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# Development of Multiplication Board Media Using the ADDIE Model to Improve Elementary Students' Mathematics Learning Outcomes

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**ABSTRACT**

This study aims to develop and examine the feasibility and effectiveness of multiplication board media in improving mathematics learning outcomes among third-grade students. The research employed a Research and Development (R&D) method using the ADDIE model, consisting of Analysis, Design, Development, Implementation, and Evaluation stages. Data were collected through observation, interviews, expert validation questionnaires, student response questionnaires, and pretest-posttest assessments. The subjects involved material and media experts as validators and third-grade students as research participants. Data analysis was conducted descriptively, while the effectiveness of the developed media was evaluated using the Wilcoxon Signed Rank Test and N-Gain analysis. The results showed that the multiplication board media achieved a feasibility score of 95% from material experts and 85% from media experts, indicating a highly feasible and feasible category, respectively. Student responses demonstrated a very positive perception, with scores ranging from 80% to 90%. The Wilcoxon test showed a significance value of <0.001, and the average N-Gain score of 0.6872 (68.72%) indicated a moderate level of effectiveness. This study implies that multiplication board media can serve as an innovative and practical learning tool to support conceptual understanding and improve students' mathematics learning outcomes.

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## INTRODUCTION

Mathematics education at the elementary level plays a crucial role in developing students' logical reasoning, problem-solving abilities, and critical thinking skills, which are essential competencies for facing academic and real-life challenges. Multiplication is one of the fundamental mathematical concepts that significantly influences students' ability to understand more advanced topics,

including division, fractions, measurement, and mathematical problem-solving. However, difficulties in mastering multiplication concepts at an early stage may lead to persistent learning barriers and reduced confidence in mathematics. Therefore, improving multiplication learning in elementary education is a social necessity because weak foundational numeracy skills can affect students' future academic development. Research has shown that students' mathematical achievement is strongly influenced by their conceptual understanding and problem-solving abilities rather than memorization alone (Harefa, 2023; Sinaga et al., 2023; Mustafa & Maulana, 2024). Consequently, innovative learning approaches are required to ensure that students develop meaningful mathematical understanding from an early stage.

The development of multiplication board media is based on the principles of constructivist learning theory, which emphasizes that students construct mathematical knowledge through direct experiences and meaningful interactions with learning objects. In elementary mathematics education, abstract concepts such as multiplication need to be represented through concrete and visual experiences to facilitate students' conceptual understanding. The Concrete-Pictorial-Abstract (CPA) approach explains that learners should experience mathematical concepts through concrete objects before moving toward symbolic representations (Azzumar & Juandi, 2023). Similarly, the use of manipulatives has been recognized as an effective strategy for supporting mathematical development because students can explore relationships between quantities and mathematical operations through physical representations (Sikhwari & Feza, 2024). Based on these principles, multiplication board media is designed as a visual and manipulative learning tool that transforms multiplication from an abstract numerical process into an interactive learning experience.

Despite the importance of conceptual understanding, mathematics learning in elementary schools still faces challenges, particularly in multiplication instruction. Many students experience difficulties because learning activities often emphasize memorization of multiplication tables rather than understanding multiplication as repeated addition and numerical relationships. This condition reduces students' ability to apply multiplication concepts in different contexts. Previous studies indicate that visual media and manipulatives can support students in understanding mathematical concepts by providing meaningful representations of abstract ideas (Schoenherr et al., 2024; Matodzi & Nosis, 2025; Rahmadan & Shudiq, 2024). However, classroom practices frequently show limited utilization of interactive learning media, causing mathematics instruction to remain teacher-centered and less engaging. As a result, students tend to become passive learners and experience difficulties

in developing mathematical reasoning. This gap between theoretical recommendations and classroom practices indicates the need for practical learning innovations that are suitable for elementary students.

The development of multiplication board media is necessary because existing mathematics learning practices often lack attractive, simple, and accessible instructional tools that can support students' conceptual understanding. Although digital-based learning media has rapidly developed, many elementary schools still require low-cost and easy-to-use learning resources that can be implemented without technological limitations. Manipulative-based learning media provides opportunities for students to actively explore mathematical concepts through direct interaction with learning materials (Niranjan & Brijlall, 2024). Previous research also confirms that multiplication board media can improve students' multiplication skills by providing concrete representations of numerical operations (Uswah & Siregar, 2024; Praditya et al., 2024; Sholehah & Ichsan, 2025). However, several existing media products focus mainly on skill improvement and have limited emphasis on systematic development, validation, and effectiveness testing. Therefore, developing a validated multiplication board media product is important to provide an innovative solution for meaningful mathematics learning.

Previous studies have demonstrated the effectiveness of various instructional media in improving elementary mathematics learning outcomes. Multiplication board media has been reported to positively influence students' understanding of multiplication concepts by providing interactive and concrete learning experiences (Filsafati & Fajrie, 2023; Gili et al., 2025). In addition, studies on visual and audiovisual learning media indicate that appropriate representations can increase students' motivation and achievement in mathematics learning (Sappaile et al., 2024; Setiawati et al., 2024; Ghozali & Syafiih, 2024). These findings highlight the importance of developing learning media that accommodate students' cognitive characteristics. However, previous studies have mostly examined the implementation of specific media rather than conducting comprehensive product development processes involving analysis, design, validation, implementation, and evaluation. Therefore, further research is needed to develop multiplication learning media using a systematic instructional design framework.

The ADDIE model has been widely applied in educational product development because it provides a structured framework consisting of analysis, design, development, implementation, and evaluation stages. This model enables researchers to create instructional products that are systematically designed according to learners' needs and evaluated for effectiveness (Abuhassna & Alnawajha, 2023; Shakeel et al., 2023). Several studies have applied ADDIE in

developing educational media, but most focus on digital platforms, multimedia, or technology-based learning resources (Sakdiah et al., 2025; Okte & Pasca, 2025). Meanwhile, research focusing on ADDIE-based development of concrete multiplication media for elementary mathematics remains limited. This indicates a research gap regarding the development of validated, non-digital, and manipulative learning media specifically designed to improve multiplication understanding among elementary learners. Therefore, this study addresses the gap by integrating instructional design principles with concrete mathematical learning media.

This research presents a novel contribution through the development of multiplication board media that combines concrete manipulation, visual representation, and structured instructional design principles. Unlike previous multiplication media that primarily focus on practicing calculation skills, this product emphasizes conceptual understanding by allowing students to visualize multiplication processes and recognize mathematical relationships. The developed media is designed to provide an interactive learning experience while remaining practical for classroom implementation. The novelty of this study lies in the integration of a systematically developed learning product with validation and effectiveness testing to ensure its feasibility as a mathematics instructional tool. Furthermore, the product is designed to support active student participation and transform multiplication learning from memorization-based activities into meaningful conceptual learning experiences.

Based on the identified problems, this research addresses the question of how to develop feasible and effective multiplication board media for improving elementary students' mathematics learning outcomes. The proposed solution is the development of an instructional medium that provides concrete, visual, and interactive representations of multiplication concepts. Therefore, this study aims to develop multiplication board media using the Research and Development (R&D) approach with the ADDIE model. Specifically, this research aims to analyze students' learning needs, design and develop the multiplication board media, evaluate its feasibility through expert validation, and examine its effectiveness in improving students' mathematics learning outcomes. The findings are expected to contribute to mathematics education by providing an innovative learning resource that supports teachers in implementing engaging, meaningful, and student-centered mathematics instruction.

## RESEARCH METHODS

This study employed a Research and Development (R&D) approach to develop and evaluate multiplication board media as a mathematics learning tool. The development process adopted the ADDIE model, which consists of five

systematic stages: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was selected because it provides a structured framework for designing, producing, implementing, and evaluating educational products based on learners' needs and learning objectives (Abuhassna & Alnawajha, 2023; Shakeel et al., 2023; Soim et al., 2026). This model is considered appropriate for instructional media development because it enables researchers to conduct continuous evaluation and revision throughout the product development process. The research focused on producing a feasible and effective multiplication board media that supports students' conceptual understanding and improves mathematics learning outcomes.

The research involved third-grade elementary students and expert validators who participated in the product evaluation process. The research subjects consisted of mathematics learning experts and instructional media experts as validators, as well as students involved in the implementation stage. The material expert was selected based on expertise in elementary mathematics education, while the media expert had competence in developing and evaluating instructional media. The student participants were third-grade learners who used the multiplication board media during mathematics instruction. The involvement of students was intended to determine the practicality and effectiveness of the developed product. The selection of participants was based on their relevance to the objectives of developing concrete mathematical learning media, as manipulative-based instruction has been shown to support students' mathematical understanding (Sikhwari & Feza, 2024; Matodzi & Nosis, 2025; Tabina & Dora, 2025).

The development procedure followed the ADDIE stages. The analysis stage identified students' learning needs, difficulties in understanding multiplication concepts, and the requirements for developing instructional media through observation and preliminary discussions. The design stage involved preparing the concept, materials, visual appearance, and instructional procedures of the multiplication board media. The development stage focused on producing the media prototype and conducting expert validation for revision. The implementation stage involved testing the product with students during mathematics learning activities. The evaluation stage was conducted continuously to improve product quality based on expert feedback and trial results. A systematic development process is essential because instructional products should be validated before classroom implementation to ensure their feasibility and effectiveness (Abuhassna & Alnawajha, 2023; Rahayu, 2025; Oyeniran et al., 2024).

Data were collected using observation sheets, interview guidelines, expert validation questionnaires, student response questionnaires, and learning achievement tests. The validation instruments were used to assess the feasibility of the multiplication board media, while student response questionnaires

measured the practicality of the product. Pretest and posttest assessments were administered to evaluate changes in students' multiplication learning outcomes after using the developed media. The collected data consisted of qualitative and quantitative data. Qualitative data from expert suggestions, comments, and observations were analyzed descriptively for product improvement. Quantitative data from validation scores, student responses, and learning tests were analyzed to determine validity, practicality, and effectiveness. Product effectiveness was examined using the Wilcoxon Signed Rank Test and N-Gain analysis, as visual and manipulative learning media have been reported to improve students' mathematics achievement and conceptual understanding (Schoenherr et al., 2024; Sappaile et al., 2024).

## RESULTS AND DISCUSSION

### Results

In this research, which employed the ADDIE research and development model, the results are systematically described. The research process consisted of the stages of analysis, design, development, implementation, and evaluation. Each stage produced data that were then thoroughly analyzed to evaluate the feasibility, effectiveness, and students' responses toward the developed multiplication board learning media.

### Analysis

The initial stage in developing the multiplication board media was conducted through an analysis of students' needs. Based on interviews with the third-grade mathematics teacher, it was found that multiplication learning had been dominated by lectures and the use of student worksheets (LKS), which only provided basic explanations of multiplication concepts without further explanation regarding strategies or visual aspects that could facilitate students' understanding. The absence of relevant interactive media caused the learning process to become monotonous and affected students' low motivation in mastering multiplication materials.

### Design

The design stage was carried out as a follow-up to the needs analysis. At this stage, the multiplication board media design was developed by considering a systematic visual layout that displays numbers and multiplication results. Equipped with usage instructions and example questions, the board design was complemented with appropriate colors and sizes to make it easier for students to understand. In addition, the learning materials were arranged with the aim of dividing basic multiplication concepts according to the mathematics

competencies of third-grade students. The validation instruments were prepared in the form of a Likert scale assessment sheet (1–4) with descriptive rubrics covering aspects of appearance, content/material, and usability. Before proceeding to the development stage, the three-dimensional multiplication board model was tested for its feasibility and effectiveness.

**Development**

The development stage was carried out by realizing the multiplication board design into a concrete and communicative learning medium. The production of the media used main materials consisting of a basic board, multiplication numbers, and visual components that supported the understanding of multiplication concepts. The developed media had undergone validation processes by media experts and material experts and was designed based on the needs of third-grade students. The validation data were then analyzed using quantitative techniques and presented in the form of scores and percentages in the research result tables (Himmah & Sulaikho, 2022) and will be presented in the following tables.

**Material Expert Validation**

The validation conducted by the material expert aimed to evaluate the content, presentation, and language use in the newly developed multiplication board learning media. As presented in Table 1, the assessment results showed that the material expert obtained a score of 38 out of a total score of 40, resulting in a feasibility percentage of 95% and categorized as highly feasible.

**Table 1. Material Expert Validation Results**

| Validator | Score Obtained | Maximum Score | Percentage | Category |
|---|---|---|---|---|
| Material Expert | 38 | 40 | 95% | Highly Feasible |

**Media Expert Validation**

As presented in Table 2, the validation conducted by the media expert was carried out to assess the appearance, content, and usability aspects of the developed multiplication board mathematics learning media. Based on the assessment results, the media expert gave a score of 36 out of a maximum total score of 40, resulting in a feasibility percentage of 85%. This percentage was categorized as feasible.

**Table 2. Media Expert Validation Results**

| Validator | Score Obtained | Maximum Score | Percentage | Category |
|---|---|---|---|---|
| Media Expert | 36 | 40 | 85% | Feasible |

## Implementation

### *Media Trial*

Students' responses were collected after the implementation of the third-grade mathematics multiplication board media trial. The research instrument used was a questionnaire consisting of 10 simple questions with answer choices of "Yes" and "No." Each "Yes" answer was assigned a score of 1, while each "No" answer was assigned a score of 0.

**Table 3. Recapitulation of Students' Responses**

| Number of Respondents | Score Obtained | Maximum Score | Percentage | Category |
|---|---|---|---|---|
| 30 | 8–9 | 10 | 80%–90% | Very Good |

The table 3 shows that the multiplication tool in mathematics learning received a very positive assessment from all students. A total of 30 students participated in the trial, with scores ranging from 8 to 9 and a percentage of 80%–90%, which was included in the "Very Good" category. The results indicate that the multiplication board media can attract students' interest in continuing to learn, facilitate their understanding of multiplication concepts, and increase their activeness and motivation in learning. Therefore, the developed multiplication board was considered feasible and effective as a mathematics learning medium for third-grade students because it was able to create a more engaging, interactive, and meaningful learning process that supports students' learning outcomes.

### *Students' Responses*

Students' responses were collected after the implementation of the third-grade mathematics multiplication board media trial. The research instrument used was a questionnaire consisting of 10 simple questions with answer choices of "Yes" and "No." Each "Yes" answer was assigned a score of 1, while each "No" answer was assigned a score of 0.

**Table 4. Recapitulation of Students' Responses**

| Number of Respondents | Score Obtained | Maximum Score | Percentage | Category |
|---|---|---|---|---|
| 30 | 8–9 | 10 | 80%–90% | Very Good |

The table 4 shows that the multiplication tool in mathematics learning received a very positive assessment from all students. A total of 30 students participated in the trial, with scores ranging from 8 to 9 and a percentage of 80%–90%, which was included in the "Very Good" category. The results indicate that the multiplication board media can attract students' interest in continuing to learn, facilitate their understanding of multiplication concepts, and increase their

activeness and motivation in learning. Thus, the developed multiplication board was considered feasible and effective as a mathematics learning medium for third-grade students because it was able to create a more engaging, interactive, and meaningful learning process that supports students' learning outcomes.

### *Media Effectiveness Analysis*

The effectiveness analysis of the multiplication board media was conducted to determine the extent to which the use of the media influenced students' learning achievement. The analysis was carried out systematically through several stages, including descriptive analysis of pretest and posttest scores, prerequisite testing using the normality test, hypothesis testing using the Wilcoxon Signed Rank Test, and N-Gain calculation to evaluate the improvement in learning outcomes.

### Description of Pretest and Posttest Results

Before conducting further analysis, the learning outcome data of 30 students were processed descriptively to provide an overview of their initial abilities and final abilities after using the learning media. This descriptive analysis included information regarding the minimum score, maximum score, and mean score of each test.

**Table 5. Summary of Descriptive Analysis Results**

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| N-Gain Score | 30 | .49 | 1.00 | .6872 | .17230 |
| N-Gain Percent | 30 | 49.06 | 100.00 | 68.7151 | 17.23035 |

*Source: processed results of SPSS version 29*

Based on the N-Gain analysis in Table 5, the average score (mean) obtained was 0.6872 or 68.72% from 30 respondents. The N-Gain score had a minimum value of 0.49 and a maximum value of 1.00, with a standard deviation of 0.17230. According to Rahmawati et al. (2024), an N-Gain value of 0.6872 is categorized as moderate, while the N-Gain percentage of 68.72% indicates that the use of multiplication board media is considered sufficiently effective in improving mathematics learning outcomes of third-grade students. In other words, the developed multiplication board media successfully improved students' learning outcomes after being implemented in learning activities.

### Prerequisite Test

Before conducting hypothesis testing, this study first performed prerequisite analysis on the obtained data. The prerequisite test aimed to determine the appropriate analytical method based on the characteristics of the

data. If the data did not meet parametric assumptions, the analysis was continued using a non-parametric test. Furthermore, hypothesis testing was conducted to determine the effectiveness of using multiplication board media in third-grade mathematics learning.

## Normality Test

The normality test was conducted to determine whether the distribution of pretest and posttest data was normal. This test used the Shapiro-Wilk test with the assistance of SPSS software, providing a basis for determining the appropriate statistical test method.

**Table 6. Normality Test Results of Pretest and Posttest Data**

| Data | Statistic | df | Sig. |
|---|---|---|---|
| Pretest | .129 | 30 | .058 |
| Posttest | .212 | 30 | .001 |

*Source: Processed data from SPSS version 29*

Based on the Shapiro-Wilk normality test results in Table 6, the pretest significance value was 0.001 and the posttest significance value was 0.058. The pretest significance value below 0.05 indicates that the pretest data were not normally distributed, while the posttest significance value above 0.05 indicates that the posttest data were normally distributed.

## Hypothesis Testing

Hypothesis testing was conducted to determine differences in students' learning outcomes before and after using multiplication board media. Data analysis was performed using the Wilcoxon Signed Ranks Test.

**Table 7. Non-Parametric Test Results**

| Ranks | N | Mean Rank | Sum of Ranks |
|---|---|---|---|
| Negative Ranks | 0 | 0.00 | 0.00 |
| Positive Ranks | 30 | 15.50 | 465.00 |
| Ties | 0 | - | - |

*Source: Processed data from SPSS version 29*

Based on the Table 7, there were 30 positive ranks, 0 negative ranks, and 0 ties. The results indicate that all students obtained better scores on the posttest compared to the pretest. Therefore, the multiplication board media improved third-grade students' mathematics learning outcomes.

**Table 8. Summary of Wilcoxon Signed Ranks Test Results**

| Test Statistic | Value |
|---|---|
| Z | -4.785 |
| Asymp. Sig. (2-tailed) | <0.001 |

*Source: Processed data from SPSS version 29*

Based on the hypothesis testing results in Table 8 using the Wilcoxon Signed Rank Test, the obtained Z value was -4.785 with an Asymp. Sig. (2-tailed) value of <0.001. The significance value was smaller than the significance level of 0.05, indicating that $H_0$ was rejected and $H_1$ was accepted. This result demonstrates that there was a significant difference between students' pretest and posttest results after using the multiplication board media. Therefore, it can be concluded that the developed multiplication board media was effective in improving third-grade students' mathematics learning outcomes and was feasible to be used in mathematics learning processes.

## Discussion

The evaluation stage demonstrated that the developed multiplication board media effectively improved third-grade students' mathematics learning outcomes. The effectiveness analysis through pretest and posttest comparisons showed an average N-Gain score of 0.6872, equivalent to 68.72%, which was categorized as moderate effectiveness. This finding indicates that the developed media successfully supported students in understanding multiplication concepts through concrete and visual representations. The effectiveness of this product is supported by previous studies emphasizing that manipulative and visualization-based learning approaches can facilitate students' conceptual development by bridging abstract mathematical ideas with meaningful experiences (Azzumar & Juandi, 2023; Schoenherr et al., 2024). Therefore, the multiplication board media contributes as an alternative instructional tool that enables teachers to implement more interactive mathematics learning while reducing students' dependence on memorization-based learning strategies.

The validation results confirmed that the multiplication board media met the criteria of a feasible instructional product. The material expert evaluation obtained a score of 95%, categorized as highly feasible, while the media expert evaluation achieved 85%, categorized as feasible. These findings indicate that the developed product has appropriate content accuracy, visual quality, and usability for elementary mathematics learning. Previous research has demonstrated that well-designed manipulative media can improve students' mathematical understanding because learners can directly interact with representations of mathematical concepts (Sikhwari & Feza, 2024; Matodzi & Nosis, 2025). The contribution of this study lies in providing a systematically

developed multiplication learning medium that integrates conceptual understanding, visual representation, and classroom practicality. Unlike conventional learning tools that mainly support calculation practice, this media emphasizes students' active exploration of multiplication concepts.

The students' responses toward the multiplication board media showed highly positive results, with response scores ranging from 80% to 90%, categorized as very good. This result indicates that the developed media was attractive, easy to use, and able to increase students' engagement during mathematics learning activities. The positive responses suggest that visual and concrete learning experiences can create a more enjoyable classroom environment and encourage students to participate actively. Previous studies have confirmed that interactive and visual learning media contribute to increasing students' motivation and achievement in mathematics by providing clearer representations of mathematical concepts (Sappaile et al., 2024; Setiawati et al., 2024). Therefore, this research contributes by demonstrating that a simple non-digital learning medium can still provide meaningful learning experiences and support student-centered mathematics instruction.

The effectiveness analysis using the Wilcoxon Signed Rank Test revealed a significant difference between students' pretest and posttest scores, with a significance value of <0.001. This result confirms that the multiplication board media had a significant effect on improving students' mathematics learning outcomes. The finding supports previous studies showing that concrete and visual instructional approaches positively influence students' conceptual understanding and mathematical achievement (Niranjan & Brijlall, 2024; Sinaga et al., 2023). The contribution of this study is not only limited to producing a validated learning product but also providing empirical evidence regarding the effectiveness of multiplication board media through statistical testing. Furthermore, the use of ADDIE-based development strengthens the research novelty because the product was developed through systematic analysis, design, validation, implementation, and evaluation processes.

The novelty of this research is reflected in the development of multiplication board media that combines concrete manipulatives, visual learning principles, and systematic instructional design within an ADDIE development framework. Previous studies have developed multiplication media; however, many studies focused primarily on improving arithmetic skills or implementing existing media without comprehensive product evaluation (Uswah & Siregar, 2024; Wardani et al., 2025). This study extends previous research by developing a structured learning product that is validated by experts, tested for student responses, and measured for effectiveness using statistical analysis. The product provides an innovative alternative for elementary

mathematics learning because it does not require digital facilities while still promoting active, meaningful, and contextual learning experiences. Thus, the developed multiplication board media represents a practical innovation for supporting mathematics instruction.

Overall, the findings indicate that the multiplication board media is a feasible, practical, and effective learning resource for improving students' understanding of multiplication concepts. The research contributes theoretically by strengthening evidence regarding the role of concrete and visual media in elementary mathematics education and contributes practically by providing teachers with an accessible instructional tool that can be implemented in classroom activities. The developed media also aligns with contemporary mathematics learning principles that emphasize active participation, meaningful experiences, and conceptual understanding. In future development, the effectiveness of the media can be improved through enhanced visual design, increased interactive features, and integration with active learning strategies. This research therefore provides a foundation for further innovation in developing elementary mathematics learning media that supports students' cognitive development and mathematical literacy.

## CONCLUSION

This study developed multiplication board media using the ADDIE model, revealing important insights that concrete and visual learning media can effectively support students in understanding abstract multiplication concepts. The main lesson obtained from this research is that well-designed manipulative media can transform mathematics learning from a memorization-oriented process into a more meaningful, interactive, and student-centered experience. The developed product demonstrated strong feasibility, with validation results of 95% from material experts and 85% from media experts, while student responses reached 80–90% in the very good category. Furthermore, the N-Gain score of 0.6872 and Wilcoxon test result (sig. <0.001) confirmed that the media contributed significantly to improving students' mathematics learning outcomes. The scientific contribution of this research lies in providing empirical evidence that systematically developed non-digital learning media can enhance conceptual understanding and support innovative elementary mathematics instruction. However, this study has limitations regarding the limited number of participants, implementation duration, and scope of testing. Future research is recommended to involve larger samples, longer implementation periods, and further development of interactive features and learning strategies to improve the effectiveness of multiplication board media.

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