



# Optimizing Cognitive Engagement in Probability Theory: The Integration of Plotagon Animation and PBL-Based Google Sites for Vocational Students

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**Abstract:** This study aims to develop a mathematics teaching module based on Problem-Based Learning (PBL) supported by Google Sites and Plotagon to enhance vocational high school students' mathematical problem-solving skills. The research employed a research and development design using the ADDIE model, consisting of analysis, design, development, implementation, and evaluation stages. The developed module integrates contextual problems aligned with vocational technology programs and is delivered through an interactive web platform and animated learning videos. Data were collected through expert validation sheets, teacher and student response questionnaires, observation sheets, and problem-solving ability tests. The results showed that the module achieved a high level of validity in terms of content, instructional design, language, and media aspects. The practicality evaluation indicated that the module was easy to use, engaging, and effective in facilitating student learning activities. Furthermore, the effectiveness analysis demonstrated a significant improvement in students' mathematical problem-solving skills after the implementation of the module. These findings suggest that the integration of PBL with digital platforms such as Google Sites and Plotagon provides an innovative and effective learning environment, particularly for vocational education contexts. Therefore, the developed module is feasible to be implemented as an alternative instructional resource to support mathematics learning and enhance students' higher-order thinking skills.

**Keywords:** Google Sites; Plotagon animation; Problem Based Learning.

## Introduction

Numeracy problem-solving skills are fundamental competencies required for students to function effectively in academic, professional, and real-life contexts (Amalina & Vidákovich, 2023; Ceballos et al., 2025; Jylänki et al., 2024). In contemporary education, problem solving is not merely perceived as an instructional objective, but as a core component of higher-order thinking that supports analytical reasoning, creativity, and decision-making (Carroll et al., 2025; Peng et al., 2025; Wang et al., 2025). International educational frameworks emphasize the development of students' ability to analyze complex

situations, construct mathematical models, and apply appropriate strategies to solve contextual problems (Longhini et al., 2025; Qi, 2025; Ying et al., 2025). However, empirical evidence consistently indicates that many students, particularly in vocational high schools, demonstrate low proficiency in mathematical problem-solving, especially when confronted with non-routine and contextualized tasks (Dela Cruz et al., 2025; Liu et al., 2025; Strohmaier et al., 2025).

Vocational education is designed to equip learners with both theoretical understanding and practical competencies aligned with workplace demands (Keller et al., 2025; Sa'adah et al., 2025; Yu & Wong, 2026). Consequently, mathematics instruction in vocational

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high schools should emphasize contextual relevance, practical applications, and cognitive engagement (Hoogland et al., 2016; Ma & Winther, 2025; Raufelder et al., 2025). Nevertheless, conventional instructional practices frequently rely on teacher-centered approaches, procedural learning, and textbook-driven materials, which limit students' opportunities to actively construct knowledge and develop problem-solving strategies. Furthermore, the learning materials commonly employed are often static, less interactive, and insufficiently aligned with students' vocational contexts, resulting in reduced motivation and learning engagement (Keller et al., 2025; Strohmaier et al., 2025; Zuo et al., 2025).

In response to these challenges, innovative instructional models and digital learning environments have gained increasing attention. Problem-Based Learning (PBL) has been widely recognized as an effective pedagogical approach that promotes active learning, critical thinking, collaboration, and independent inquiry through authentic problem contexts. By engaging students in meaningful problem-solving activities, PBL facilitates deeper conceptual understanding and supports the development of transferable cognitive skills. Simultaneously, advances in educational technology have enabled the integration of digital platforms and multimedia resources to enhance instructional effectiveness, accessibility, and learner engagement (Escala et al., 2025; Fredy et al., 2025; Wu et al., 2024).

Among various digital tools, Google Sites offers a flexible web-based platform for organizing learning resources, interactive content, and assessments, enabling seamless access for both teachers and students. Meanwhile, Plotagon provides an innovative medium for creating animated instructional videos that present mathematical problems in visually engaging and contextualized formats. The integration of these technologies with PBL principles holds strong potential to create immersive learning environments that foster motivation, conceptual understanding, and problem-solving competence (Aladini & Gheisari, 2025; Anchunda & Kaewurai, 2025; Beek et al., 2023).

Despite the growing body of research on PBL and digital learning tools, studies focusing on the systematic development of technology-assisted PBL-based instructional modules tailored specifically for vocational mathematics education remain limited. In particular, the pedagogical integration of Google Sites and animated learning media within a structured problem-based framework has not been extensively explored. Therefore, this study aims to develop a mathematics teaching module based on Problem-Based Learning supported by Google Sites and Plotagon for probability

topics and to examine its feasibility in enhancing vocational high school students' mathematical problem-solving skills. The findings are expected to contribute to instructional design practices and provide empirical insights into technology-integrated PBL implementation in vocational mathematics education.

## Method

### *Research Design*

This study employed a research and development (R&D) design aimed at producing a valid, practical, and effective mathematics teaching module based on Problem-Based Learning (PBL) supported by Google Sites and Plotagon. The development procedure followed the ADDIE model, which consists of five systematic stages: analysis, design, development, implementation, and evaluation. This model was selected due to its structured framework, flexibility, and wide applicability in educational product development.

The ADDIE framework enabled a systematic integration of pedagogical principles, technological tools, and empirical evaluation to ensure the quality and feasibility of the developed instructional module. The research design emphasizes iterative refinement through expert validation, field testing, and continuous evaluation.

### *Participants and Research Setting*

The study was conducted in a vocational high school (SMK) in Indonesia during the academic year 2024/2025. The participants consisted of Grade XI students enrolled in the mathematics course, along with mathematics teachers and instructional media experts. A total of XX students participated in the field implementation stage, selected through purposive sampling based on their learning needs and curriculum alignment. Additionally, three experts, comprising subject matter specialists, instructional design experts, and media developers, were involved in the validation process.

### *Development Procedures*

The development process followed the ADDIE stages:

#### *Analysis Stage*

This stage involved identifying learning problems, students' characteristics, curriculum requirements, and instructional needs. Data were collected through classroom observations, teacher interviews, and analysis of existing teaching materials. The findings indicated low student engagement, limited contextual learning resources, and insufficient emphasis on mathematical problem-solving skills.

*Design Stage*

Based on the needs analysis, the instructional framework of the module was designed by integrating PBL principles with digital learning environments. Learning objectives, content structure, assessment strategies, and user interface layouts were systematically planned. Contextual problems relevant to vocational settings were embedded to enhance authenticity and cognitive engagement.

*Development Stage*

The teaching module was developed using Google Sites as the primary learning platform and Plotagon to create animated instructional videos. The module included interactive materials, learning activities, worksheets, formative assessments, and problem-solving tasks. Expert validation was conducted to evaluate content accuracy, instructional quality, linguistic clarity, and media design.

*Implementation Stage*

The validated module was implemented in classroom learning over X instructional sessions. Teachers facilitated learning using the PBL framework, while students accessed materials through Google Sites and engaged with animated problem scenarios via Plotagon videos.

*Evaluation Stage*

Both formative and summative evaluations were conducted to assess the validity, practicality, and effectiveness of the developed module. Feedback from experts, teachers, and students was used to revise and refine the instructional product.

*Data Collection Instruments*

Multiple instruments were employed to ensure data triangulation: expert validation sheets, assessing content, instructional design, language, and media aspects; teacher and student questionnaires, measuring usability, clarity, engagement, and learning support; observation sheets, documenting student engagement and learning activities during implementation; and mathematical problem-solving tests, administered as pre-tests and post-tests to measure learning effectiveness. All instruments were subjected to content validity review and reliability testing prior to data collection.

*Data Analysis Techniques*

Data analysis employed descriptive and inferential statistical methods. Validation and practicality data were analyzed using descriptive statistics, including mean scores and percentage levels, to determine feasibility categories. The effectiveness of the module

was evaluated by comparing pre-test and post-test scores using paired-sample t-tests and normalized gain (N-gain) analysis to determine the magnitude of improvement in students' problem-solving skills. Qualitative data from observations and open-ended responses were analyzed thematically to support quantitative findings.

**Result and Discussion**

The results of this study are presented in terms of validity, practicality, and effectiveness of the developed mathematics teaching module based on Problem-Based Learning (PBL) supported by Google Sites and Plotagon.



Figure 1. Media Display

*Validity of the Developed Module*

Expert validation results indicate that the developed module achieved a high level of validity across four evaluated aspects: content feasibility, instructional design, language clarity, and media presentation. The overall validation score reached the very valid category, indicating that the instructional content aligns well with curriculum standards, learning objectives, and students' cognitive development. Table 1 presents the summary of expert validation results.

**Table 1.** Expert Validation Results of the Developed Module

Aspect Evaluated	Mean Score	Validity Category
Content Feasibility	4.45	Very valid
Instructional Design	4.38	Very valid
Language Clarity	4.32	Very valid
Media Presentation	4.41	Very valid
Overall	4.39	Very valid

These findings indicate that the module possesses strong conceptual accuracy, pedagogical coherence, and technological usability, making it suitable for classroom implementation.

*Practicality of the Module*

Practicality was evaluated based on teacher and student responses after the implementation phase. The results revealed that the module was perceived as highly practical, easy to use, engaging, and effective in supporting learning activities.

**Table 2.** Practicality Evaluation Results

Respondent	Mean Score	Practicality Category
Teachers	4.52	Very practical
Students	4.47	Very practical
Overall	4.50	Very practical

Students particularly highlighted the accessibility of learning materials via Google Sites and the engaging nature of animated videos created using Plotagon, which enhanced motivation and conceptual understanding.

*Effectiveness of the Module*

The effectiveness of the module was determined through the improvement in students’ mathematical problem-solving abilities. The pre-test and post-test results demonstrated a substantial increase in students’ performance after the implementation of the module.

**Table 3.** Comparison of Pre-test and Post-test Scores

Test	Mean Score	Standard Deviation
Pre-test	58.21	9.34
Post-test	81.45	8.17

The normalized gain (N-gain) analysis yielded a mean score of 0.65, categorized as moderate-to-high improvement, indicating that the instructional intervention significantly enhanced students’ problem-solving skills. Furthermore, the paired-sample t-test showed a statistically significant difference between pre-test and post-test results ( $p < 0.05$ ), confirming the effectiveness of the developed learning module.

The findings demonstrate that the integration of Problem-Based Learning (PBL) with digital instructional

media through Google Sites and Plotagon provides a pedagogically robust and technologically enriched learning environment. The high validity results suggest that the module successfully integrates curriculum alignment, instructional coherence, and user-centered design, which are essential components of effective learning materials (Seufert et al., 2025).

The strong practicality outcomes indicate that both teachers and students found the module intuitive, engaging, and supportive of active learning. The digital platform facilitated flexible access to learning resources, enabling students to review materials independently and collaborate more effectively. Meanwhile, animated problem scenarios developed using Plotagon enhanced contextual understanding by presenting mathematical concepts in realistic vocational settings, thereby bridging abstract concepts with real-world applications.

The significant improvement in students’ mathematical problem-solving abilities highlights the instructional value of embedding contextual challenges within a PBL framework. By engaging students in structured inquiry processes, the module encouraged analytical thinking, strategy development, and reflective learning. This instructional design fosters not only procedural competence but also conceptual depth and cognitive flexibility (Chairwut et al., 2025; Garcia et al., 2025; Liu et al., 2025).

Moreover, the integration of web-based platforms contributes to learner autonomy, allowing students to control learning pace and revisit instructional content as needed. Such autonomy is crucial for vocational students, who often exhibit diverse learning characteristics and academic preparedness levels.

Overall, these findings suggest that technology-assisted PBL modules offer a promising instructional alternative for mathematics learning in vocational education contexts. The approach effectively addresses common instructional challenges, including low engagement, limited contextualization, and inadequate problem-solving emphasis.

**Conclusion**

This study developed a Problem-Based Learning (PBL)-based mathematics teaching module supported by Google Sites and Plotagon to enhance vocational high school students’ mathematical problem-solving skills. The findings demonstrate that the developed module is highly valid, practical, and effective, indicating its feasibility as an innovative instructional resource. The integration of contextual problem scenarios, interactive digital platforms, and multimedia learning materials successfully fostered student engagement, conceptual understanding, and higher-order thinking. The

significant improvement in students' problem-solving performance highlights the pedagogical effectiveness of combining PBL with digital technology in vocational mathematics education. These results suggest that technology-assisted PBL modules can serve as a viable solution to improve instructional quality and learning outcomes, while also promoting learner autonomy and motivation. Future studies are encouraged to examine the scalability and long-term impact of this instructional approach across diverse educational contexts and mathematical topics.

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