

# Needs Analysis for Designing Hybrid Learning with Problem-Based Scaffolding to Enhance Mathematical Problem-Solving Skills

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## ABSTRACT

This study aimed to identify the need for developing a hybrid learning design integrated with problem-based scaffolding to improve students' mathematical problem-solving skills in a differential equations course. A quantitative approach was employed, involving surveys and in-depth interviews with 104 mathematics education students at Sultan Ageng Tirtayasa University. The results showed that 88% of students valued the flexibility of hybrid learning, while 85% agreed that problem-based learning effectively supported their ability to solve complex problems. Additionally, 83% found step-by-step scaffolding helpful, and 88% emphasized the importance of timely feedback. These findings highlight the critical need for structured scaffolding tailored to student abilities, supported by multimedia instructional tools such as videos combining PowerPoint and screencast recordings. The study recommends integrating these components into mathematics instruction and regular formative assessments to enhance student engagement and problem-solving competence. The results provide practical guidance for curriculum designers and educators seeking to implement more effective and relevant learning models in higher education mathematics.

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## 1. INTRODUCTION

Hybrid learning is an educational approach that combines face-to-face instruction with computer-based learning, conducted online or offline [1], [2]. Thorne describes hybrid learning as integrating advancements in online learning technology with direct interaction in traditional face-to-face instruction [3]. Meanwhile, Bersin defines hybrid learning as combining different training 'media' (technology, activities, and event types) to create an optimal training program for a specific audience [4]. In this context, "hybrid" integrates

traditional instructor-led learning with other electronic formats. The hybrid learning model combines face-to-face teaching methods with computer-assisted instruction, both offline and online, to form an integrated educational approach [5], [6]. Hybrid learning aims to provide the most effective and efficient learning experience [7].

The advancement of information and communication technology in education increasingly encourages the implementation of the hybrid learning model. In higher education, hybrid learning is expected to improve the quality of instruction by combining the advantages of online and offline learning [8]. This approach provides flexibility in accessing learning materials while maintaining meaningful interaction between instructors and students [9]. In line with this, a study shows that hybrid learning combined with a Problem-Based Learning (PBL) approach has been proven effective in improving students' learning outcomes [10]. This learning method allows easy access to learning materials and encourages students to solve real-world problems actively, thereby enriching their learning experience [11].

Problem-based learning (PBL) is an approach that uses real-world problems as a context for students to learn critical thinking problem-solving skills, and applying fundamental concepts from the learning material [12]. PBL is based on cognitive theory, particularly constructivist learning theory, which states that thinking and problem-solving skills develop more effectively when students can directly interact with and solve problems independently [13], [14]. The primary goal of PBL is to develop flexible knowledge that can be applied in various situations and enhance intrinsic motivation, problem-solving skills, collaboration, and self-directed learning [15].

One important aspect of the implementation of PBL is scaffolding [16]. It refers to the support provided to assist students through their learning stages. Scaffolding offers a structure that supports the development of student's abilities until they can work independently [17]. Wang cites Vygotsky's view, who defines scaffolding as the role of educators and others in providing the necessary support for students to develop and reach their potential developmental level through guidance [18]. This concept refers to the Zone of Proximal Development (ZPD), the area between a student's current developmental level and their higher potential development that can be achieved with assistance from a more competent individual.

Preliminary studies indicate that mathematics education students still face challenges in optimally developing their mathematical problem-solving abilities, particularly in learning environments that have not been fully integrated with appropriate approaches. Research by Puguh reveals that students tend to have limitations in procedural skills, conceptual understanding, and representation in mathematical problem-solving [19]. One solution to enhance problem-solving abilities is implementing a PBL learning model with scaffolding, significantly improving the learning experience and problem-solving skills [16].

While numerous studies have explored the implementation of Problem-Based Learning (PBL) and hybrid learning individually, limited research has integrated both approaches with scaffolding in the context of mathematics education. Furthermore, existing studies often overlook the specific needs of students in designing a hybrid learning

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model that incorporates problem-based scaffolding. This gap highlights the need for a study that explores how such an integrated approach can enhance students' mathematical problem-solving abilities.

Given the limited integration of hybrid learning, PBL, and scaffolding in mathematics education, this study seeks to address the following research question: What are the students' needs for a hybrid learning design supported by problem-based scaffolding that can effectively enhance their mathematical problem-solving skills?

## **2. METHOD**

The research employed a quantitative approach with a survey design conducted at the Mathematics Education Program of Sultan Ageng Tirtayasa University during the odd semester of the 2023-2024 academic year. The quantitative research aimed to collect numerical data that could be analyzed statistically [20], [21]. A quantitative approach was chosen because it allowed for a clear and measurable understanding of students' needs regarding hybrid learning and problem-based scaffolding. Although this study predominantly used a quantitative method, qualitative data from interviews were also utilized to complement and validate the quantitative findings, providing a deeper understanding of students' perceptions and experiences. The survey was conducted to gather information on many respondents' attitudes, perceptions, opinions, or behaviors, which could then be analyzed statistically to identify patterns or relationships. Additionally, the interviews provided contextual insights that supplemented the quantitative data obtained. Prior to data collection, the population and sample to be used as research subjects were first determined [22].

### **a. Research Subjects**

The research subjects were all students enrolled in the differential equations course, totaling 104 students consisting of 13 males and 91 females, aged 20 to 22 years.

### **b. Research Instruments**

The instruments used were a needs questionnaire and interviews to design the learning process, employing a Likert scale. The questionnaire was validated through content and construct validation. Two experts in mathematics education carried out content validation to ensure that the questionnaire covered all aspects relevant to the research topic. The experts evaluated the alignment of the statements in the questionnaire with the research objectives and ensured that the instrument was theoretically valid. Subsequently, construct validation was performed to examine the relationship between the indicators in the questionnaire and the theoretical foundations underlying hybrid learning, PBL, and scaffolding. After the validation, the instrument was also tested for readability to address potential ambiguities in the statements. Below are the indicators used in the questionnaire and interview instruments:

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Table 1. Indicators of the Needs Questionnaire

No	Indicator	Statement
1	Hybrid Learning Needs	I feel that learning which combines face-to-face and online methods (hybrid) helps me understand mathematics material better. The combination of online and face-to-face learning allows me to study flexibly according to my needs. I need clear scaffolding support when learning online to be able to follow the lessons well.
2	Problem-Based Scaffolding Needs	I feel that the problem-based learning model trains me better in solving complex mathematics problems. Scaffolding assistance (tutors, step-by-step guidance) greatly helps me when facing difficult mathematical problems. <i>The scaffolding provided during learning makes me more confident in solving mathematical problems.</i>
3	Mathematical Problem-Solving Ability	I feel that my ability to solve mathematical problems improves through hybrid learning that applies problem-based scaffolding. I need contextual and real-world related practice problems to enhance my problem-solving skills.
4	Supporting Media and Technology	The use of digital learning media (tutorial videos, interactive applications) helps me understand mathematical concepts more deeply. Adequate access to technology (internet, devices) is important to support effective hybrid learning.
5	Evaluation and Feedback	I need regular formative evaluations (quizzes, practice problems) to measure my learning progress during hybrid learning. Prompt and clear instructor feedback helps me improve my understanding and problem-solving skills.

Table 2. Interview Indicators

No	Indicator	Statement
1	Hybrid Learning Experience	How is your experience participating in learning that combines face-to-face and online methods? What challenges do you face in hybrid learning?
2	Implementation of Problem-Based Scaffolding	What is your opinion about implementing the problem-based learning (PBL) model in mathematics courses? How does scaffolding assist you in the problem-solving process?
3	Needs for Mathematical Problem-Solving Skills	What are your main needs to improve your mathematical problem-solving skills in hybrid learning? Are the practice problems provided sufficiently contextual and challenging?
4	Supporting Media and Technology	What media or technology helps you the most during the hybrid learning process? Do you experience any technology access issues during hybrid learning?
5	Evaluation and Feedback	What is your opinion about the evaluation and feedback system during hybrid learning? What suggestions do you have to make evaluation and feedback more effective in supporting problem-solving skills?

In addition to administering a needs questionnaire and conducting interviews, this study also included an initial test of students' mathematical problem-solving abilities in

the Differential Equations course. This test aimed to identify the student’s initial level of competence in solving mathematical problems, which then served as the basis for designing the instructional process.

**c. Data Collection**

In this study, the data analyzed included an initial mathematical problem-solving ability test, a needs analysis questionnaire, and in-depth interviews. The initial test was a critical step to determine students’ baseline capabilities in solving mathematical problems, forming the basis for developing appropriate and adaptive learning strategies [23]. The data collection process was continued by distributing a needs analysis questionnaire through the Google Form platform. The questionnaire was designed using a Likert scale to explore students’ perspectives, experiences, and expectations in learning. In addition to the questionnaire, in-depth interviews were conducted with selected respondents to complement the quantitative data. These interviews allowed students to express their insights more openly, which a structured survey might not have fully captured [24]. The collected data were analyzed qualitatively through a triangulation process involving the initial test results, questionnaire responses, and interview findings. The data collection procedure is as follows:

- 1) Preparation
  - a) Determining the purpose of data collection
  - b) Selecting respondents (students)
  - c) Preparing instruments (questionnaire, interview guidelines)
- 2) Implementation
  - a) Questionnaire distribution: Distributing questionnaires to respondents online
  - b) Conducting interviews: Carrying out interviews with relevant parties based on prepared guidelines
  - c) Observation: Administering an initial test of problem-solving ability
  - d) Document analysis: Collecting and reviewing relevant documents.

**d. Data Analysis**

Data analysis in needs analysis aims to identify the gap between current learning and desired conditions. This process includes data processing, interpretation, and presentation of results to obtain recommendations for improving learning. The questionnaire was analyzed using a Likert scale. The scoring determination for the questionnaire is presented in Table 3 [25].

Table 3. Questionnaire Scoring

Response	Score
Strongly Agree	4
Agree	3
Disagree	2
Strongly Disagree	1

The calculation of the criterion score is based on the scale value and the number of respondents using the following formula [26]:

$$\text{Criterion Score} = \frac{\text{Answer Scale Value}}{\text{Maximum Scale Value}} \times 100 \quad 1)$$

The initial ability test was analyzed by categorizing the data based on the stages of mathematical problem-solving developed by Polya [27], which included understanding the problem, formulating the model, solving the problem, and interpreting the results. The analysis of the initial ability test was calculated using the following formula:

$$\text{Percentage} = \frac{\text{Number of respondents in a specific category}}{\text{Total number of students}} \times 100 \quad 2)$$

### 3. RESULTS AND DISCUSSION

#### 3.1. Potential and Problems

The following is a picture of the quantitative results of the needs questionnaire that was given to respondents:

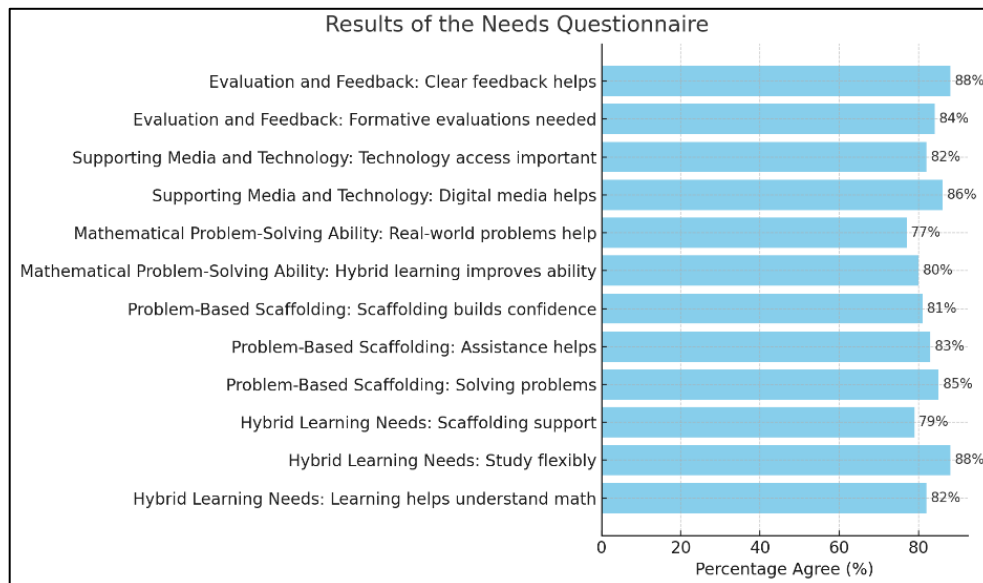


Figure 1. Results of the Needs Questionnaire

The results of the needs questionnaire administered to students showed that most respondents considered hybrid learning, which combined face-to-face and online methods, to be very helpful in understanding mathematics material, with 82% agreeing. Additionally, 88% of participants appreciated the flexibility of learning through a combination of online and face-to-face methods, while 79% stated that they needed clear scaffolding support when learning online to follow the lessons optimally. These results aligned with the findings of Koes-Hadi et al. [28], who stated that e-scaffolding in hybrid learning could help students develop systematic thinking and improve their problem-solving skills by overcoming difficulties in non-routine problems, thus enhancing their conceptual understanding and problem-solving abilities.

Regarding problem-based scaffolding, 85% of participants agreed that the problem-based learning (PBL) model effectively trained them to solve complex mathematics problems. Scaffolding assistance, such as step-by-step guidance, was very helpful for 83% of participants, and 81% felt more confident in solving mathematical problems due to the

scaffolding provided. These findings were consistent with Salam et al. [29], who found that scaffolding techniques in the PBL model significantly improved students' mathematical problem-solving abilities by providing gradual support tailored to their needs.

Regarding mathematical problem-solving skills, 80% of participants stated their abilities had improved by implementing hybrid learning with scaffolding. This was consistent with the findings of Zainudin et al. [30], which showed that combining PBL and hybrid learning significantly enhanced students' problem-solving skills. Moreover, 77% of participants felt they needed contextual and real-world practice problems to enhance their problem-solving skills further. Salam et al. [29] also highlighted the importance of scaffolding adjusted to learners' needs in the context of contextual learning to address mathematical problem-solving difficulties effectively. Ilma et al. [31] also found that the hybrid project-based learning model, which combined real-world contexts and scaffolding, significantly increased students' problem-solving skills and creativity.

Digital learning media, such as tutorial videos and interactive applications, also received positive responses. 86% of participants reported that these media helped them understand mathematical concepts more deeply. Lin et al. [32] also affirmed that a multidimensional scaffolding design in hybrid learning increased learning effectiveness and problem-solving skills through interactive media and integrated evaluation.

Most participants (82%) rated adequate technological access, including the internet and electronic devices, as important to support effective hybrid learning. Regarding evaluation and feedback, formative assessments such as quizzes and routine exercises were considered important by 84% of participants, while 88% stated that prompt and clear feedback from instructors greatly helped improve their understanding and problem-solving skills. This was consistent with findings by Arifia and Nurdyansyah [33], which showed the positive impact of hybrid PBL-based learning on mathematical problem-solving abilities, supported by effective formative evaluation and feedback.

Based on interview results, students expressed that hybrid learning provided significant flexibility, allowing them to study independently through online materials while receiving direct explanations during face-to-face sessions. However, some technical issues, such as internet stability and difficulties in managing independent study time, remained obstacles affecting the effectiveness of hybrid learning. This indicated the importance of technical support and good time management to ensure smooth learning processes.

Furthermore, implementing the problem-based learning model effectively encouraged students to actively seek solutions independently. However, scaffolding in the form of step-by-step guidance provided by instructors was necessary to help students overcome confusion and increase their confidence in solving mathematical problems. This scaffolding approach became crucial in maximizing students' understanding and problem-solving skills.

Regarding learning media, students showed a strong need for interactive and contextual media. Learning videos that combined PowerPoint presentations with screencasting were the main choice, as they helped students understand difficult concepts more clearly and engagingly. Moreover, problem exercises oriented toward real-world

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situations were also considered important to improve mathematical problem-solving skills practically and in ways that are relevant to real-life contexts.

Overall, these quantitative results confirmed the strong need for a hybrid learning design that integrates problem-based scaffolding, technological support, and effective formative evaluation to enhance students' mathematical problem-solving abilities.

### 3.2. Mathematical Problem-Solving Skills

The pre-test results on students' mathematical problem-solving abilities, specifically in the Differential Equations course, showed significant variation at each stage of the problem-solving process. The following chart presents the quantitative results:

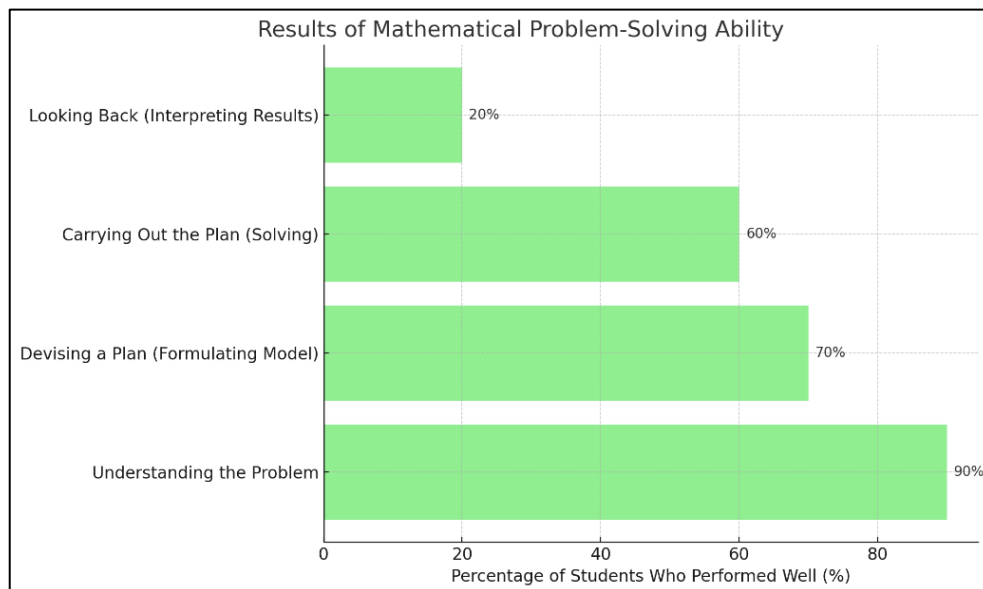


Figure 2. Results of Mathematical Problem-Solving Ability

The results showed that 90% of students understood the problem by identifying the known elements and what was asked and assessing the sufficiency of the information. However, performance significantly dropped at the next stage, formulating the mathematical model, with only 70% of students able to correctly construct a differential equation model. This suggests that while most students understood the problem, many struggled to translate that understanding into the correct mathematical framework.

Moreover, students' ability to apply solution strategies dropped to 60%, with some students struggling due to insufficient mastery of the indefinite integral concept, which is crucial for solving differential equations. At the final stage, interpreting results, only 20% of students demonstrated adequate ability. This low score indicates that students struggled to relate their mathematical results to real-world contexts, essential for meaningful problem-solving.

These results suggest the need for a hybrid learning design that integrates problem-based scaffolding. Such an approach would provide students with structured, step-by-step guidance at each stage of the problem-solving process, from understanding the problem, formulating the mathematical model, and applying solution strategies to interpreting the

results. The scaffolding would help ensure that students understand the steps involved and gain the confidence and skills necessary to solve mathematical problems and interpret their solutions. These data highlighted the need for a hybrid learning design that integrated problem-based scaffolding. This approach was expected to provide structured and continuous support at each stage of problem-solving, from understanding the problem, formulating the mathematical model, applying solution strategies, and interpreting the results to improve students' mathematical problem-solving abilities.

### **Pedagogical Implications:**

Based on the insights from this study, educators can improve students' mathematical problem-solving abilities through the following actions:

- a. **Strengthen Conceptual Understanding:** Build on students' strength in understanding problems by integrating real-world problems to deepen their grasp of mathematical models and strategies.
- b. **Focus on Scaffolding:** Implement problem-based learning (PBL) frameworks with step-by-step scaffolding to help students construct models and apply solution strategies effectively.
- c. **Promote Reflective Learning:** Encourage students to reflect on how their solutions relate to real-world contexts. Use formative assessments to provide feedback on their ability to interpret results.
- d. **Incorporate Hybrid Learning Tools:** Integrate interactive tutorials, videos, and virtual simulations to offer immediate feedback and help students visualize complex problems.
- e. **Increase Collaborative Learning:** Encourage collaborative problem-solving, where students work in teams to tackle real-world problems, enhancing peer learning and problem-solving skills.

When incorporated into a hybrid learning environment, these pedagogical strategies will provide the necessary support for students to improve their problem-solving skills at every stage of the mathematical problem-solving process.

## **4. CONCLUSION**

Based on the needs analysis and student interviews, it was concluded that developing a hybrid learning design integrating problem-based scaffolding is essential for improving students' mathematical problem-solving abilities in differential equations instruction. Hybrid learning offers substantial flexibility, though technical challenges such as internet stability and managing self-directed study time require careful attention to ensure an optimal learning experience.

Implementing step-by-step scaffolding proved critical in guiding students through problem-solving and bolstering their self-confidence. The use of instructional media, particularly videos combining PowerPoint presentations with Screencastify, emerged as a key tool in facilitating a visual and interactive understanding of complex mathematical concepts. Moreover, students expressed a clear preference for contextual, real-world problems that could better help them apply and reinforce their problem-solving skills.

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The needs assessment survey revealed several crucial points: (1) the integration of real-life problems to make learning more relatable and engaging, (2) the use of PowerPoint and Screencastify videos to aid comprehension, (3) the application of scaffolding strategies that offer structured, tailored assistance to match students' problem-solving capabilities, and (4) the combination of hybrid learning with problem-based scaffolding to enhance problem-solving competence. Formative evaluations and prompt feedback were also identified as essential components to support and reinforce this approach.

Therefore, integrating these elements into a well-structured learning design will significantly improve students' learning outcomes and problem-solving abilities. This integrated approach strengthens students' theoretical understanding and builds practical problem-solving skills through structured support and real-world applications.

#### Recommendations for Future Curriculum and Instructional Design:

- a. Integrate problem-based and hybrid learning to make mathematical concepts more relevant and engaging.
- b. Implement personalized scaffolding to cater to student's individual learning needs.
- c. Prioritize the development of interactive technologies and virtual platforms to support independent and collaborative learning.
- d. Provide training for educators on effective scaffolding strategies and hybrid learning tools.
- e. Address technical challenges to ensure equitable access to learning materials and technologies.

#### Suggestions for Future Research:

Further studies should explore larger sample sizes and extended durations to validate the effectiveness of this hybrid learning model. Additionally, more individualized needs analyses are recommended to refine instructional strategies and better meet students' diverse learning needs.

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