



Development of Smart Ladder Media for Mathematics Material on Length Units for Grade II Elementary Schools

Muhammad Munir¹

¹Muhammadiyah Islamic Education College, Kediri, East Java

*Corresponding Author: masmunnn97@gmail.com

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Abstract:

Mathematics learning at the elementary level often presents difficulties, especially when introducing abstract concepts such as units of length. To overcome these challenges, engaging and concrete instructional media are required to support students' understanding. This study aimed to develop Smart Ladder learning media for length units by applying the ADDIE development model, which consists of Analysis, Design, Development, Implementation, and Evaluation. The research involved media experts, material experts, instructional experts, teachers, and students as respondents. Data were collected through interviews, questionnaires, and pre- and post-test evaluations. Validation results showed scores of 78.12 (good) from media experts, 88.75 (very good) from material experts, and 78.94 (good) from instructional experts. Teacher responses reached 97.36 (very good), while student trials averaged 83.99 (very good), improving from 78.07 in the first trial to 89.92 in the second. Student achievement also increased from an average pre-test score of 54.58 to a post-test score of 84.58. These findings confirm the feasibility and effectiveness of Smart Ladder media, highlighting its novelty in transforming abstract mathematics into tangible, interactive experiences. The study contributes to the field of educational media development, suggesting that similar models can be adapted for other mathematical concepts to enhance meaningful learning at the elementary level.

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INTRODUCTION

Education is universally recognized as the foundation of a nation's progress. A strong education system not only prepares individuals with knowledge and skills but also builds character, morality, and critical thinking capacity needed to compete in the global era. In the Indonesian context, the National Education Law No. 20 of 2003 affirms that education aims to develop learners' potential holistically, including spiritual, intellectual, and social competencies (Foster et al., 2022; Nurhikmah, F. & Kurniati, 2021; Putri, 2023; Siregar, S. & Widodo, 2022). However, these national expectations require practical and innovative teaching approaches in classrooms, especially at the elementary school level. Without relevant and engaging learning experiences, students struggle to internalize abstract knowledge and fail to apply it meaningfully in daily life (Rahmadani, 2021; Muslimin, 2022). Therefore, developing effective learning media is crucial, as it plays a

vital role in shaping students' understanding, motivation, and participation, which ultimately impacts the broader goal of preparing a competitive future generation.

Despite the central role of education, learning mathematics in elementary schools remains a significant challenge. Mathematics, with its abstract and hierarchical nature, is often perceived as a challenging subject by students (Mardiyana, 2022; Fajaroh, 2021). Many learners experience anxiety or even fear when faced with mathematical concepts, which reduces their motivation to learn. The root of this issue lies not only in the complexity of the material but also in the teaching methods and the lack of engaging instructional media. Particularly, the concept of units of length is frequently misunderstood, as students are unable to visualize the conversion process from one unit to another (Hartini, 2022; Nur, 2021). Such difficulties hinder the achievement of learning objectives and weaken students' problem-solving skills. This indicates that without concrete and innovative learning media, mathematics education risks becoming an obstacle rather than a means of empowerment for elementary school children.

Observations at KaranggaYam 2nd State Elementary School clearly highlight this issue. In the second grade, students were found to face significant difficulties in understanding the material on units of length. Many were unable to perform conversions correctly, confusing multiplication and division in their calculations. Teachers, meanwhile, relied mainly on verbal explanations and written exercises, without developing media tailored to students' cognitive stages. This gap in instructional strategy caused limited comprehension and poor learning outcomes. Furthermore, the absence of engaging media reduced students' motivation, leading to boredom and passivity in class. Teachers acknowledged the challenge of making abstract content concrete, especially for younger learners who are still at the concrete operational stage, as outlined in Piaget's theory. Thus, there is an urgent need for teaching media that is simple, interactive, and appealing to support teachers in overcoming these learning barriers.

Previous research has widely acknowledged the importance of media in mathematics learning. Studies by Asmawati (2021), Setyawan (2021), and Novianti (2021) demonstrated that three-dimensional media provide concrete representations that stimulate student engagement and help avoid verbalism. Similarly, Suwondo (2021), Prahmana (2021), and Pratiwi (2021) found that mathematics learning using concrete media encouraged critical and creative reasoning. Research by Ramadan (2020) and Riana (2021) has emphasized that elementary students in the concrete operational stage require learning aids, such as manipulatives, to understand abstract concepts. However, most of these studies were either limited to specific topics or explored general media effectiveness without a deep focus on length unit conversions (Carey, 2021; Gunansyah, 2020; Kurniawan, 2021). In addition, while three-dimensional models have been introduced, their systematic development and integration into curriculum objectives remain underexplored, creating a gap that needs to be addressed through more targeted and innovative designs.

Another line of research has suggested integrating playful, game-based media to enhance student motivation and learning outcomes. For example, Romlah (2025) and Hayati (2023) argued that well-designed media can arouse curiosity, foster active participation, and positively influence students' psychological readiness to learn. Nevertheless, these studies often lacked practical application in lower-grade mathematics, particularly in the domain of unit conversions, where students consistently face learning barriers. Moreover, existing media often prioritized theoretical appeal over

user-friendliness and did not incorporate features that align with young learners' cognitive and affective needs (Jumadi, 2023; Rohimah, 2023). This indicates a gap in existing scholarship: while the role of media is acknowledged, the design of specific, context-sensitive, and engaging tools remains insufficiently developed. Therefore, addressing this limitation is crucial for making meaningful contributions to mathematics education, particularly for early-grade learners who struggle with foundational concepts.

Responding to this gap, the development of Smart Ladder Media offers a novel approach to teaching units of length. Unlike traditional two-dimensional teaching aids, this media employs a three-dimensional ladder model that visualizes the unit conversion process in a concrete and interactive manner. Each step represents multiplication or division by ten, allowing students to physically and visually internalize the concept. The Smart Ladder is not only designed with mathematical accuracy but also with visual attractiveness, using colors and illustrations that capture students' interest (Azzahra, 2022; Lestari, 2021; Rachmadyanti, 2020). This state-of-the-art innovation combines the pedagogical principle of concreteness with playful engagement, making abstract concepts more accessible and engaging. By situating the design within students' cognitive developmental stage, this media provides a fresh contribution to the field, filling the void left by previous media designs that were either too abstract or lacked contextual relevance for elementary learners.

The central research problem is: how can Smart Ladder Media be developed to enhance the learning of units of length for second-grade elementary students, and how feasible is its application? The argument of this study is that concrete, three-dimensional, and visually engaging media can significantly reduce learning difficulties, increase motivation, and improve comprehension in mathematics. The originality of this contribution lies in its combination of physical manipulatives with the ladder metaphor, a model that has not been systematically explored in prior studies. By addressing both pedagogical and psychological aspects, the Smart Ladder surpasses existing approaches, providing not only a teaching tool but also a strategic innovation that aligns with curriculum demands and students' developmental needs. Thus, this study contributes both theoretically to the body of literature on instructional media and practically to classroom practice, providing teachers with a concrete solution to a longstanding challenge.

Based on the background and gaps identified, the objective of this research is twofold. First, to design and develop Smart Ladder Media as an innovative teaching aid for the mathematics topic of units of length in second-grade elementary schools. Second, to evaluate its feasibility and effectiveness in supporting learning processes, particularly in improving students' understanding and engagement. By achieving these objectives, this research aims to provide evidence-based recommendations for integrating concrete, three-dimensional media into early mathematics education. Ultimately, this development is expected to contribute to enhancing student outcomes, strengthening teachers' instructional strategies, and advancing the broader goal of educational quality improvement in Indonesia.

RESEARCH METHOD

The research method used by researchers in developing the Smart Math Ladder media is Research and Development (R&D) (Awan Asri et al., 2021). Research and Development (R&D) is the exploratory stage that involves researching, developing, and testing a product in a specific field of application. The resulting product is expected to be helpful for the wider community,

particularly in education. This study uses the ADDIE development model. This model was chosen based on the consideration that it is systematically developed, structured, and grounded in the theoretical foundation of learning design, aiming to address learning problems related to learning resources that are tailored to the needs and characteristics of students, thereby optimizing the learning process. The ADDIE development model consists of five stages: analysis, design, development, implementation, and evaluation.

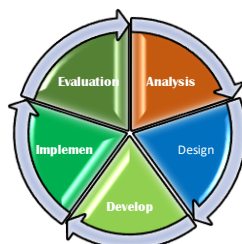


Figure 1. R&D Research Methods

The first step in designing learning media and technology using the ADDIE model is analyzing the learning situation and student characteristics, including general characteristics such as age, education level, prior knowledge, and learning styles. This needs analysis was conducted through interviews with second-grade students and teachers. The second stage is design. After conducting the analysis, the next step is to plan the creation of smart ladder learning media for length units. In the planning stage, the researcher took several steps to design the material, the smart ladder learning media, and the design for using the smart ladder learning media for length units. A panel of experts then validated the resulting design. A media expert carried out the design validation. A material expert then validated the material selection. A learning expert validated the learning flow. In this study, the developed learning media design was a smart ladder learning media for length units.

The third stage is development, which involves creating smart ladder learning media for units of length in accordance with the design steps outlined. In addition, researchers validated the smart ladder learning media for units of length. At this stage, product trials were also conducted with experts, and improvements or revisions were made based on their assessments and reviews. Experts who validate the smart ladder learning media for units of length function determine the quality of the learning media in terms of design, appearance, and suitability for use in the learning process. In addition, experts also serve as quality control for the smart ladder learning media for units of length before they are tested in terms of content or accuracy of the material to be delivered. This aims to provide a basis for determining the feasibility of smart ladder learning media for units of length, which is developed to make the learning media product a viable product.

The fourth stage is Implementation, where a product trial will be conducted for grade II at SD Negeri 2 Karanggayam. The trial subjects in this study are grade II students. The purpose of this trial is to obtain student responses to the smart ladder learning media for length units. This implementation will be carried out through product trials with students, in addition to providing a questionnaire sheet for students to record their responses to the smart ladder learning media for length units. The fifth stage, Evaluation, evaluates the entire product development process, including product trials. This stage analyzes the data obtained from the product trials. The goal is to analyze the data to identify necessary revisions and to determine whether the developed product is practical and feasible for use.

After knowing the development steps, the next step is the product trial stage. Several key aspects of the product trial stage must be understood, including trial design, trial subjects, and data types. The trial design stage in this study is presented in several steps as follows. Creating a product design or initial product; carrying out product validation with media and material experts; carrying out product validation with educational practitioners/teachers; revising the initial product by considering input from media, material experts and educational practitioners; carrying

out product tests with students and distributing questionnaires to obtain data about the product developed from students; making revisions by considering the results of the questionnaire given to students; and the final results include the final development product.

The trial subjects in this study were 25 second-grade students at SD Negeri 2 Karanggayam. The data used in this development research consisted of two types: qualitative and quantitative. The quantitative data consisted of suggestions, input, criticism, and comments on the developed media. The quantitative data consisted of scores from distributed questionnaires. The scoring guidelines are as follows:

Table 1. Scoring Guidelines

Information	Score
Very Worthy (SL)	4
Worthy (L)	3
Fairly Decent (CL)	2
Not Eligible (TL)	1

Data collection instruments are the means by which data is collected. The data obtained will later be used as the results of the media assessment. Observation sheets are addressed to media experts, content experts, learning experts, classroom teachers, and student responses are addressed using assessment questionnaires. Data collection instruments include interviews and media assessment questionnaires. Data analysis techniques, including data collection methods obtained from the media expert feasibility test instrument, the material expert feasibility test, and the learning expert feasibility test, were used to analyze student responses. The scores obtained are then determined using the formula according to Arikunto (2024):

$$X = \frac{\text{Total value obtained}}{\text{Maximum value amount}} \times 100$$

Information :
 X =Percentage of eligibility or quality of media

The method used to determine media eligibility applies a percentage formula, where the total score obtained is divided by the maximum possible score, then multiplied by 100. This calculation produces the value of X , representing the percentage of eligibility or media quality. Validator scores are then averaged using Arikunto's formula to ensure reliable assessment results. These are the results:

$$x \frac{\sum x}{N}$$

Information :
 $\sum x$ = Total value
 X = Average
 N = Number of assessments

The formula used to analyze quantitative data is $X = \frac{\sum x}{N}$, where $\sum x$ represents the total score and N the number of assessments. The result, X , indicates the average score. This average is then converted into eligibility or feasibility criteria to interpret the quality of the media systematically.

Quantitative Score Range	Qualification
Score Between 81-100	Very good
Score Between 61-80	Good
Score Between 41-60	Enough
Score Between 21-40	Not good
Score Less Than 20	Very Poor

The assessment criteria are categorized into five levels: very good (81–100), good (61–80), enough (41–60), not good (21–40), and abysmal (<20). Referring to these categories, the Smart Ladder learning media is considered feasible if it achieves a score between 61 and 80, which falls within the 'Good' qualification, indicating an acceptable quality for classroom use.

RESULT AND DISCUSSION

Result

The development model used in this research is the ADDIE development model. The ADDIE development model has five stages: analysis, design, development, implementation, and evaluation. The following are the results of the development carried out by the researcher at each stage.

Analyze

Previously, researchers conducted a needs analysis for teachers and students. The results of the student needs analysis revealed a lack of understanding among students regarding mathematics lessons on units of length, despite teachers' explanations, due to the limited use and development of learning media. Students need learning media other than textbooks that can be used to study the learning material. The results of teacher needs are the use of media that can facilitate teachers when explaining learning materials. Next, analyze the learning materials that are equated with KI and KD of the school curriculum, and prepare the facilities and infrastructure that will be used to design the development of mathematics learning media.

Design

Researchers designed a learning product for units of length using colorful Styrofoam and origami paper to attract students' attention and focus on learning units of length and how to calculate them. The following is a clever ladder learning product design for units of length.



Figure 3. The Example of the Design

The smart ladder learning media design, developed using Styrofoam and origami paper, is designed to be as engaging as possible, encouraging students to participate in and utilize classroom learning. This media was created to meet the characteristics of students who tend to require concrete and engaging media.

Development

This media has been validated by media experts, content experts, and learning experts. The following are the assessment results from each validator:

Media Expert Validation

Media expert validation of the innovative ladder media for length units was conducted by one of the teachers at SD Negeri 2 Karanggayam, who has expertise in the field of learning technology. Based on the results of the media expert validation test on the smart ladder learning media for length units, the total score was 50, and the calculated value using the formula was 78.12, with the criteria of "Good". The media expert provided the formula for calculating the value.

$$X = \frac{\text{Total value obtained}}{\text{Maximum value amount}} \times 100$$
$$= \frac{50}{64} \times 100$$
$$= 78,12$$

The calculation of media expert validation results was obtained by dividing the total value (50) by the maximum possible value (64), then multiplying by 100, resulting in a percentage score of 78.12%. According to the assessment criteria, this score falls within the "Good" category, meaning the Smart Ladder media for length units is declared feasible to proceed to product testing. However, the assessment also indicated that some aspects still require improvement. Therefore, the media is considered appropriate with revisions, ensuring that the product becomes more effective and suitable for supporting mathematics learning in the classroom.

Subject Matter Expert Validation

Validation by material experts on the innovative ladder media for length units was conducted by Teacher Karanggayam 2 Public Elementary School, which has demonstrated competency in elementary school mathematics learning. Based on the validation results of the material expert on the smart ladder learning media for length units, the material obtained a score of 71. The resulting value obtained was 88.75 with the criteria of "Very Good". The following is the formula used by the material expert to calculate the value.

$$X = \frac{\text{Total value obtained}}{\text{Maximum value amount}} \times 100$$
$$= \frac{71}{80} \times 100$$
$$= 88,75$$

The validation conducted by material experts yielded a score of 88.75%, placing it in the Very Good category. This percentage indicates that the Smart Ladder learning media already meet high standards in terms of content accuracy, clarity of concepts, and

relevance to the mathematics curriculum, particularly in the area of length units. The high score shows that the media is feasible for product testing and can effectively support student understanding. However, experts still recommend several minor revisions, particularly in refining instructions, adjusting examples, and enhancing the visual presentation of the material, so that the media can function optimally in the classroom.

Learning Expert Validation

Validation of learning experts is carried out by Teacher SD Negeri 2 Karanggayam, who has competency in elementary school mathematics, and obtained a score of 60 from the learning expert validation test for the innovative ladder media on length units. This score then resulted in a score of 78.94, categorized as "Good." The following outlines the method for calculating the value of the learning expert validation test results.

$$\begin{aligned}
 X &= \frac{\text{Total value obtained}}{\text{Maximum value amount}} \times 100 \\
 &= \frac{60}{76} \times 100 \\
 &= 78,94
 \end{aligned}$$

The results of the validation by material experts showed a score of 78.94%, which is categorized as Good. This percentage indicates that the Smart Ladder learning media for length units are generally appropriate and feasible for classroom application. The assessment demonstrates that the media can help clarify abstract concepts and improve student understanding. However, experts emphasized the importance of making revisions before broader product testing, particularly in adjusting examples, refining visual design, and ensuring consistency with curriculum standards. With these improvements, the media is expected to become more effective and engaging for elementary school students.

Table 3. Results of Expert Assessment of Media

No	Assessor	Mark	Category
1	Media Expert	68.12	Good
2	Subject Matter Expert	88.75	S Good
3	Pmbjrn Expert	78.94	Good
	Amount	245.81	S Good
	Average	81.93	S Good

The results of expert assessments indicate that the Smart Ladder learning media received scores of 68.12% from the media expert, categorized as "Good"; 88.75% from the subject matter expert, categorized as "Very Good"; and 78.94% from the learning expert, also categorized as "Good". The total score reached 245.81 with an overall average of 81.93%, which falls into the Very Good category. These findings suggest that the media have strong feasibility for use in learning, although several aspects still require revision to optimize clarity, functionality, and alignment with student learning needs.

Implementation

Next, the validated media stage was applied to students. The implementation of the first and second trials of the media was carried out with grade II students, comprising a total of 25 students, by distributing questionnaires to obtain student responses regarding the use of the innovative ladder mathematics media on the length unit material. Furthermore, the researcher also examined the teacher's response scores regarding the Smart Ladder learning media for the length unit material implemented in Grade II learning. The following table shows the results of the responses of grade II students at SDN 2 Karanggayam:

Obtaining student response questionnaires

The results of the student response questionnaires provide an overview of how learners perceived the Smart Ladder learning media during its implementation. In the first trial, the media received a score of 78.07, categorized as “good,” indicating that students began to respond positively to its use. In the second trial, the score increased significantly to 89.92, placing it in the “outstanding” category. With a total score of 167.99 and an average of 83.99, the overall student responses fall into the “outstanding” category, confirming that the Smart Ladder media is well-received and effectively supports learning.

Table 4. Student Response Questionnaire Results

No	Assessor	Mark	Category
1	Trial I	78.07	Good
2	Trial II	89.92	S Good
	Amount	167.99	S Good
	Average	83.99	S Good

The average score obtained by second-grade students during the first trial was 78.07, which falls within the good category. In the second trial, the average score obtained by students was 89.92, which falls within the excellent category. Based on the trial, the smart ladder learning media product is suitable for use in the learning process. The process for calculating the score is as follows:

$$\begin{aligned}\sum x &= 78.07 + 89.92 \\ X &= \frac{\sum x}{n} \\ &= \frac{167.99}{2} \\ &= 83.99\end{aligned}$$

The results of Trials I and II produced an average score of 83.99%, which falls into the Very Good category. This outcome indicates that the Smart Ladder learning media is highly feasible and effective for use in the mathematics learning process, particularly on length units. The high average score reflects positive improvements between the two trials, showing that revisions made after the first trial had a significant impact on enhancing the quality and usability of the media. Therefore, the product is considered ready to be implemented in classroom learning with only minimal adjustments if needed.

Results: *Pretest and Posttest*

The study's results showed a difference in scores between the pretest and posttest after using Smart Ladder media on the unit of length material. Based on the data in Table 5, the average pretest score for students was 54.58, while the average posttest

score increased to 64.58. This increase suggests that the use of the developed learning media had a positive influence on student understanding, although the level of improvement still requires further analysis.

Table 5. Results: *Pretest and Posttest*

No	Evaluation	Total Value	Average
1	Pretest	1310	54.58
2	Posttest	2030	64.58

The 10-point increase in average scores from pretest to posttest indicates that Smart Ladder is effective in helping students grasp previously complex concepts of units of length. This aligns with Piaget's theory, which suggests that students in the concrete operational stage require tangible media to facilitate understanding. This media enhances the learning process, making it more engaging and easier to follow, which results in improved learning outcomes. However, further development is needed to achieve optimal results.

Teacher Response Results

The teacher's trial results showed a score of 97.36%, which falls into the Excellent category. This score indicates that the Smart Ladder learning media is considered highly feasible and appropriate for use in mathematics learning, particularly for units of length. Teacher assessment is an important indicator because it reflects the media's suitability to practical classroom needs.

$$\begin{aligned}
 X &= \frac{\text{Number of marks obtained}}{\text{Maximum value amount}} \times 100 \\
 &= \frac{74}{76} \times 100 \\
 &= 97,36
 \end{aligned}$$

The teacher's score of 97.36% indicates a very high level of appropriateness for using Smart Ladder in learning. This figure indicates that almost all assessment aspects were met, from the appropriateness of the material to the clarity of presentation and ease of implementation in the classroom. With a score approaching the maximum, Smart Ladder is considered not only effective in helping students understand the concept of units of length but also significantly supports teachers in creating interactive, engaging learning that aligns with curriculum objectives.

Evaluation

Evaluation is the final stage of this learning media development model. If deficiencies are found, revisions must be made to improve the learning experience. The Smart Ladder learning media for units of length is a product developed with student characteristics in mind to foster interest and promote a firm understanding of the topic. The media must be contextualized to maximize learning activities and achieve optimal learning objectives.

Expert teachers validated this media to determine its suitability for use with students. The assessment results obtained by media experts, material experts, and learning experts gave scores of 78.12 (good) for media experts, 88.75 (very good) for material experts, and 78.94 (very good) for learning experts, respectively. This media is

considered highly suitable for use due to its attractive and simple appearance, which makes students feel happy while learning.

The validator suggested revising the media before implementation, and then using it in mathematics lessons on units of length. Students were required to complete a questionnaire to gauge their response to the media, and a response rate of 83.99% was obtained, categorized as very appropriate. This issue aligns with research conducted by Development Results, specifically Smart Ladder Media, on mathematics learning for Grade 3 students in elementary school. Based on the research results, media experts obtained a score of 3.71 (very valid). Display experts obtained a score of 3.64 (very valid). Judging from the average score of the mathematics learning media assessment, the overall score was 3.67, with the category (very valid). Based on the results of this study, it can be concluded that the innovative ladder media for mathematics learning is highly valid and can be effectively utilized in mathematics education, particularly in grade III of Elementary School.

This research is also in line with research conducted, which shows that the assessment of the feasibility of the Smart Ladder media by media experts obtained a percentage value of 89% with the criteria of very feasible, and the assessment by the second media expert obtained a percentage value of 94% with the category of very feasible. This research is also in line with research conducted. The pretest and posttest results showed an increase in students' understanding of measurement units. The average student learning outcome increased from 59 to 83. Learning using the Smart Ladder method received a very positive response from participants and provided a new learning experience for students in the classroom.

Data analysis

Results regarding the relationship between AI as a virtual tutor and student self-efficacy in learning show various perceptions. Most of the students involved in this research reported that using AI as a virtual tutor had a positive impact on their confidence in completing academic assignments. However, students face challenges adapting to this technology, primarily related to human-machine interactions that sometimes feel stiff. The implication of the relationship between AI as a virtual tutor and student self-efficacy in learning is that AI can potentially increase student self-confidence in facing academic challenges.

Qualitative Data Analysis

The first is the analysis of media expert data. Comments and suggestions provided by media experts include enlarging the letters and numbers, adding engaging animations relevant to the material, fine-tuning color selection, and completing the development of the Smart Ladder learning media for units of length. Second, analysis of data from subject matter experts. This analysis aims to gather suggestions and comments regarding the material and media being developed. Comments and suggestions provided by subject matter experts include presenting the material in order of difficulty, from low to medium to complex, enlarging the font and number sizes in the draft, and providing a sufficient number of questions.

Third, analysis of learning expert data. This analysis is necessary to ensure a match between the media and the learning process related to the media being developed. Comments and suggestions include revising indicators as suggested, adjusting achievement characteristics to suit the learning process, discussing the apperception section in detail, and adapting the material to student characteristics. Fourth, data from

teacher and student responses. Comments and suggestions provided by teachers included that the media used was good, engaging, and suitable for learning number symbols and counting. Student responses included that the media was good, they enjoyed learning with the smart ladder, and the pictures were cute.

Quantitative Data Analysis

Quantitative data analysis in this study was conducted to evaluate the feasibility and quality of the Smart Ladder learning media through a systematic assessment by various assessors. The assessment involved media experts, subject matter experts, development experts, teachers, and student trial results. Each provided scores based on specific criteria covering aspects of content accuracy, media design, practicality, and usability in classroom settings. The calculation of values was processed using established formulas, ensuring objectivity and accuracy in the results. By compiling these assessments, the analysis provides a comprehensive overview of how well the media meets educational standards. The detailed results of each assessor's evaluation are presented in the following table.

Table 6- Quantitative Data Analysis

No	Assessor	Mark	Category
1	Media Expert	78.12	Good
2	Subject Matter Expert	88.75	Very good
3	Development Expert	78.94	Very good
4	Teacher Response	97.36	Very good
5	Trial I	78.07	Good
6	Trial 2	89.92	Very good

The quantitative data analysis shows varied yet consistently positive assessments of the Smart Ladder learning media. The media expert gave a score of 78.12% in the Good category, while the subject matter expert provided a higher evaluation of 88.75%, categorized as Very Good. The development expert assessed the product at 78.94%, also classified as Very Good. Meanwhile, teacher responses reached the highest score of 97.36%, indicating Very Good quality and strong practicality for classroom use. In product trials, Trial I scored 78.07% (Good), and Trial II increased significantly to 89.92% (Very Good). These results indicate that Smart Ladder media is feasible and practical, with clear improvements after revisions, making it highly suitable for mathematics learning.

Discussion

The development process for the smart ladder learning media is carried out in a step-by-step manner, following specific development steps to produce media that is suitable for use. These development steps are based on the ADDIE model of development. The following are the stages carried out: 1) Analysis, 2) Design, 3) Development, 4) Implementation, and Evaluation.

After these stages are completed, the next step is to calculate the overall results of the media assessment. Based on this media validation, the media expert obtained a score of 78.12 in the "good" category, the material expert's assessment was 88.75 in the "excellent" category, and the learning expert's score was 78.94 in the "good" category.

The assessment, based on the results of Trial I and Trial II, obtained an average student response questionnaire score of 83.99, which fell in the “outstanding” category. The teacher’s assessment, based on the questionnaire given, obtained a score of 97.36, which falls in the “excellent” category. The pretest results showed an average score of 54.58, and the posttest results obtained an average score of 84.58; the change in the average score showed an increase after using the media during learning.

Based on these results, it can be said that the developed media is suitable for use and makes it easier for students to understand the material in learning activities on units of length for grade II Elementary School. This is in line with the opinion expressed by Fawaid et al. (2025), Herlina (2024), and Heru (2024) that good media to use has the characteristics of media content that is interesting for students, appropriate content, media that is adapted to the characteristics of students, and in accordance with the objectives or material being taught (Abdullah, 2024; Umar & Khaer, 2024; Zamroni et al., 2025). These guidelines were used in the development of smart ladder learning media, where innovative ladder media is designed according to these characteristics. The final product of the smart ladder learning media for length units consists of several parts (Jali, 2025; Khoiroh et al., 2024; Safitri, 2025). The following is a presentation of the final product for each part of the smart ladder learning media, specifically for length units.

The smart ladder media board consists of seven steps, each marked with the symbols Km, Hm, Dam, M, Dm, Cm, and Mm. The right and left sides of the ladder have dividers to place the numbers of the questions that will be given to students.



Figure 4.- Smart Ladder Media

These colored sticks are part of the smart ladder media for units of length, used for calculations and measurement. There are two types of colored sticks: blue and yellow. The blue sticks have the numbers 1-9 on them, while the yellow ones only have zero on them.



Figure 4. Smart Ladder Media Number Stick

Figures 3 and 4 illustrate concrete examples of smart ladder media designed to help students understand units of length more visually and interactively. Theoretically, the findings support the constructivist learning perspective, which posits that knowledge is constructed through active interaction with concrete tools. The Smart Ladder, with its seven steps representing units of length (km, Hm, Dam, m, dm, Cm, Mm), operationalizes this concept by offering a tangible medium for abstract numerical conversion. Unlike

purely verbal explanations that often confuse students, this tool embodies the principles of meaningful learning described by Hina (2024), Sain (2025), and Baharun (2023), where new information is anchored to prior knowledge through concrete experiences. Therefore, the Smart Ladder strengthens the theoretical claim that learning media should align with cognitive development stages to maximize effectiveness.

Practically, the Smart Ladder media has significant implications for classroom practice. Teachers benefit from a tool that not only simplifies their explanation of mathematical material but also engages students actively through the use of number sticks and step-by-step conversions (Aziz, 2025; Qushwa, 2024; Munawwaroh, 2024). The teacher's evaluation score of 97.36 reflects high practicality, meaning the media is user-friendly and adaptable to real teaching contexts. Moreover, the increased student achievement from pretest to posttest demonstrates that the Smart Ladder does not merely entertain but also substantially improves learning outcomes (Nisa', 2024; Hasanah, 2024; Widiyasari, 2024). These findings suggest that schools should consider integrating such innovative media into regular mathematics instruction to reduce student anxiety toward the subject.

In conclusion, the development of Smart Ladder media confirms both theoretical and practical benefits in mathematics education. Its strong alignment with educational theories, Piaget's cognitive stages, and constructivist approaches proves its validity as a learning tool. At the same time, empirical results from trials and teacher evaluations demonstrate its practicality and effectiveness. Compared to previous studies, this research extends the contribution by specifically addressing length units in grade II elementary schools through a media design that is both simple and powerful. Thus, Smart Ladder represents an innovative and feasible solution to bridge abstract concepts with concrete learning, providing both researchers and practitioners with valuable insights for future educational development.

CONCLUSION

The findings of this research highlight that the Smart Ladder media, developed through the ADDIE model (Analysis, Design, Development, Implementation, Evaluation), is both feasible and effective in enhancing students' understanding of length units in mathematics at the elementary level. Validation results demonstrated strong feasibility, with scores of 78.12 from media experts (good), 88.75 from subject matter experts (excellent), and 78.94 from instructional experts (excellent). Classroom implementation further reinforced these results, as students' responses averaged 83.99 (very good), accompanied by a notable improvement in learning outcomes from a pretest average of 54.58 to a posttest average of 84.58. The teacher's evaluation also supported the product's practicality, with a score of 97.36 (very good). The key insight gained is that simple, visually based media can significantly bridge the gap in students' conceptual understanding of abstract mathematical ideas.

The primary contribution of this study lies in extending the literature on instructional media development by confirming the effectiveness of ADDIE-based design for elementary mathematics learning. Empirically, it demonstrates how concrete, interactive tools can increase student engagement and comprehension, which is valuable for both theory and practice. Nevertheless, the study has limitations, as it was conducted only in one school (SDN 2 Karanggayam) and focused exclusively on the topic of length units. Future research should examine the Smart Ladder media across diverse

educational contexts and apply it to other mathematical concepts to test its broader applicability and scalability.

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