



Development of Stick Model Manipulative Learning Media to Improve Addition and Subtraction Skills with Regrouping in Elementary School Students

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Abstract

This study aims to develop stick model manipulative learning media to enhance addition and subtraction skills among elementary school students using the ADDIE development model. The media was designed with acrylic material and tested with 30 grade III students and 2 teachers at SD Negeri 1 Kemenuh. The development process included needs analysis, design, physical construction, and validation by five experts. The implementation phase evaluated the media's effectiveness in teaching, assessed its practicality using teacher and student response questionnaires, and measured its effectiveness through addition and subtraction tests administered before and after using the media. The results indicate that the media is effective in improving addition and subtraction skills with regrouping, evidenced by an average pre-test score of 69.8 and a posttest score of 77.2 with a significance level of $\text{Sig.} < 0.05$. The media's practicality was rated as "Good," with average teacher and student response scores of 43 (86 percent) and 44,3 (88.6 percent), respectively. These findings suggest that the stick model manipulative media is well-received by both teachers and students and is effective in enhancing basic math learning, improving students' understanding and motivation.

Keywords: media development; stick model manipulatives; addition and subtraction skills

INTRODUCTION

Mathematics is a crucial component of the educational curriculum in Indonesia, integrated at all levels to equip students with the skills needed for critical thinking, reasoning, and logical analysis essential for navigating advancements in science and technology (Kemdikbud, 2022). The application of mathematics in education is highly relevant due to its significant impact on daily life (Mashuri, 2019; Retnodari et al., 2020). Mathematical concepts can be widely applied in scientific and technological development as well as in solving social, economic, and environmental problems (Sari & Hasanudin, 2023; Siregar & Dewi, 2022). Therefore, ensuring that students have a strong foundation in mathematics is essential.

Despite its applicability in daily life, mathematics often involves abstract concepts, including notions, facts, principles, operations, and mathematical relationships (Krisnadi, 2022; Nurcahyono & Novarina, 2020; Nurhayanti et al., 2021). This abstract nature can be a significant barrier for students in understanding and constructing mathematical concepts. This is particularly true for elementary school students, who are at the concrete operational stage of cognitive development (Agustyaningrum & Pradanti, 2022; Marinda, 2020). At this cognitive stage,

understanding abstract concepts is challenging, necessitating the use of teaching aids that translate these concepts into concrete or semi-concrete forms.

One element of mathematics that students often find challenging is numerical operations (Mandasari & Rosalina, 2021; Nengsih & Pujiastuti, 2021). A solid understanding of numerical operations is vital because of its relevance to everyday activities and as a foundation for more advanced mathematical concepts. This understanding aids students in various tasks such as counting money, managing personal finances, measuring ingredients, and dividing items equally (Sari & Hasanudin, 2023; Valentina & Wulandari, 2022). However, many students struggle with understanding numerical operations, particularly addition and subtraction with regrouping, due to their abstract nature (Mandasari & Rosalina, 2021; Nengsih & Pujiastuti, 2021). Well-designed instructional media can make these concepts more concrete, helping students overcome difficulties and build a solid mathematical foundation.

Research indicates that students frequently encounter difficulties with addition and subtraction with regrouping, such as misunderstanding place value, confusion when borrowing in subtraction with tens valued at 0, and trouble distinguishing between problems requiring addition or subtraction (Napfiah & Zahro, 2022; Rohani et al., 2021; Sidik et al., 2021). Many students also struggle to place numbers correctly according to their place value (Rosanti et al., 2022), and although they may follow procedures, they often do not grasp the underlying concepts (Mauhibah & Karso, 2020). These difficulties are often due to a focus on delivering content rather than reinforcing concepts, coupled with a lack of engaging media, which can lead to boredom and diminished understanding (Awalia et al., 2019; Pratama, 2019; Sidik et al., 2021; Witraguna & Wahyuni, 2021).

In line with these issues, observations and interviews with elementary school teachers in Gugus 2 Sukawati District reveal similar challenges. Teachers often struggle to instill the concepts of addition and subtraction, especially techniques involving carrying or borrowing. Instruction tends to be classical, with teachers explaining and demonstrating without utilizing educational media or teaching aids. Ideally, mathematics instruction at the elementary level should be presented in a concrete or semi-concrete manner since students are not yet capable of fully grasping abstract concepts (Agustyaningrum & Pradanti, 2022; Marinda, 2020). Moreover, available educational media in schools are often inadequate for teaching addition and subtraction with regrouping. Teachers should ideally use tangible everyday objects as teaching aids (Ummah, 2021; Winarbin, 2020).

To address these issues, there is a need to develop educational media that can assist students in understanding addition and subtraction with regrouping. Student-centered learning media enable active knowledge construction (Hasiru et al., 2021; Nurfadhillah, 2021; Riady, 2021). One solution is the development of manipulative media, which involves objects that students can handle and move to help understand abstract concepts (Ardina et al., 2019; Hikmah et al., 2020). The stick model manipulative media, which uses sticks to represent units, tens, and hundreds, is a relevant example for teaching addition and subtraction (Alwi & Wandini, 2023a). The stick model manipulative allows students to visualize the processes of addition and subtraction in a more concrete and visual manner, aiding their understanding of abstract concepts (Safitri et al., 2023).

This study aims to develop a valid, practical, and effective mathematical learning media using the stick model manipulative to improve students' ability to perform addition and subtraction with regrouping. The media employs units, tens, and hundreds sticks to concretely visualize mathematical operations. It is hoped that this media will engage and motivate students to actively build their knowledge. Additionally, the study aims to provide an alternative solution to the underutilization of media in elementary school mathematics education.

METHOD

This study employs a research and development approach using the ADDIE model. The subjects of the research are teachers and grade III students of SD Negeri 1 Kemenuh. The development process of the learning media involves five stages according to the ADDIE model. The first stage is *Analysis*, which includes analyzing the needs, curriculum, and student development to determine the requirements for the development of learning media. This analysis aims to identify the media needs that can help students understand vertical addition and subtraction operations. The second stage is *Design*, based on the results of the analysis. At this stage, the stick model manipulative learning media is designed according to the needs of the students, with the physical media to be made using acrylic material. Additionally, a draft of the user manual and Student Worksheet (LKPD) is also prepared.

The third stage is *Development*, which focuses on constructing the physical form of the stick model manipulative learning media, as well as preparing drafts of the user manual and LKPD. The developed media is then validated by five experts to ensure its validity in terms of media, content, and language. The fourth stage is *Implementation*, where the validated media is tested with 30 grade III students and 2 teachers. This field trial aims to measure the practicality and effectiveness of the media. The final stage is *Evaluation*, which aims to assess the practicality and effectiveness of the learning media. Practicality is measured using questionnaires from teachers and students, while effectiveness is assessed through tests on addition and subtraction skills.

The instruments used in this research include a validation questionnaire, teacher and student response questionnaires, and addition and subtraction tests. The validation questionnaire is used to measure the validity of the learning media, covering aspects of media, content, and language. The teacher and student response questionnaires are used to measure the practicality of the media, administered after the field trial. The addition and subtraction tests are used to assess the effectiveness of the media, with tests administered before (pre-test) and after (posttest) the field trial.

The collected data are analyzed using both quantitative and qualitative descriptive methods. Media validity is measured using the Content Validity Ratio (CVR); if $CVR > 0$, the media is considered valid; if $CVR = 0$, the media needs revision; and if $CVR < 0$, the media is considered invalid. Practicality is analyzed through the conversion of questionnaire scores, with the following categories:

Table 1. Convert Quantitative to Qualitative Data

Total Score	Category
$X > 48$	Excellent
$36 < X \leq 48$	Good
$24 < X \leq 36$	Enough

$$12 < X \leq 24$$

$$X \leq 12$$

Less
Very Lacking

Effectiveness is assessed by analyzing pre-test and posttest results using a paired t-test with SPSS; if the Sig. value < 0.05 , the media is considered to significantly improve students' addition and subtraction skills. Qualitative data, including interview results, observations of media use during learning, and expert assessments and suggestions, are analyzed descriptively. This qualitative analysis is based on input from the validation instruments completed by experts, recorded suggestions and feedback, and observations made during media use in learning. The results of this analysis serve as the basis for improving the developed learning media. Observations are conducted during the field trial to assess the implementation of learning using the developed media.

RESULT AND DISCUSSION

Result

This study was conducted following the ADDIE development model. In the Analysis phase, the researcher conducted interviews with teachers and observed mathematics lessons in grade III classrooms. This step was undertaken to analyze the needs, curriculum, and characteristics of grade III students to ensure that the developed learning media aligns with the conditions and learning needs of the students. The analysis revealed that the use of concrete media in teaching addition and subtraction is still limited. Additionally, the material presented by teachers remains abstract and is not connected to students' daily lives, making it difficult for students to grasp concepts, especially in addition and subtraction with regrouping. Furthermore, teachers do not yet have media to assist students in understanding these concepts. Based on the curriculum analysis, since the school uses the "Kurikulum Merdeka", the stick model manipulative learning media was developed according to the mathematics learning outcomes for Phase B.

In the Design phase, the stick model manipulative learning media was developed based on the findings from the Analysis phase. This process involved using the insights and results obtained during the Analysis phase to ensure that the media effectively addresses the identified educational needs and learning objectives. Based on these analysis results, the developed manipulative media focuses on teaching addition and subtraction with regrouping. The media was designed according to Realistic Mathematics Education (RME) theory, which emphasizes connecting mathematical content to students' real-world experiences. To enhance relatability and understanding, the learning materials integrate Balinese cultural elements that are closely connected to the students' everyday lives. By incorporating these familiar cultural references, the media aims to make mathematical concepts more engaging and meaningful, bridging the gap between abstract ideas and students' personal experiences.

The stick model manipulatives learning media developed in this study consist of several components: the manipulatives themselves, an instructional manual, and student worksheets. The manipulatives include a media board, unit sticks, tens sticks, and one-hundred sticks. The media board serves as the base for arranging and displaying the sticks. Unit sticks represent single units, tens sticks represent groups of ten units, and one-hundred sticks represent groups of one hundred units. This combination of materials is designed to facilitate hands-on learning and aid in the

visualization of mathematical concepts for students. The stick model manipulatives learning media can be seen in Figure 1.

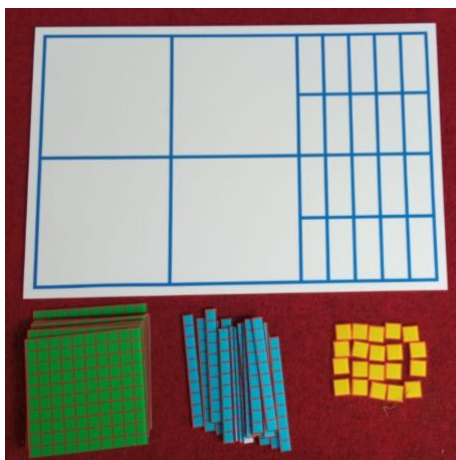


Figure 1. Stick model manipulatives

In this study, the term "stick" refers to models resembling ice cream sticks, which are made from acrylic material. These acrylic sticks are used as manipulatives in the development of mathematical learning media. The use of acrylic provides durability and a clear, consistent structure for the mathematical models, allowing for effective visualization and manipulation of mathematical concepts. In the developed media, the ten's stick is designed as a stick with a length of 10 cm, which consists of 10 small squares. This means that 1 ten's stick is equivalent to 10 unit sticks. Similarly, if 10 ten's sticks are combined, they will consist of 100 small squares, which means that 10 ten's sticks are equivalent to 1 hundred's stick. This system helps students understand the concepts of addition and subtraction through regrouping.

After the media design, instructional manual, and student worksheets were created in their physical form, the next step was validation by five experts. The validation focused on the media, content, and language aspects. Feedback from these experts was used to refine and enhance the media to ensure it meets educational standards and effectively supports student learning. The results of the validation can be seen in Table 2.

Table 2. Recapitulation of the Validity

Validity Aspects	CVR	Category
Media	1	Valid
Content	1	Valid
Language	1	Valid

The validation results for the stick model manipulative learning media, conducted by five experts and presented in Table 1, indicate a $CVR > 0$, signifying that the developed media is valid. However, the validators provided several suggestions to enhance the media, including the need for a video tutorial on how to use the media, ensuring that the content in the student worksheets aligns with the curriculum, and simplifying the language, considering the media is designed for elementary school students.

After the validation, the next step was to conduct a field trial with 30 grade III students. The field trial began with a pre-test to assess the students' initial abilities in performing addition and subtraction with regrouping. At the end of the field trial, the practicality of the media was evaluated by administering a questionnaire to 2 teachers and the 30 students. A posttest was also given at the end of the trial to measure any improvements in the students' understanding of these concepts. The responses of the teachers and students are presented as follows.

Table 3. Teacher and Student Responses to Stick Model Manipulative Learning Media

Responden	Average Score	%	Kriteria
Teacher	43	86 %	Good
Student	44,3	88,6 %	Good

The student response results showed a total score of 1329, which corresponds to 88.6% and falls within the "good" category. Similarly, the teacher responses yielded a total score of 86, equating to 86%, also categorized as "good." These results indicate that both students and teachers found the media to be practical for use in classroom learning. Therefore, the developed product has met the practicality aspect of a product.

To evaluate the effectiveness of the media, the pre-test and posttest results were analyzed using a paired t-test, following an assessment of data normality to ensure that the distribution met the test's requirements. The paired t-test revealed a statistically significant improvement in students' scores from the pre-test to the posttest ($Sig. < 0.05$), indicating that the media positively impacted their understanding of addition and subtraction with regrouping. The detailed statistical results are provided in Table 4. These findings confirm that the media was effective in enhancing students' performance and comprehension of the mathematical concepts.

Table 4. Paired T-test Result

Data	N	Mean	Std. Deviation	t	Sig.
Prettest	30	69,8	9,24	21,77	0.00
Posttest	30	77,2	9,24		

Discussion

The results of this study indicate that the stick model manipulative learning media developed has been deemed valid by experts, with a positive Content Validity Ratio ($CVR > 0$), indicating that the media meets the necessary validity standards for use in mathematics

instruction, particularly in enhancing students' skills in addition and subtraction. Additionally, the media has proven to be practical and effective. The practicality of the media is reflected in the positive responses from both teachers and students, with student response scores reaching 88.6% and teacher response scores at 86%, both categorized as "good." In terms of effectiveness, the paired t-test statistical analysis shows a significance value ($\text{sig.} < 0.05$), indicating a significant improvement in students' learning outcomes. The average pre-test score of students was 69.8, and after using the media, the average posttest score increased to 77.2, demonstrating that the media effectively improved students' skills in addition and subtraction.

During the field trials, it was observed that students showed great enthusiasm for the lessons. The use of manipulative learning media made students interested and motivated to learn (Anggoro, 2019; Anjani et al., 2021; Imamuddin, 2020). This media provided an enjoyable and engaging learning experience for the students. Specifically, the stick model manipulative in addition lessons effectively demonstrated the "carrying" process in a tangible way, making it easier for students to understand the process. The sticks in this media illustrated how regrouping occurs, both from units to tens and from tens to hundreds. This concrete representation of abstract concepts helped students to better understand mathematical concepts and enhanced their overall learning experience (Ardina et al., 2019; Hikmah et al., 2020).

In teaching subtraction, the stick model manipulative learning media effectively illustrates the process of "borrowing" in a tangible manner, making it easier for students to understand. This media proves particularly useful for students who initially struggle with subtracting three-digit numbers that involve zeros. By using this manipulative, students can clearly see the process of "borrowing" and regrouping from hundreds to tens and from tens to units. This concrete representation helps students overcome difficulties they might face with abstract subtraction concepts (Krisnadi, 2022), facilitating a better grasp of the borrowing process and improving their overall understanding. These findings align with Kwon & Capraro (2018), who found that using manipulatives can be an effective strategy in mathematics education. Similarly, research shows positive results in students' addition and subtraction abilities after implementing stick media in their learning (Alwi & Wandini, 2023b; Safitri et al., 2023).

One of the challenges encountered in teaching with the stick model manipulative learning media is that teachers need to ensure that students have a solid understanding of place value in numbers. Understanding place value is crucial as it forms the foundation for students to comprehend numerical operations, including addition and subtraction (Mulyasari & Fahrozy, 2023; Rittle-Johnson & Siegler, 2022). Without a strong grasp of place value, students may struggle to use this manipulative effectively, as they might not accurately identify how the regrouping process occurs in the context of larger numbers. Therefore, before employing this media, teachers should emphasize instruction on place value to ensure that students have a solid foundation for understanding numerical operations.

The findings from this study suggest that the stick model manipulative learning media can be a valuable tool in mathematics education, especially for teaching addition and subtraction with regrouping. Teachers can integrate this media into their lesson plans to make abstract concepts more concrete and accessible to students. By using this media, educators can help students build a stronger foundational understanding of mathematical operations, which is crucial for their continued success in mathematics.

While the stick model manipulative learning media is effective for teaching addition and subtraction with regrouping, it has certain limitations. The media is primarily designed for operations involving three-digit numbers, which limits its applicability to other types of mathematical operations or more complex number sets. Furthermore, since the media is physical, a substantial quantity is required when used in larger classrooms, which could create challenges in terms of making, distributing, and storing the media. These limitations suggest that while the media is a valuable tool, its use may need to be supplemented or adapted depending on the specific needs and scale of the classroom.

CONCLUSIONS

Conclusions

The study concludes that the stick model manipulative learning media developed is a valid, practical, and effective tool for enhancing students' abilities in addition and subtraction with regrouping. The media has been validated by experts, ensuring its appropriateness and reliability for educational use. It is also practical, as evidenced by positive responses from both teachers and students, indicating ease of use and high engagement. Moreover, the effectiveness of the media is demonstrated by the significant improvement in students' learning outcomes, as reflected in the increase in their test scores. Overall, the stick model manipulative learning media can be effectively applied in teaching to help students understand the fundamental concepts of addition and subtraction with regrouping.

Recommendations

Future research should consider conducting trials on a larger population through experimental studies to further examine the significance of the stick model manipulative's impact. Expanding the sample size and including diverse student groups would provide a more comprehensive understanding of the media's effectiveness in enhancing students' mathematical abilities, particularly in addition and subtraction with regrouping.

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