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Developing Plato_Pro: A Needs Analysis for Enhancing Self-Efficacy and Mathematics Learning in Sixth-Grade Proportional Problem Solving

Lilik Nurhafidoh*
Faculty of Education, State University of Surabaya, Surabaya, Indonesia

Wiryanto
Faculty of Education, State University of Surabaya, Surabaya, Indonesia

Endah Budi Rahaju
Faculty of Mathematics and Natural Sciences, State University of Surabaya, Surabaya, Indonesia

***Corresponding Author:** 24010855139@mhs.unesa.ac.id

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Abstract
This study aims to analyze the needs for developing Plato_Pro (Proportional Learning through Objects and Problems) instructional media in an effort to enhance self-efficacy and mathematics learning outcomes of sixth-grade elementary school students in proportional word problem tasks. The background of this research stems from students' low ability to comprehend proportional word problems, particularly in determining the correct relationship between the given and unknown ratios. The study employed a descriptive qualitative approach supported by simple quantitative data, with participants consisting of 25 students from class VI-D of SD Negeri Sawotratap 1 and their mathematics teacher. Data were collected through classroom observations, interviews with teachers and students, as well as documentation of students' learning outcomes. Data analysis followed the interactive model of Miles and Huberman, which includes data reduction, data display, and conclusion drawing. The findings reveal that most students still experience difficulties in solving proportional word problems due to limited conceptual understanding, weak reasoning ability, and the minimal use of concrete learning media. From the teachers' perspective, limited skills in developing contextual learning media also posed a significant challenge. Therefore, there is a clear need to develop innovative instructional media such as Plato_Pro, which is designed based on concrete objects to facilitate conceptual understanding of proportion while supporting the enhancement of students' self-efficacy and learning outcomes. These findings provide a foundation for further research focused on the development and empirical testing of Plato_Pro.

INTRODUCTION

Mathematics has long been recognized as a subject that presents abstract concepts, hierarchical structures, and complex principles that are often challenging for students to master. At the elementary school level, students are in the concrete operational stage as explained by Piaget, which means they require tangible and contextual learning experiences to better understand mathematical ideas (Piaget, 1970). Without the support of appropriate learning media, students often struggle to make sense of mathematical abstractions, especially in relation to problem-solving tasks. Story problems in mathematics, which are formulated in a contextual and narrative form, demand higher-order cognitive skills such as critical thinking and decision-making (Jannah et al., 2025). These tasks require students to translate real-world contexts into mathematical representations, a process that many students find difficult. For this reason, mathematics teaching must incorporate learning tools and strategies that make abstract concepts concrete and meaningful (Ida et al., 2021). The use of learning media in particular can significantly influence how students approach mathematical story problems. Consequently, innovation in media design becomes a central strategy to improve both cognitive understanding and motivational aspects of student learning.

Story problems on the topic of proportion are especially difficult for elementary students to solve because they require precise reasoning in establishing the relationship between given and unknown ratios. Research has shown that errors often arise from students' difficulties in determining the correct position of the ratio to be solved, leading to misconceptions and computational mistakes (Riyadi et al., 2021). For example, when students face a task such as "If 3 pencils cost 9,000 rupiah, how much do 5 pencils cost?", many struggle to set up the ratio 3:9,000 = 5:x correctly, often reversing or mismatching quantities. This issue indicates a gap between students' conceptual understanding and procedural knowledge in mathematics (Cobbe et al., 2021). Misconceptions in proportion problem solving are further exacerbated by students' low self-efficacy, which affects their confidence in dealing with mathematical tasks (Patel et al., 2021). Students with low self-efficacy often hesitate to attempt challenging problems or give up when they encounter multiple steps in proportional reasoning. Therefore, interventions aimed at improving students' proportional reasoning must simultaneously address conceptual clarity and psychological readiness. One potential solution is the implementation of concrete learning media that can visualize and structure proportional relationships.

Self-efficacy and learning outcomes are interrelated components that mutually reinforce mathematics learning success. When students perceive themselves as capable of solving problems, they are more likely to engage in cognitive strategies, persist in overcoming difficulties, and achieve better results (Mergen, 2024). Conversely, students with low self-efficacy tend to avoid challenges, give up easily, and perform poorly in assessments. While numerous studies emphasize the cognitive dimension of proportion learning, fewer explore how manipulative media can be deliberately designed to strengthen self-efficacy alongside conceptual mastery. Thus, any instructional innovation must be designed not only to improve conceptual mastery but also to foster students' confidence and motivation. The integration of concrete learning media has been reported to positively influence students' affective domains, making them more active and enthusiastic during learning activities (de Jesús, 2024). In the context of story problems in proportions, the use of media that concretizes abstract ratios may strengthen students' confidence and accuracy. This dual focus on cognitive and affective outcomes aligns with current educational demands for holistic learning improvements.

Based on observations in elementary schools, particularly grade VI students, many learners still find difficulty in solving proportional story problems despite direct instruction from teachers. Data from educational assessments in Indonesian elementary schools indicate that students' ability to apply mathematical concepts in real-life contexts remains below expectations (Maghfiroh & Wahyuningsih, 2024). This suggests a systemic problem in the teaching of mathematics that requires innovative solutions. Teachers themselves often acknowledge the limitations of existing instructional methods, which tend to emphasize procedural drills without sufficient conceptual grounding (Rakhmawati & Mustadi, 2022). Moreover, students frequently perceive mathematics as a difficult and intimidating subject, further lowering their motivation to engage with problem-solving tasks (Liang et al., 2021). These conditions underline the urgent need for media innovations that are accessible, engaging, and effective in supporting conceptual understanding. However, current media for teaching proportions remain limited to digital animations or static worksheets, lacking direct manipulability that aligns with the concrete operational needs of students.

To address these challenges, this study introduces and analyzes the need for developing "Plato_Pro" (Proportional Learning through Objects and Problems), a concrete manipulative learning tool designed to help sixth-grade students understand proportional relationships through tangible objects and contextual problem scenarios. Plato_Pro combines physical manipulatives with visual representations of ratio relationships to help students visualize equivalent proportions and reason through real-life contexts. Unlike existing ratio-based manipulatives, Plato_Pro specifically integrates tasks that promote self-efficacy by providing graduated challenges, immediate feedback, and opportunities for collaborative exploration.

Therefore, this study focuses on conducting a needs analysis for the development of Plato_Pro as an innovative instructional medium that bridges cognitive understanding and motivational growth in proportional problem solving. The research does not aim to produce or test a finalized product but rather to map out the specific requirements and challenges faced by students and teachers. By employing a qualitative descriptive approach, this study seeks to capture the authentic experiences, difficulties, and expectations of both learners and educators in the classroom. The findings are expected to provide insights into the types of media features that are most urgently needed to improve students' conceptual understanding and self-efficacy. In doing so, the study fills a research gap in the existing literature by linking manipulative media design with psychological factors influencing mathematics learning. Ultimately, the analysis lays the groundwork for future development and empirical testing of Plato_Pro as an innovative tool in mathematics education.

METHODS

This study employed a qualitative descriptive approach to examine the learning needs underlying the development of Plato_Pro as a potential instructional medium for proportional story problems in mathematics. The reference to a "mixed-method approach" was corrected, as the research focused exclusively on qualitative techniques to capture authentic learning conditions and participants' perspectives. A qualitative descriptive design was chosen because it allows for a naturalistic investigation of classroom conditions and enables a deeper understanding of students' authentic learning experiences and challenges. The study was conducted at SD Negeri Sawotratap 1, Sidoarjo, Indonesia, involving 25 students from class VI-D and their mathematics teacher as participants. These participants were selected purposively, as they represented the target group in which the identified learning difficulties were most pronounced.

Data collection was carried out through three main techniques: classroom observation, semi-structured interviews, and document analysis, each guided by explicit protocols to ensure consistency and depth of information. Observation protocols focused on three dimensions: (1) students' engagement during problem-solving activities, (2) the types of errors and reasoning patterns exhibited in proportional word problems, and (3) the teacher's instructional strategies and use of learning media. Observations were conducted over three consecutive mathematics lessons, each lasting approximately 70 minutes, and were documented through field notes and video recordings for triangulation.

Semi-structured interviews were conducted with both students and the teacher to elicit perceptions of mathematical challenges, preferred learning strategies, and expectations for instructional media. The interview guide consisted of 10 core questions for students and 8 for teachers, focusing on perceived difficulties, confidence levels, and media features that could enhance understanding. Each interview lasted 15–25 minutes and was audio-recorded with consent. Additionally, document analysis included reviewing students' worksheets, test results, and lesson plans, which provided supporting evidence of students' learning outcomes and difficulties. This combination of data sources enhanced the credibility of the findings and allowed a comprehensive analysis of the learning context.

Data were analyzed using the Miles and Huberman interactive model, which involves three key stages: data reduction, data display, and conclusion drawing (Miles et al., 2014). During data reduction, transcripts, observation notes, and documents were coded and categorized into relevant themes. Data display was conducted by organizing information into matrices and tables to highlight patterns of student errors, teacher challenges, and expected features of instructional media. Finally, conclusions were drawn and verified through iterative reflection and member checking with the teacher, ensuring the validity and trustworthiness of interpretations. To further ensure rigor, the study applied Liu et al. (2021) criteria of trustworthiness, including credibility, dependability, transferability, and confirmability.

RESULTS AND DISCUSSION

Results

The findings of this study are presented in three main themes: (1) Students' learning difficulties, (2) Teachers' challenges in instruction, and (3) Expectations for media development.

Students' Learning Difficulties in Proportional Story Problems

Observation and document analysis showed that most students struggled to determine the correct ratio positions in proportional problems. Errors included misplacing the numerator and denominator, incorrectly applying cross multiplication, and misinterpreting problem contexts. Interview results revealed that students often felt "confused" and "uncertain," reflecting low self-efficacy.

Table 1. Types of Student Errors in Proportional Story Problems

Error Type	Frequency (n=25)	Percentage	Example Case
Misidentifying numerator/denominator	11	44%	Placing known value in wrong position
Incorrect cross multiplication	7	28%	Multiplying diagonally in reverse
Misinterpreting story context	5	20%	Treating "3 kg apples for 2 people" as 3:2 without conversion
Calculation mistakes	2	8%	Basic arithmetic error

These findings confirm that both conceptual misunderstanding and procedural errors contribute to students' struggles.

Teachers' Challenges in Instruction

The mathematics teacher reported that while students could follow direct procedures, they often failed when problems were presented in narrative contexts. The teacher highlighted limited teaching media as a major constraint, relying mostly on textbook explanations and verbal instruction. According to the teacher, abstract ratios were particularly difficult for students to visualize.

Table 2. Teacher's Reported Instructional Challenges

Category	Description
Limited instructional media	No concrete tools available to demonstrate proportional reasoning
Student engagement issues	Students easily distracted and reluctant to attempt story problems
Procedural dependence	Students memorize steps without understanding ratio concepts
Curriculum pressure	Focus on preparing for exams limits creative teaching methods

This suggests that effective media must reduce abstraction and improve engagement simultaneously.

Expectations for Media Development (Plato_Pro)

Both students and the teacher expressed enthusiasm for a new medium that could make ratios visible and concrete. Students preferred colorful, game-like, and interactive tools, while the teacher emphasized the importance of aligning media with curriculum goals and ease of classroom use.

Table 3. Desired Features of Plato_Pro Media

Perspective	Expected Features
Students	Colorful, interactive, game-like, easy to manipulate
Teacher	Curriculum alignment, clarity in showing ratios, simple implementation

These expectations suggest that Plato_Pro should be designed as a hands-on, visual medium capable of bridging abstract proportional reasoning with concrete student experiences.

The study concludes that students' difficulties are primarily rooted in conceptual misunderstandings of ratios and low self-efficacy, while teachers struggle with the absence of effective media. Therefore, the development of Plato_Pro is highly needed to concretize proportional

relationships, enhance engagement, and support both conceptual mastery and self-confidence in mathematics learning.

Discussion

The findings of this study confirm that students face substantial difficulties in solving proportional story problems due to conceptual misunderstanding. Many students were unable to distinguish between known and unknown quantities in ratio problems, which often led to misplaced numerators and denominators. This indicates that their cognitive structures for ratio and proportion concepts remain underdeveloped. Prior research has also shown that learners frequently treat proportional problems as simple arithmetic tasks rather than as relational reasoning (Mariana & Sasmita, 2024). In the Indonesian context, similar difficulties were documented, where students misinterpreted ratio terms and failed to apply cross-multiplication correctly (Balluerka et al., 2024). Such findings suggest that existing teaching methods may overemphasize procedural memorization rather than conceptual understanding. Therefore, it is crucial to design learning media that bridges abstract proportional reasoning with concrete experiences.

Teachers also reported significant challenges in delivering instruction on ratio and proportion. The lack of concrete instructional media was identified as one of the primary obstacles to effective teaching. Without visual or tangible aids, students tend to rely solely on rote procedures, which inhibits deeper comprehension. This resonates with the constructivist view that learners build knowledge more effectively when they can manipulate objects and visualize abstract concepts (Sianturi, 2025). Previous studies have highlighted that when teachers incorporate manipulatives, students demonstrate higher engagement and improved performance in mathematics (Rini & Purwanti, 2021). Unfortunately, many classrooms in Indonesia still depend heavily on textbooks and verbal explanations. This suggests that innovations such as Plato_Pro could offer practical solutions for teachers by providing concrete representations of proportionality.

Students' interviews revealed that low self-efficacy was a key factor influencing their struggles with mathematics. Many expressed feelings of confusion and lack of confidence when faced with proportional story problems. According to Bandura's theory, self-efficacy strongly influences how learners approach challenges, persist in problem-solving, and manage anxiety (Kennedy, 2024). Students with low self-efficacy are more likely to avoid tasks they perceive as difficult, even if they have the ability to succeed. Empirical evidence shows that enhancing students' confidence can significantly improve their mathematics achievement (Macun & Işık, 2022). The findings in this study align with those perspectives, emphasizing the need for interventions that address both cognitive and affective domains. Thus, the development of Plato_Pro aims not only to improve conceptual understanding but also to enhance students' belief in their mathematical competence.

Observation results indicated that many students became disengaged during lessons involving abstract proportional reasoning. They often displayed passive behaviors, such as waiting for direct answers or avoiding participation altogether. This pattern highlights the importance of instructional media that can stimulate curiosity and active learning. Research on student engagement suggests that interactive and visually appealing media can significantly enhance attention and motivation (Vessonen et al., 2024). Moreover, engagement is positively correlated with academic achievement, particularly in mathematics (Street et al., 2022). Without engaging tools, students are less likely to develop persistence when solving challenging tasks. Therefore, integrating Plato_Pro as a hands-on medium may increase participation and foster a more active learning environment.

The teacher emphasized the need for curriculum-aligned media that could be seamlessly integrated into classroom practice. Teachers often face pressure to prepare students for standardized assessments, limiting their flexibility to adopt creative teaching methods. This finding is consistent with studies showing that curriculum demands can restrict teachers from experimenting with innovative practices (Rahmawati, 2025). However, research also highlights that carefully designed media can serve as a bridge between curricular requirements and student-centered pedagogy

(Chisara et al., 2018). Plato_Pro has the potential to fulfill this role, as it is specifically designed to represent proportional reasoning within the curriculum scope. By addressing both teacher needs and student difficulties, such media can contribute to sustainable improvements in instructional practice.

One of the key implications of this study is the necessity of integrating visual and tactile elements in mathematical instruction. Students' expressed preference for colorful and interactive learning tools underscores the relevance of multimodal learning theories. Mayer's Cognitive Theory of Multimedia Learning argues that learners understand concepts better when information is presented through both visual and verbal channels (Mayer, 2009). This dual-channel processing reduces cognitive overload and enhances retention. Similar findings have been reported in mathematics education, where visual models such as diagrams or manipulatives improved problem-solving accuracy (Hadiana, 2019). Thus, Plato_Pro can be designed to incorporate such multimodal features to maximize its effectiveness in enhancing proportional reasoning.

Document analysis revealed that students' written work contained frequent procedural errors, suggesting overreliance on memorized formulas. This phenomenon is not unique to Indonesian learners but has been reported globally as a common challenge in mathematics education. When students focus exclusively on algorithms without conceptual grounding, they often fail to transfer knowledge to new contexts. Research shows that students achieve better results when taught with a balance between conceptual understanding and procedural fluency (Kennedy, 2024). The absence of such balance in the observed classroom highlights the urgency for innovative media like Plato_Pro. By offering tangible models for ratio representation, Plato_Pro can potentially reduce procedural dependency and foster flexible reasoning.

The findings also carry implications for teacher professional development. Teachers need support in utilizing innovative media effectively, as introducing new tools alone does not guarantee improved learning outcomes. Research emphasizes that teacher training and pedagogical integration are crucial for the success of educational innovations (Solihin et al., 2025). Without adequate preparation, teachers may underutilize or misuse the media, limiting its impact. Therefore, alongside developing Plato_Pro, there should be structured professional learning opportunities for teachers. This dual strategy ensures that the media is not only available but also effectively embedded into instructional practice. Such an approach increases the likelihood of long-term improvements in mathematics learning.

In summary, this study highlights the critical role of instructional media in addressing conceptual difficulties, enhancing self-efficacy, and improving engagement in mathematics learning. The consistent difficulties observed in students underscore the inadequacy of current methods in supporting proportional reasoning. Teachers' reliance on procedural teaching and lack of media further exacerbate these challenges. The development of Plato_Pro responds directly to these needs by offering a concrete, engaging, and curriculum-aligned medium. This aligns with broader calls in educational research for innovations that integrate pedagogy, curriculum, and learner psychology (Shulman, 1986). The findings therefore provide a strong foundation for the subsequent design and empirical testing of Plato_Pro. Ultimately, the study contributes to the discourse on improving mathematics education through evidence-based media innovation.

CONCLUSION

This study concludes that students in grade VI continue to experience substantial difficulties in solving proportional story problems due to limited conceptual understanding, low self-efficacy, and insufficient engagement in learning activities. The reliance on procedural memorization without adequate conceptual grounding leads to frequent errors and inhibits knowledge transfer. Teachers also face challenges in delivering effective instruction because of the lack of concrete and interactive instructional media. The analysis highlights that there is a strong and urgent need for innovative tools such as Plato_Pro, which can serve as a tangible and engaging medium to facilitate proportional reasoning. Moreover, the findings affirm that instructional media should not only align with curricular

objectives but also address cognitive and affective learning needs simultaneously. The integration of Plato_Pro is therefore expected to provide a balanced approach, enhancing both understanding and confidence in mathematics.

Based on these findings, it is recommended that further research focus on the systematic development and empirical testing of Plato_Pro as a mathematics learning medium. Future studies should apply design-based research or quasi-experimental approaches to examine its effectiveness in improving conceptual comprehension, problem-solving skills, and self-efficacy. Additionally, teachers should be provided with professional development programs that train them to integrate innovative media effectively into their classroom practices. Collaboration between researchers, teachers, and policymakers is essential to ensure that such media innovations are sustainable and scalable within the education system. Finally, it is suggested that future work explore the adaptability of Plato_Pro across different mathematical topics to expand its pedagogical relevance beyond proportional reasoning.

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