Based on the needs analysis, three major needs were identified. First, students need instructional activities that strengthen their conceptual understanding and mathematical problem-solving skills, particularly in solving contextual Pythagorean Theorem problems. Second, students need a learning environment that supports the development of a positive mathematical self-concept through active participation, collaboration, and successful problem-solving experiences. Third, teachers need an innovative and accessible instructional medium that can support the implementation of PBL and provide students with flexible access to learning resources. Therefore, the development of a Google Sites-assisted Problem-Based Learning model is considered relevant to address the identified cognitive, affective, and instructional needs in mathematics learning.

Planning

The needs analysis provided the basis for designing a Google Sites-assisted Problem-Based Learning (PBL) model for the Pythagorean Theorem. The product was developed to address several needs identified in the learning process, particularly the need to improve students' mathematical problem-solving skills and self-concept through a more active and technology-supported learning environment.

Google Sites was selected as the digital platform for organizing the learning components. The developed site contains the learning objectives, instructional materials, contextual problems, activity guidelines, learning resources, worksheets, and assessment activities. The learning sequence follows the five stages of PBL: presenting students with a problem, organizing them for learning, facilitating individual and group investigations, presenting the results, and evaluating the problem-solving process. These activities guide students to understand the problems, determine appropriate strategies, work through the solutions, and communicate their findings.

The problems were developed from situations related to students' everyday experiences to help them understand the Pythagorean Theorem in a meaningful context rather than simply applying formulas. Group discussions and collaborative activities were also included to encourage students to share ideas, express their opinions, and work together in solving problems. Learning materials and additional resources were provided through Google Sites to support students during the investigation and problem-solving activities.

The product was also equipped with assessment instruments to examine students' mathematical problem-solving skills and self-concept. Problem-solving skills were assessed through four aspects: understanding the problem, planning a solution, carrying out the solution, and reviewing the result. Students' self-concept was assessed based on their perceptions and beliefs about their own abilities in learning mathematics and solving mathematical problems.

Overall, the product was designed to combine the PBL learning process with the use of Google Sites in a structured learning environment. Through this integration, students are expected to have more opportunities to engage with contextual mathematical problems, work collaboratively, and reflect on their own learning. These experiences are also expected to support the development of greater confidence in their ability to learn and solve mathematical problems.

Develop Preliminary Form of the Product

The preliminary product was developed based on the results of the needs analysis and product design. At this stage, the Google Sites-assisted Problem-Based Learning (PBL) model was developed for the Pythagorean Theorem by integrating digital learning resources with PBL activities to support students' mathematical problem-solving skills and self-concept.

The product consists of learning objectives, instructional materials, contextual problems, student activities, learning resources, worksheets, and assessments. The learning activities follow the five stages of PBL: presenting the problem, organizing students for learning, conducting individual or group investigations, presenting the results, and analyzing and evaluating the problem-solving process. Through these activities, students are guided to identify relevant information, determine solution strategies, discuss their ideas, and reflect on the results.

The product also provides opportunities for students to participate actively, express their ideas, collaborate with peers, and present their work. These activities are intended to develop students' problem-solving skills while supporting the development of a more positive self-concept in mathematics.

Figure 2. Product Design

Preliminary Field Testing

A limited trial involving 10 students was conducted to assess students' self-concept after participating in learning activities using the Google Sites-assisted PBL model on the Pythagorean Theorem. The results showed an average self-concept score of 84%, indicating a high level of self-concept. Overall, the findings suggest that the learning model positively

supported the development of students' self-concept. The detailed results are presented in Table 1.

Table 1. Limited Testing Results

No.	Indicator	Average per Indicator
1	Able to present or speak in front of the class about the material on the Pythagorean Theorem	83%
2	Gain attention from friends or teachers in Mathematics lessons on the Pythagorean Theorem material related to self-presentation	83%
3	Able to receive Mathematics lessons on the Pythagorean Theorem material	82%
4	Able to complete assignments and review on the Pythagorean Theorem material	88%
5	Confident in working on exercises on the Pythagorean Theorem by myself	81%
6	Confident in working on assignments on the Pythagorean Theorem by myself	81%
7	Overcoming difficulties in working on assignments on the Pythagorean Theorem	83%
8	Able to ask questions about the Pythagorean Theorem material	89%
9	Able to express opinions about the Pythagorean Theorem material	88%
10	Having a sense of responsibility for the Pythagorean Theorem material	83%
11	Having initiative in the Pythagorean Theorem material	86%
12	Gaining trust from friends and teachers in Mathematics lessons on the Pythagorean Theorem material	86%
13	Having a sense of pride related to low academic achievement in Mathematics lessons on the Pythagorean Theorem material	84%
	Average	**84%**

Based on the results of the media and content validation, several aspects of the product still required revision. The media validator suggested adjusting the validation indicators to align with the media requirements, while the content validator recommended adding an evaluation page and simulation instructions. Therefore, the product was revised according to the validators' recommendations before proceeding to the next trial stage.

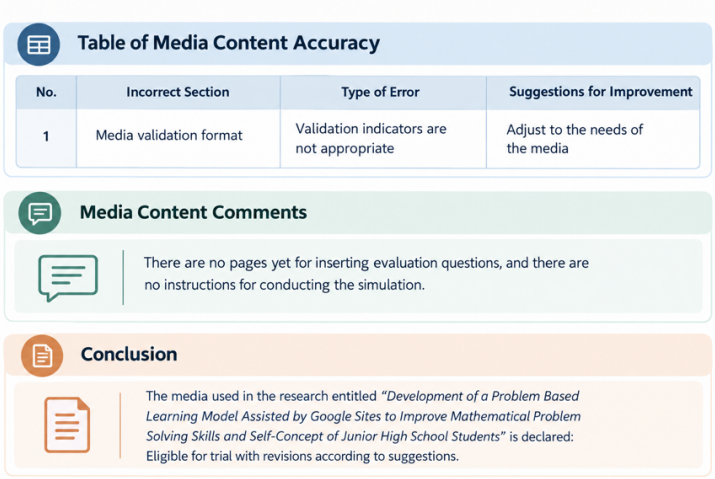

Figure 3. Media and Content Validation Results

Main Product Revision

Based on the results of media and content validation, the product was revised in accordance with the feedback provided by the validators. The revisions included adjustments to the validation indicators, the addition of an evaluation page, and improvements to the instructions for using the simulation. These revisions resulted in a more feasible and refined product that is ready to be implemented in a broader field trial. The subsequent trial is expected to provide more comprehensive data regarding the effectiveness of the developed product.

Table 2. Extensive Test Analysis Results

No.	Indicator	Average per Indicator
1	Able to present or speak in front of the class about the material on the Pythagorean theorem.	90%
2	Pays attention to friends or teachers during learning Mathematics material on the Pythagorean theorem related to everyday life.	90%
3	Able to accept Mathematics lessons on the Pythagorean theorem.	90%
4	Able to complete tasks and reviews on the Pythagorean theorem.	93%
5	Confident in working on reviews on the Pythagorean theorem independently.	89%
6	Confident in working on assignments on the Pythagorean theorem independently.	94%
7	Overcomes difficulties in working on assignments on the Pythagorean theorem.	88%
8	Able to ask questions about the material on the Pythagorean theorem.	91%
9	Able to express opinions about the material on the Pythagorean theorem.	90%
10	Has a sense of responsibility for the material on the Pythagorean theorem.	93%
11	Has initiative in the material on the Pythagorean theorem.	90%
12	Gains trust from friends and teachers in learning Mathematics on the Pythagorean theorem.	90%
13	Has good self-esteem related to low academic achievement in learning Mathematics on the Pythagorean theorem.	91%
Average		**91%**

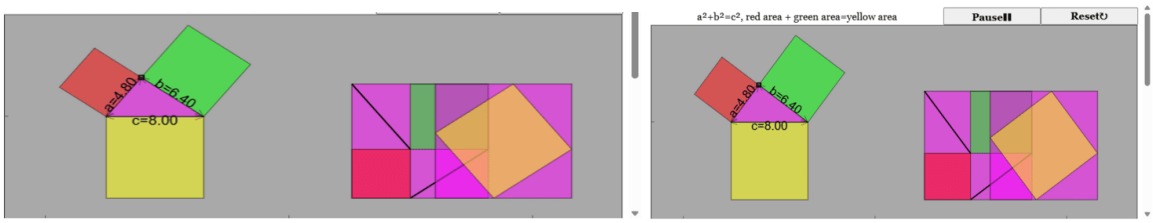

Figure 4. Learning Media Before (Left) and After (Right) Revision

Main Field Testing

At the Main Field Testing stage, the developed product was implemented in an experimental class consisting of 20 students, identified by student codes A–T. Based on the data presented in the table, the students obtained a total score of 1,090, with a mean score of 54.5. The scores varied across the students, reflecting differences in their performance on the assessed items. The highest score was 90, achieved by student P, while the lowest score was 5, achieved by

student Q. Overall, these results provide an initial overview of student performance in the experimental class during the main field testing stage and serve as a basis for further analysis of the effectiveness of the developed product.

Table 3. Test Questions for Experimental Class

Question No.	Mean Score
1	7.25
2	10.50
3	6.50
4	10.25
5	9.50
6	10.50
Total	**54.50**

During the Main Field Testing stage, the developed product was assessed in a control class consisting of 20 students, identified by student codes A–T. Based on the data presented in the table, the students obtained a total score of 1,260, with a mean score of 63.0. The results indicate variation in student performance across the assessed items. The highest score was 90, obtained by student T, whereas the lowest score was 15, obtained by student M. The data obtained from the control class were subsequently used as comparative data against the experimental class to examine the effectiveness of the developed product during the Main Field Testing stage.

Table 4. Pilot Testing of Control Group Questions

Question No.	Mean Score
1	7.75
2	10.50
3	11.00
4	11.75
5	11.25
6	10.75
Total	**63.00**

During the implementation, several challenges were encountered by students while completing the assessment. Some students experienced difficulties in understanding and responding to the questions, particularly items that required deeper comprehension and greater accuracy in determining the appropriate answers. In addition, limited time for completing the assessment was identified as another factor affecting students' performance. Several students were unable to complete all of the questions within the allotted time, indicating that the results may not have fully represented their abilities. These findings were taken into consideration during the Operational Product Revision, particularly in improving the clarity of the instructions, simplifying the presentation of relatively difficult items, and adjusting the time allocation to ensure that the learning and assessment processes could be conducted more effectively.

Operational Product Revision

The operational product was revised to improve the clarity, contextual relevance, and mathematical accuracy of the problem. The initial version of the item presented a pedestrian bridge problem involving a right-angled triangle; however, several aspects of the information and mathematical relationships required further clarification. In the revised version, the context was specified more explicitly by describing the bridge as a right-angled triangular structure. The height of the bridge was stated as 8 meters, while the length of the ramp was given as 17 meters. The question was subsequently reformulated to require students to determine the length

of the bridge's base. This modification establishes a clear relationship among the three sides of the right triangle and directs students toward the appropriate use of the Pythagorean theorem.

The revision was conducted to ensure that the problem provides sufficient information for students to identify the known and unknown quantities and apply the relevant mathematical concept systematically. Furthermore, the contextualization of the problem as a pedestrian bridge is intended to enhance the connection between mathematical reasoning and a real-world situation. Therefore, the revised product is expected to provide a clearer, more coherent, and instructionally appropriate assessment of students' understanding of the Pythagorean theorem.

Operational Field Testing

The revised experimental trial was conducted after improving the test items based on the findings from the previous trial. The revision focused on improving the clarity of instructions, conceptual representation, and alignment of the questions with students' learning characteristics. The results showed an improvement in students' conceptual understanding after the revision. The trial involved 20 students and resulted in a total score of 1,260, with a mean score of 63. The students' scores ranged from 15 to 90, indicating variations in their conceptual understanding. Overall, the findings suggest that the revised questions were more effective in facilitating students' understanding of the concepts and in measuring their ability to apply the concepts to the problems presented.

Table 5. Revised Trial Questions for Experimental Class

Question No.	Mean Score
1	7.75
2	10.50
3	11.00
4	11.75
5	11.25
6	10.75
Total	**63.00**

The revised control question trial was conducted after revising the test items based on the findings from the previous trial. The revisions focused on improving the clarity of the questions, their alignment with the conceptual understanding indicators, and their ability to measure students' conceptual understanding. The trial involved 20 students and obtained a total score of 1,410, with a mean score of 70.5. The students' scores ranged from 20 to 100, indicating variations in their levels of conceptual understanding. These results suggest that the revised questions were better able to provide an overview of students' conceptual understanding. Compared with the revised experimental trial, which obtained a mean score of 63, the revised control trial showed a higher mean score by 7.5 points. This finding indicates that the revised instrument demonstrated better performance in measuring students' conceptual understanding.

Table 6. Revised Trial Questions for Control Class

Question No.	Mean Score
1	5.75
2	10.25
3	11.00
4	14.50
5	14.00
6	15.00
Total	**70.5**

The effectiveness test results, as presented in the descriptive statistics, were obtained from 20 participants. The N-Gain Score ranged from 0.10 to 1.00, with a mean score of 0.4603 and a standard deviation of 0.28234. Meanwhile, the N-Gain Percentage ranged from 10.00% to 100.00%, with a mean of 46.0316% and a standard deviation of 28.23436.

Table 7. Descriptive Statistics

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Ngain_Skor	20	.10	1.00	.4603	.28234
Ngain_Persen	20	10.00	100.00	46.0316	28.23436
Valid N (listwise)	20				

Based on the mean N-Gain Score of 0.4603, equivalent to 46.03%, the improvement in students' learning outcomes falls within the moderate category. These findings indicate that the developed product was moderately effective in improving students' learning outcomes. Although the intervention demonstrated a positive improvement, the magnitude of the increase remained at a moderate level.

Final Product Revision

The final product revision was conducted based on the results of the effectiveness test and the evaluation of students' learning outcomes. The effectiveness analysis involving 20 participants showed a mean N-Gain Score of 0.4603, equivalent to 46.03%, which falls within the moderate category. These findings indicate that the developed product was moderately effective in improving students' learning outcomes.

Based on these results, the final product was refined to further improve its effectiveness and instructional quality. The revision focused on enhancing the clarity of the learning activities, strengthening the presentation of mathematical concepts, and providing more structured guidance to support students in applying the Pythagorean theorem to contextual problems. In addition, the problem-solving activities were refined to encourage students to identify known and unknown quantities, select appropriate mathematical procedures, and interpret the results systematically.

Therefore, the final revision was not only intended to maintain the strengths of the developed product but also to address areas that could contribute to a higher level of learning improvement. The revised product is expected to provide more effective learning support and facilitate students' understanding and application of the Pythagorean theorem in real-world contexts.

Dissemination and Implementation

The dissemination and implementation stage was conducted after the final product had undergone revision based on the results of the development and effectiveness tests. At this stage, the developed learning product was introduced and implemented as a learning resource to support students in understanding and applying the Pythagorean theorem through contextual mathematical problems.

The implementation was carried out by providing students with opportunities to engage directly with the developed product and solve problems related to real-life situations. The learning activities were designed to encourage students to identify relevant information, determine the appropriate mathematical strategy, apply the Pythagorean theorem, and interpret the results obtained. Through this process, students were expected to develop not only conceptual understanding but also mathematical problem-solving skills.

The dissemination of the product was intended to provide broader access to the developed learning resource and demonstrate its potential use in mathematics learning. The product can be utilized by teachers as an alternative learning resource, particularly for teaching the Pythagorean theorem through contextual and problem-based activities. Based on the effectiveness results, which showed a mean N-Gain Score of 0.4603 (46.03%) in the moderate category, the product demonstrated sufficient potential to support the improvement of students' learning outcomes.

Therefore, the dissemination and implementation of the final product represent an important stage in ensuring that the developed learning resource can be applied in actual learning contexts. Further implementation on a wider scale is recommended to examine its effectiveness across different groups of students and learning environments, as well as to identify opportunities for continuous improvement.

Discussions

The findings of this study indicate that the developed learning product has a positive contribution to improving students' learning outcomes in understanding and applying the Pythagorean theorem. Based on the effectiveness test involving 20 participants, the mean N-Gain Score was 0.4603, equivalent to 46.03%. This result falls within the moderate category, indicating that the implementation of the developed product resulted in a meaningful, although not yet optimal, improvement in students' learning outcomes.

The moderate level of improvement may be related to the characteristics of the learning activities and students' initial understanding of the Pythagorean theorem. The developed product presents mathematical concepts through contextual problems, such as determining the dimensions of a pedestrian bridge. This approach provides students with opportunities to connect abstract mathematical concepts with real-world situations. Through contextual problems, students are encouraged to identify known and unknown quantities, determine the appropriate mathematical strategy, and apply the Pythagorean theorem to obtain a solution. Consistent with the findings of Fauzy et al (2023) students' mathematical problem-solving abilities (KPMM) showed a significant improvement following the implementation of learning activities using instructional materials developed through a problem-based learning approach. These findings support the view that problem-based instructional materials can provide meaningful opportunities for students to develop their mathematical problem-solving abilities.

Nevertheless, the N-Gain result also indicates that there is still room for improvement in the effectiveness of the product. Some students may require additional guidance in understanding the relationship between the sides of a right-angled triangle and in determining which mathematical procedure should be applied. Therefore, the revision of the final product emphasizes clearer instructions, more structured problem-solving activities, and stronger conceptual explanations. These improvements are expected to provide greater support for students with different levels of mathematical understanding.

Overall, the findings suggest that the developed product is sufficiently effective as a learning medium for supporting students' understanding of the Pythagorean theorem. The moderate improvement demonstrated by the N-Gain analysis also highlights the importance of continuous refinement of instructional materials. Future implementation may consider providing more varied contextual problems, additional guided examples, and opportunities for students to practice independently. Such improvements may further enhance students' conceptual understanding and problem-solving abilities. In line with the findings of Abdullah & Putra (2024) Student Worksheets (LKPD) play a significant role in enhancing students' conceptual understanding. This is evidenced by students' learning outcomes, which demonstrate their ability to understand, establish connections between, and apply mathematical concepts, as well

as solve problems related to the learning material. These findings suggest that the use of well-designed LKPD can facilitate students in developing a deeper conceptual understanding and applying mathematical knowledge in problem-solving contexts.

CONCLUSION

Based on the results of the development and effectiveness testing, the developed learning product can be concluded to be sufficiently effective in supporting students' understanding and learning outcomes related to the Pythagorean theorem. The product was developed and refined through several stages, including product revision, effectiveness testing, and final product refinement, to ensure its clarity, relevance, and suitability for mathematics learning.

The effectiveness test involving 20 participants resulted in a mean N-Gain Score of 0.4603, equivalent to 46.03%, which falls within the moderate category. This finding indicates that the developed product contributed positively to improving students' learning outcomes, although the level of improvement was not yet optimal. The use of contextual problems, particularly those related to real-life situations, provided students with opportunities to connect the Pythagorean theorem with practical applications and develop their mathematical problem-solving skills.

Overall, the developed product has potential as an alternative learning resource for teaching the Pythagorean theorem through contextual and problem-solving activities. Further development and implementation on a wider scale are recommended to improve the effectiveness of the product and examine its applicability across different student characteristics and learning environments.

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