# Development of Smart Box Learning Media for Mathematics Learning in Elementary School

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**Abstract.** This study aims to develop and evaluate the effectiveness of the Smart Box learning media for first-grade mathematics, specifically focusing on addition and subtraction. Observations at an elementary school revealed a lack of diverse learning media, leading to decreased student engagement. Using a Research and Development (R&D) approach with the ADDIE model, this study involved 32 first-grade students, one homeroom teacher, and three expert validators specializing in media, material, and learning. Data collection was conducted through structured observations, semi-structured interviews, expert validation, and student response surveys, with analysis employing descriptive statistical methods. The findings indicate that the Smart Box, constructed from durable plywood and integrating interactive learning features, was highly validated by experts (94% validity score) and received a 95.7% positive response from students, confirming its effectiveness in enhancing engagement and comprehension. Despite its success, challenges such as classroom management and initial unfamiliarity with the tool were noted. These results highlight the potential scalability of the Smart Box for other subjects and educational levels. Future research should explore its long-term impact, cost-effectiveness, and adaptability in diverse educational settings to maximize its application in early childhood mathematics education.

**Keywords:** learning media, mathematics education, smart box, elementary school, educational technology

## 1 Introduction

The role of learning media in education is pivotal in enhancing student engagement, comprehension, and overall academic performance. Learning media serve as tools that facilitate the delivery of educational content[1], making lessons more interactive and accessible for students[2]. Effective learning media not only support educators in presenting material clearly but also foster a deeper understanding by catering to various learning styles[3]. In mathematics education, particularly at the elementary school level, the use of interactive and engaging learning media is essential for helping young learners grasp foundational concepts[4][5] such as addition and subtraction.

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However, observations at an Islamic elementary school indicate that the use of diverse learning media remains limited. Traditional teaching methods, such as blackboard explanations and printed textbooks, continue to dominate[6], leading to a lack of variation in instructional strategies. This has resulted in decreased student enthusiasm and engagement in mathematics learning[7]. While some teaching aids, such as the number wheel, are available, their usage is restricted to specific lessons, limiting their effectiveness in providing a comprehensive learning experience. To address these challenges, there is a need for innovative, interactive, and structured learning media that can enhance student participation and improve learning outcomes.

One such innovation is the Smart Box, a learning tool designed to facilitate mathematics education in a more engaging and interactive manner. The Smart Box consists of a custom-built plywood box containing visual materials, games, and learning activities tailored to support early mathematics learning. Unlike previous versions, which were primarily made of cardboard and used for basic content delivery, this study introduces a more durable, multi-functional Smart Box specifically designed for addition and subtraction learning. Additionally, elements from English language learning, such as number flashcards in English, have been integrated to promote cross-disciplinary learning.

Previous studies have explored the effectiveness of Smart Box learning media in different educational contexts. Research by Cahyaningtyas in 2023 focused on using Smart Box media for students with disabilities, achieving an 83% validation score[8], while Fitriani et al. applied Smart Box media to teach the water cycle, demonstrating positive learning outcomes[9]. Maryana and Wulandari have developed smart box learning media based on problem-based learning and found it is effective in improving science environmental learning outcomes[10].

However, existing studies have primarily relied on cardboard-based models with limited content, lacking long-term feasibility and durability. This research aims to improve upon these limitations by developing a plywood-based Smart Box, incorporating multisensory learning features to enhance student engagement and comprehension in mathematics learning.

This study employs a Research and Development (R&D) methodology, following the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) to develop, test, and refine the Smart Box as an effective learning tool. The study involves first-grade students and teachers at an Islamic elementary school, using a combination of observations, expert validation, and student response surveys to assess the feasibility and effectiveness of the Smart Box in real classroom settings.

The findings from this research are expected to contribute to the field of educational media development, providing insights into the role of interactive learning tools in improving student engagement and mathematics comprehension. By integrating play-based learning, interactive activities, and cross-disciplinary content, the Smart Box has the potential to serve as a scalable model for other subjects and grade levels. Future research should explore its long-term impact, cost-effectiveness, and adaptability in diverse educational settings to further advance the development of interactive learning media in elementary education.

## 2 Method

This study employs a Research and Development (R&D) approach, following the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) to systematically develop, test, and refine the Smart Box learning media for elementary mathematics education. The research was conducted at an Islamic elementary school in Jember, East Java, Indonesia. The study involved 32 first-grade students and one homeroom teacher, with expert validation conducted by three specialists in media, material, and learning.

### 2.1 Research Design and Procedure

The research followed five stages based on the ADDIE model:

1. Analysis – Field observations and interviews were conducted to identify the challenges in existing mathematics learning media and determine the specific needs of students and teachers.
2. Design – The Smart Box concept was developed, including the selection of materials, interactive features, and visual design tailored to enhance addition and subtraction learning.
3. Development – The prototype was created using durable plywood, integrating visual, tactile, and interactive elements. The prototype underwent expert validation to assess its content accuracy, usability, and educational effectiveness.
4. Implementation – The Smart Box was tested in a classroom setting, where students engaged in hands-on learning activities. Teacher observations and student interactions were recorded to measure engagement and comprehension.
5. Evaluation – Data were collected through questionnaires, structured classroom observations, and expert assessments to determine the effectiveness, feasibility, and areas for improvement.

### 2.2 Data Collection and Analysis

Data collection involved multiple methods to ensure a comprehensive evaluation of the Smart Box:

1. Structured classroom observations were conducted over several sessions (30–45 minutes each) to assess the effectiveness of current teaching methods and the impact of the Smart Box on student engagement.
2. Semi-structured interviews with the Grade I homeroom teacher and students provided qualitative insights into instructional challenges and experiences with the new learning media.
3. Expert validation was performed using a Likert-scale questionnaire, where media, material, and learning experts evaluated the Smart Box's content validity, usability, and practicality.
4. Student response surveys measured engagement levels and ease of use. The questionnaire used a Gutman scale (Yes/No format) and a Likert scale to quantify feedback.

### 2.3 Data Analysis

Quantitative data were analyzed using descriptive statistical analysis, calculating validation scores, student response percentages, and feasibility ratings. The validity score was computed using the formula:

$$V = \frac{Tse}{Tsh} \times 100\%$$

**Description:**
V = Validity
TSe = Total Empiric Score
TSh = Total Maximal Score

Where V represents validity, TSe is the total empirical score, and TSh is the maximum possible score. Student response scores were also calculated using the following formula:

$$P = \frac{\text{Maximum Score}}{\text{Total Score}} \times 100\ \%$$

### 2.4 Interpretation Criteria:

81–100% = Very Feasible

61–80% = Feasible

41–60% = Moderately Feasible

21–40% = Less Feasible

0–20% = Not Feasible

To ensure ethical compliance, informed consent was obtained from teachers, parents, and school administrators before data collection. Students participated voluntarily, and their identities remained confidential. The study adhered to ethical research guidelines, ensuring the protection of participants' rights and well-being.

**Table 1.** Likert Scale Rating Score Categories

| Score | Description |
|---|---|
| **5** | Very Good, Strongly Agree, Very Suitable, Very Appropriate |
| **4** | Good, Agree, Appropriate, Feasible |
| **3** | Fair, Undecided, Moderately Appropriate, Moderately Feasible |
| **2** | Not Good, Disagree, Not Suitable, Not Appropriate |
| **1** | Very Poor, Strongly Disagree, Not Appropriate, Not Appropriate |

## 3 Result

The first stage of the ADDIE development model is analysis. In this stage, researchers collected data through observations and interviews regarding teaching and learning activities in Grade I Mathematics. Observations and interviews were conducted in person with the resource person, Mrs. Lutvi Ayu Wulandari, the Grade I teacher, as well as with Grade I students.

Based on the researchers' observations, Mathematics lessons currently lack varied learning media. Teachers primarily use basic media, such as whiteboards, student textbooks, and single-use printed images. The limited variety of media has caused students to become bored and less enthusiastic in responding to the material presented by the teacher.

The second stage is planning. In this stage, researchers designed the necessary equipment and materials and created an outline for the Smart Box media. Following this, they prepared the content for the Smart Box, focusing on addition and subtraction material for Grade I.

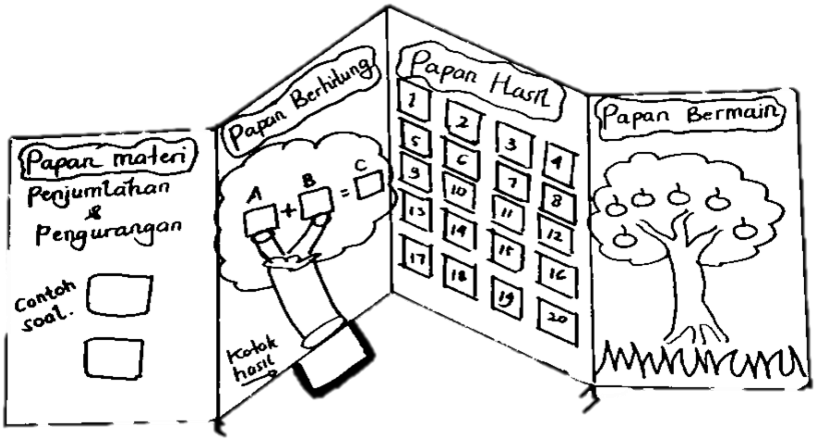


**Fig. 1.** Smart Box Media Sketch

The tools and materials needed include:

**Table 2.** Smart Box Media Tools and Materials

| N. | Tools and Materials | N. | Tools and Materials | N. | Tools and Materials | N. | Tools and Materials |
|---|---|---|---|---|---|---|---|
| 1 | Plywood | 6 | Hammer | 11 | Glue gun | 16 | Cardboard |
| 2 | Nails | 7 | Ruler | 12 | Roll stickers | 17 | Ice cream sticks |
| 3 | Zinc | 8 | Marker | 13 | Printed stickers | 18 | Flannel fabric |
| 4 | Hinge | 9 | Magnet | 14 | Lockers | 19 | Color paper |
| 5 | Screws | 10 | Sticky staples | 15 | Clear duct tape | 20 | Cardboard |

The third stage is Development, where the Smart Box media is produced and refined. Researchers began by conducting a product validation test, assessed by three validators—media experts, material experts, and learning experts—through a questionnaire. This validation helped determine the feasibility of the Smart Box media and provided constructive feedback for improvement. The steps to create the Smart Box are as follows:

1. Cut the plywood into six pieces: two sides measuring 22 cm x 40 cm, two sides measuring 28 cm x 40 cm, and two sides measuring 22 cm x 28 cm for the base and lid.
2. Assemble the plywood pieces into a rectangular prism using nails.
3. Attach hinges on both sides for easy opening and closing.
4. Cover each side with zinc, securing it with a staple gun.
5. Apply roller stickers to cover all sides.
6. Use the Canva application to design the four sides of the media:
    a. The first side serves as a material board with addition and subtraction content.
    b. The second side is a counting board, designed as a tree for addition and subtraction operations.
    c. The third side, the result board, displays flashcards with numbers 1 to 20.
    d. The fourth side, the play board, is designed like a miniature apple tree.
7. Print the designs as stickers and adhere them to each side of the media.
8. Design and print flashcards and miniature apples with mathematical answers on thick, laminated paper.
9. Attach magnets to the backs of the flashcards and miniature apples.
10. For the number spinners, cut cardboard into two rectangles and attach them to the spinner stand.
11. Cut another piece of cardboard into a circle, attaching ice cream sticks so that the spinner can rotate.
12. Design a cover for the Smart Box using Canva, print it as a sticker, and affix it to the outside.
13. The Smart Box media is now ready for use.

For more details, the media making process can be seen in the following figure:

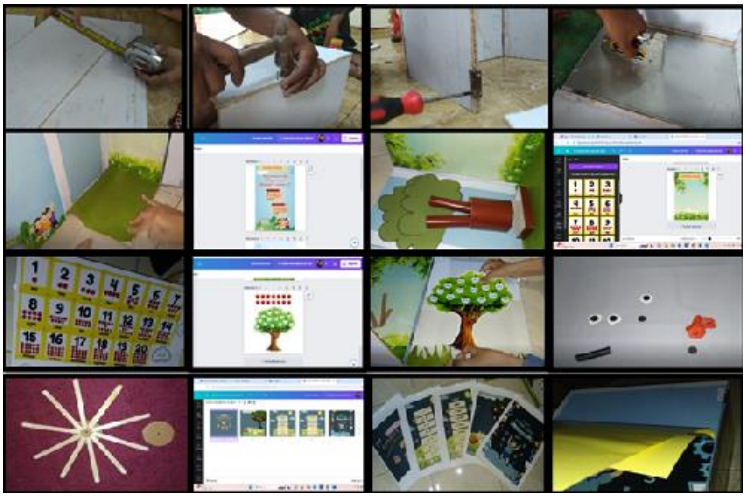

**Fig. 2**. Smart Box Media Making Process


**Fig. 3.** Inside and Outside View of Smart Box Media

**Table 3.** Validation Results

| No | Validator | Validation Result | Category |
|---|---|---|---|
| **1** | Media expert | 92% | Highly valid |
| **2** | Material expert | 97,5% | Highly valid |
| **3** | Learning expert | 92% | Highly valid |
| **Average Percentage Score** | | **94%** | **Highly valid** |

Based on the data analysis results in the table above, the validation score from media validators is 92%, indicating "very valid" criteria. The material validators provided a score of

97.5%, also categorized as "very valid," and the learning expert validators gave a score of 92%, further confirming the "very valid" criteria. The average validation score from the three validators is 94%, indicating that this Smart Box learning media is highly valid and suitable for use in teaching addition and subtraction in Mathematics. Consequently, the researchers proceeded to the field trial stage, incorporating feedback and suggestions from the validators to further refine the Smart Box media for optimal application.

The fourth stage is implementation, where the validated Smart Box media is applied in a learning setting. This was conducted on Wednesday, March 27, 2024, in the IB class.

In the initial implementation, the researcher began by explaining the addition and subtraction concepts using illustrated problem examples. After ensuring that the students understood the material, the researcher demonstrated how to use the Smart Box media for addition and subtraction. This involved spinning the number wheel and writing the resulting numbers on the board.

**Fig. 4.** The Use of Smart Box in Classroom

After students understood how to perform addition and subtraction, the researcher called on them one by one to use the Smart Box media directly. The students were very enthusiastic, eagerly volunteering to come forward. The researcher encouraged them to line up neatly and in an orderly manner. During this activity, students appeared excited to practice addition and subtraction with the Smart Box. Although most students waited their turn patiently, a few needed additional guidance to stay organized while using the media.

Following the trial, students completed a questionnaire to provide feedback on their experience with the Smart Box learning media. This feedback helped the researcher assess the feasibility of the media.

The final stage of product development is evaluation. The data collected from the students' responses on the questionnaire serve as the product feasibility results. The questionnaire consisted of ten statements with "yes" or "no" answer options, and data collection began on March 28, 2024. The results of the student response questionnaire are as follows:

**Table 4.** Feasibility of Student Responses

| Data | Score | Student response category |
|---|---|---|
| **Student interest** | 95,7% | Very interesting |

With the method of obtaining the score as follows:

$$P = \frac{\sum X}{X_1} \text{ x } 100\ \%$$

**Description:**

P = Amount in percentage form
$\sum X$ = Total score
$X_1$ = Maximum number

$$P = \frac{287}{300} \text{ x } 100\ \%$$
$$P = 95{,}7\%$$

The total score from the student response questionnaire is 287 out of a maximum of 300, resulting in a percentage of 95.7%. This score places the Smart Box learning media in the "very interesting" category for students.

In addition to the questionnaire, student responses were also observed directly during the product trial. While using the Smart Box, students demonstrated high enthusiasm. They were visibly excited to turn the number spin wheel, move the flashcards, and interact with the apples containing answers.

The Smart Box proved to be an effective learning medium, as evidenced by its high validation scores from experts (94%) and positive student responses (95.7%). Its interactive and multisensory features helped engage students and improve their understanding of addition and subtraction, making learning more enjoyable. However, challenges included the initial unfamiliarity of students in using the media, requiring additional teacher guidance, and the time needed for setup and management in class. Despite these challenges, the Smart Box aligns with constructivist learning theory, which emphasizes hands-on, experiential learning, and dual coding theory, which suggests that combining visual and textual elements enhances retention. By integrating both play-based and structured learning approaches, the Smart Box successfully supported early mathematical skill development in young learners.

The Smart Box in this study has proven to be an innovative and effective learning medium. Made from more durable plywood, it offers greater longevity compared to previous versions. Its multifunctional design enables the use of various interactive features, such as a material board, a counting board, a results board with magnetic cards, and a play board. Additionally, the integration of two subjects—Mathematics and English—makes it a tool that not only helps students grasp arithmetic concepts but also recognize numbers in a foreign language. With its

combination of durability, multifunctionality, and an integrated learning approach, the Smart Box enhances students' interest and comprehension in learning.

This study contributes to the field of educational media development by demonstrating how interactive, multisensory tools like the Smart Box can enhance engagement and learning outcomes in early mathematics education. The Smart Box model has strong potential for adaptation across different subjects and grade levels by modifying its content to align with various curricula, such as integrating science concepts, literacy skills, or social studies topics. Additionally, its hands-on, game-based approach can be tailored to meet the needs of diverse learning styles and abilities. However, scaling this media for broader use may present challenges, including production costs, the need for teacher training, and classroom management issues in larger or more resource-limited settings. Future research could explore cost-effective materials, digital integration, or modular designs to expand its accessibility and impact in diverse educational contexts.

## 4 Discussion

The findings suggest that the Smart Box learning media successfully fostered student engagement and enthusiasm in mathematics learning, particularly in practicing addition and subtraction. The observed willingness of students to actively participate and volunteer indicates that the interactive nature of the Smart Box effectively captured their interest. This aligns with previous research emphasizing that hands-on, game-based learning approaches enhance motivation and active learning in young children[8], [9].

Furthermore, the structured use of the Smart Box not only facilitated mathematical problem-solving but also reinforced behavioral skills, such as patience and orderly participation. While most students were able to wait for their turn, a few required additional guidance, suggesting that interactive learning tools should be accompanied by classroom management strategies to ensure smooth implementation. This finding supports the argument that physical and interactive learning media should be integrated with structured teacher facilitation[11] to maximize both cognitive and behavioral benefits in early childhood education.

The Smart Box media developed in this study represents a significant advancement over previous research, offering improvements in material durability, design, and interdisciplinary integration. Unlike earlier iterations that primarily used cardboard, this study introduces a more durable plywood-based Smart Box, enhancing its longevity and usability in classroom settings. The structured design—a rectangular prism measuring 40 cm high, 26 cm long, and 22 cm wide—ensures better organization of learning materials, making it more practical for teachers and engaging for students. Additionally, the use of Canva for design and sticker-coated surfaces enhances visual appeal[12], which is essential for capturing young learners' interest and sustaining engagement[13].

A key innovation in this version of the Smart Box is its multidisciplinary approach, integrating both mathematics and English language learning[14], [15]. In addition to interactive material and games focusing on addition and subtraction, the Smart Box includes English-language flashcards featuring numbers from 1 to 20. This feature aligns with contemporary educational approaches that emphasize cross-disciplinary learning, enabling students to simultaneously

develop numeracy skills and early literacy in a foreign language[16]. Research has shown that dual-subject integration can enhance cognitive development[17], improve retention, and provide a more holistic learning experience[18][19].

Furthermore, the game-based learning elements embedded in the Smart Box align with constructivist learning theories, which emphasize hands-on[20], student-centered learning experiences[21]. By engaging students in interactive play, this tool reinforces conceptual understanding of mathematical operations while fostering independent problem-solving skills. Prior studies have demonstrated that tactile learning tools improve student engagement[22] and conceptual grasp[23] compared to traditional lecture-based instruction. The multisensory approach used in this study—combining visual, textual, and interactive elements—supports diverse learning styles[24], [25], catering to both kinesthetic and visual learners[26][27].

Unlike its predecessors, which were primarily constructed from cardboard, the Smart Box in this study was developed using plywood, offering improved durability and long-term usability. The increased structural integrity ensures that the tool can withstand repeated use in classroom settings, making it a more sustainable and cost-effective solution for educators.

**Impact on Student Engagement and Learning Outcomes**

This study attributed increased enthusiasm and comprehension to the Smart Box's multisensory design, aligning with constructivist theory and dual-coding principles. Indeed, hands-on interaction—spinner wheels, magnetic flashcards, and tactile apples—can heighten motivation[20], yet the study stops short of reporting pre- and post-test gains in arithmetic proficiency. For a wider contribution, embedding standardized assessment scores or effect sizes (e.g., Cohen's d) would substantiate claims of enhanced learning outcomes[28] beyond subjective enthusiasm. Moreover, disaggregating response data by learner profiles (e.g., kinesthetic vs. visual learners) could uncover patterns of differential benefit.

By integrating English-number flashcards, the Smart Box adopts a cross-disciplinary approach that resonates with CLIL (Content and Language Integrated Learning) frameworks[29]. This pedagogical innovation supports cognitive load theory's split-attention principle[30], yet the study does not report on language outcomes. In addition, adding a brief language proficiency pre-post measure (e.g., number recognition in English) would strengthen claims of interdisciplinary efficacy. Furthermore, situating findings within broader multisensory research (e.g., [25], [27]) could illuminate mechanisms by which sensory modalities interact to reinforce number concepts.

These findings underscore the importance of developing interactive, durable, and integrated learning media to support elementary education. The Smart Box's success demonstrates how well-designed educational tools can bridge pedagogical gaps[31], providing students with a stimulating, multisensory, and interdisciplinary learning experience.

These enhancements position the Smart Box as an effective instructional tool, not only for improving numeracy skills but also for promoting early exposure to English as a second language. Future studies could explore the scalability of this model across different subjects and educational levels, as well as its long-term impact on student learning outcomes. Additionally, investigating teacher perceptions and implementation strategies could provide insights into optimizing its integration into formal curricula.

## 5 Conclusion

The Smart Box contributes to improving Mathematics learning outcomes by providing an interactive, hands-on approach that enhances student engagement, comprehension, and retention of mathematical concepts. Its multisensory features, such as visual aids, magnetic flashcards, and game-based elements, make abstract concepts like addition and subtraction more tangible and enjoyable for young learners. The study's findings, with a 94% expert validation score and 95.7% positive student response, highlight its effectiveness in fostering active learning and problem-solving skills. Given its success, the Smart Box model could serve as a foundation for developing similar tools for other subjects or educational levels. By adapting its content, structure, and interactive components, it could be applied to science experiments, literacy activities, or social studies learning. However, modifications would be needed to align with subject-specific pedagogies, and further research could explore its scalability, cost-efficiency, and integration with digital learning tools to maximize its educational impact.

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