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Development of a digital-based number pocket game for enhancing addition and subtraction skills in second grade elementary students

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Abstract
This research is motivated by a low understanding of the concept of addition and subtraction of the arrangement of grade 2 elementary school students. To overcome these problems, this study aims to develop a digital based number of pocket media as a tool for mathematics learning. The method used is Research and Development (R&D) with the ADDIE development model which includes five stages: Analysis, Design, Development, Implementation, and Evaluation. The media is developed in the form of an interactive web application using the HTML, CSS, and JavaScript programming languages, and is supported by Firebase for data storage and Google Sheets for visualization of learning outcomes. The validation results showed that the media obtained a feasibility score of 90.91% from media experts and 85% from material experts, both of which are included in the "Very Feasible" category. The implementation was carried out on 14 students, and the media obtained a practicality score of 94% from the teachers ("Very Practical" category and proved to be effective in improving student learning outcomes with an average N-Gain of 0.645 ("Medium" category). Thus, this digital-based number pocket media is declared feasible, practical, and effective to be used as an interactive learning medium to increase students' understanding of addition and subtraction materials.

1. Introduction

Learning media is defined as a support tool that teachers can utilize to convey information or messages to students, thereby facilitating the learning process (Sitepu, 2021). Learning media has been identified as a tool that can assist educators in the effective delivery of learning materials, thereby fostering student engagement and interest in their academic endeavors (Wulandari et al., 2023). The provision of enjoyable and varied experiences for students, in conjunction with the expansion of knowledge through the acquisition of new competencies, has been identified as a pivotal aspect of the educational experience (Novitasari & Kristin, 2021). However, one of the known obstacles for students in learning at the elementary school level is the limited availability of learning media (Adilah & Minsih, 2022). Given the limited time that teachers have to prepare lessons, learning media are still often ignored (Ardiana & Himmawan, 2023). The utilization of this medium is accompanied by a considerable degree of complexity, primarily due to the necessity of comprehensive preparation and the requirement of supplementary equipment for electrical connection (Anggeraini & Nasirun, 2020). However, due to the high cost and length of the manufacturing process, learning media is rarely used by teachers (Muryaningsih, 2021). In the context of pedagogy, educators frequently employ conventional approaches, relying predominantly on lecture methods and textbooks. This practice often results in a learning environment that lacks engagement and interest, as it does not effectively utilize multimedia or interactive learning materials (Setiawan et al., 2023). Furthermore, to ensure comprehension, students at the concrete operational level require activities, visual aids, and illustrative examples (Nainggolan & Daeli, 2021). It has been determined that digital learning media is a solution that can provide a more interactive learning experience, in accordance with the development of the characteristics of elementary school students. Digital learning media has the capacity to offer more than just interesting visuals and audio; it can also facilitate independent and collaborative exploration of the material through its interactive features.

Digital learning media plays a pivotal role in supporting a more effective and enjoyable learning process in elementary school. Digital learning media can be adapted to the individual characteristics of students, thereby allowing them to access learning in the most optimal way for their development (Takwin et al., 2024). Digital

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media that employ technological elements possess the capacity to transform abstract concepts into more concrete ones (Maisarah et al., 2023). This transformation is achieved by presenting material through text and images, thereby facilitating students' comprehension and enhancing their interest through the use of real visualization displays. Furthermore, the integration of digital media within the learning process is imperative, as it not only facilitates learning activities but also enables students to acquire experience in utilizing technology for educational purposes. The advent of learning media in digital form has been shown to facilitate student learning by offering greater flexibility in terms of access, both in terms of time and location (Pinatih & Putra, 2021). This is consistent with the era of the Industrial Revolution 4.0, which is characterized by changes in all scientific domains. 21st-century learning is characterized by a number of competencies, including critical thinking skills, collaboration, communication, problem-solving, and creativity (Cynthia & Sihotang, 2023).

Mathematics is a subject in elementary school that requires appropriate learning media to support its instruction. The utilization of suitable media is purported to facilitate students' comprehension of abstract concepts, which are frequently impediments in mathematics education. Mathematics instruction is a fundamental component of the education system, spanning from elementary school to college. This subject plays a foundational role in the development of scientific and technological knowledge. A solid foundation in mathematics at the elementary level is instrumental for successful progression to the next educational level, and acquiring this foundation from an early age is paramount (Fauzi & Suryadi, 2020). Mathematics education in primary schools necessitates concerted attention from various stakeholders, including educators, parents, and government entities. This is due to the foundational role of mathematics in facilitating advanced learning and technological mastery. The importance of mathematical aptitude in fostering critical thinking, problem-solving, and the advancement of science and technology has been well-documented (Utami et al., 2018). In line with this perspective. The field of mathematics can facilitate problem-solving in daily life, promote the advancement of science and technology, and enhance critical thinking and reasoning skills (Pradiani et al., 2023). However, many students regard mathematics to be a challenging subject, which can lead to feelings of anxiety and fear when studying it (Haerunnisa & Imami, 2022). The dearth of student engagement in learning discourse, compounded by the monotony of pedagogical approaches, serves to exacerbate this predicament. Some students encounter difficulties in general, while others only experience challenges with specific materials (Rosdianah et al., 2022). The hypothesis that mathematics is exclusively concerned with numerical data and formulae is a fallacious one, as it engenders a diminution of students' interest in the subject, thereby resulting in a comparatively diminished level of mathematical competence in comparison to their performance in other subjects. This challenge is particularly pronounced in the context of second-grade mathematics education, where students frequently encounter difficulties in performing basic counting operations (Thoyyibah, 2020).

The act of summation in elementary school mathematics can be effectively imparted through pedagogical methodologies that facilitate student-centered learning, wherein educators employ appropriate learning media to enable students to construct their own solutions and identify answers independently (Romana, 2023). In the grade 2 addition and subtraction material, media such as skewers, abacuses, ice cream sticks, flashcards, and bridge cards have been employed to facilitate student visualization of the concept of counting. Furthermore, educators employ flannel boards, which feature numbers that can be affixed, to facilitate comprehension for students. However, these media continue to exhibit limitations in terms of flexibility and interactivity. Consequently, there is a need for innovations in digital-based media to enhance the engagement and efficacy of learning. One such innovation is the development of digital number bags. Concrete tools, which originally possessed pockets of place values (units, tens), can undergo a transformation into interactive digital forms. The utilization of number bag media is anticipated to enhance the comprehension of material, facilitate the engagement of students, and captivate their attention, thereby impacting learning outcomes (Sabilla et al., 2022). Preliminary observations suggest that some students continue to demonstrate deficiencies in their understanding of the fundamental principles of arithmetic operations, specifically the initiation of these processes from units. Additionally, a subset of students exhibits a persistent challenge in implementing the correct storage technique for tens. Furthermore, students exhibit a reduced level of engagement in the learning process, attributable to the scarcity of media and teaching aids. A close observation of the class reveals a striking lack of attention from the students during the teacher's explanations of fundamental concepts in arithmetic. It has been observed that a number of students have been seen to place their chin on the table, while simultaneously scribbling on paper and conversing with their peers. Teachers' reliance on the whiteboard as the sole medium of instruction, devoid of supplementary materials or teaching aids, hinders a conducive learning environment. The objective of this study is to facilitate the comprehension of the material concept, particularly in mathematics lessons, by teachers and students. This objective is to be achieved through the utilization of digital number bag media.

The use of number bag media in conjunction with pipettes has been employed as a pedagogical tool to facilitate the comprehension of mathematical concepts pertaining to addition and subtraction (Marudin, 2019). The present study is constrained in its scope, as it focuses exclusively on the aspect of learning interest, neglecting to assess the comprehension of concepts or the comprehensive student learning outcomes. Moreover, the utilization of media is confined to manual methods, lacking integration with digital technologies. Number bags and straws have been used as media in the context of mathematics learning (Nisa, 2023). The present study

is subject to certain limitations, as its scope is constrained to the application of large-scale materials. Furthermore, the research underscores the necessity of enhancing learning outcomes without delving into the intricacies of conceptual understanding. Number bags and ice cream sticks adorned with animal imagery have been used to facilitate the learning of addition and subtraction in mathematics (Diyana et al., 2024). The present study is limited in its scope, as it exclusively examines cognitive learning outcomes through the medium of written tests. It does not delve into other pertinent aspects, such as learning motivation, student engagement, or a comprehensive grasp of conceptual understanding.

The three studies demonstrate the efficacy of concrete media in facilitating mathematics education. However, the utilized media remains physical, exhibiting constraints in terms of flexibility and interactivity. Additionally, it falls short in its ability to present dynamic simulations in real time. Consequently, this research introduces an innovation in the form of a digital-based number bag constructed using HTML5, CSS3, and JavaScript with interactive features such as drag and drop, automatic feedback, and data storage in Firebase to monitor student progress directly. This innovation is expected to provide solutions to the limitations of physical media and support more effective and enjoyable learning. The objective of this study is to develop digital-based number pocket media in mathematics learning materials for grade two elementary school students, with a focus on addition and subtraction.

2. Method

This research is classified as a type of research and development, commonly referred to as "R&D". This method aims to produce products by going through the process of identifying possible problems, designing, and developing a product as the best solution (Waruwu, 2024). The product developed in this study is a digital number of pocket media for the instruction of second-grade students in the domain of addition and subtraction.

The development model under consideration in this study is known as ADDIE. This learning design model is implemented in order to produce a learning system that is characterized by a broad scope. According to Trisiana and Wartoyo (2016), the ADDIE model (Analysis-Design-Develop-Implement-Evaluate) is a developmental design that utilizes five stages, as illustrated in the Figure 1 below:



Figure 1. ADDIE Model Development Stages

The analysis stage encompasses two activities: problem analysis and curriculum analysis. The analysis of problems is conducted through the observation of problems that arise in learning activities and the identification of potential solutions to be employed. The curriculum analysis encompasses the evaluation of the Learning Outcomes (CP) and Learning Objectives that will be incorporated into digital-based number bag media.

The design stage commences with the determination of the software to be utilized in the production of the product and the collection of product format/content references that align with the characteristics of grade 2 elementary school students. Furthermore, it employs a multifaceted approach by utilizing instruments such as validation questionnaires for media and material experts, practicality questionnaires for grade 2 teachers, and student learning outcome tests. These assessments are designed to evaluate the efficacy of the developed learning media. The questionnaire has been meticulously structured to encompass various aspects of the assessment and a range of indicators. Subsequently, the researcher will devise an assessment rubric, thereby facilitating the evaluation of validators.

The development stage is the phase in which the product is realized. The products that have been developed will undergo a series of validation tests and limited trials to assess their feasibility. The validation test activities are conducted by competent experts who assess learning media and provide suggestions and inputs that will become revision guidelines. These guidelines are aimed at improving product results. The validation test of learning media experts with one validator is a lecturer who is experienced in the field of learning media, and the validation questionnaire of material experts with one validator is a lecturer who has experience in the field of mathematics subjects. The limited trial was carried out by five second-grade students. Validation will be carried out until the conclusion of the evaluation process, at which point a determination will be made regarding its suitability for incorporation into learning activities.

The Implementation Stage is designed to ascertain the practicality and effectiveness of the media. This stage of the study involved the research subjects of 14 students and 1 teacher of SD Negeri 2 Belung. The practicality of the media was assessed through a questionnaire administered to the second-grade teacher, while the effectiveness of the media was assessed through the provision of pretests and posttests to 14 second grade students to ascertain the improvement of learning outcomes. The data obtained from the results of the

questionnaire and test was then analyzed to determine the level of practicality and effectiveness of the learning media developed.

The evaluation stage is carried out in two forms: formative and summative evaluation. Formative evaluations are conducted during the development process by engaging validation from media experts, subject matter experts, and limited trials to obtain input and product improvements. Concurrently, summative evaluation is conducted following the completion and implementation of the product in a small-group trial. The objective of this evaluation is to assess the final outcomes of the development process through the level of practicality, as determined by the teacher's questionnaire, and the effectiveness of the media, as determined by the analysis of enhancing student learning outcomes through pretest and posttest. The data from these two forms of evaluation were then analyzed to assess the overall feasibility, practicality, and effectiveness of the media. The data collection and analysis techniques employed in this study are delineated in Table 1 below.

Table 1. Data Collection and Analysis Techniques

Quantitative	Qualitative
Quantitative analysis was employed to utilize the results of validation questionnaires from media and material experts, teacher practicality questionnaires, and product effectiveness test results on digital-based number pocket media development products on addition and subtraction of stacking materials for second grade elementary school students.	Qualitative analysis employs the results of suggestions from validation questionnaires of media experts, material experts, and grade 2 teachers.

The research instrument under consideration includes validation questionnaires for media experts and material experts, as well as student learning outcome tests. Prior to the initiation of the product trial, students are administered a series of pre-test questions, and subsequently, post-test questions are administered following the conclusion of the trial. Both tests have been validated by media and subject matter experts, and have been revised based on suggestions from the validation committee. The objective of administering pre-tests and post-tests is to evaluate the efficacy of the developed products. In the validation and response questionnaire of students, five (5) Likert scale answer criteria were employed. The Likert scale has the capacity to provide alternative responses to instrument questions, with very good to very poor interpretation. The degree to which media is effective is determined by calculating the extent of student learning outcomes on pre-test and post-test using the N-Gain test (Ningsih et al., 2023).

3. Results and Discussion

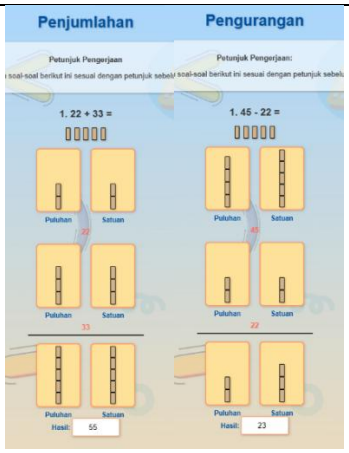
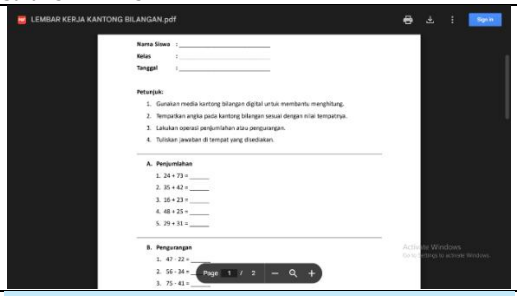
ADDIE is a research and development model that progresses sequentially through the stages of analysis, design, development, implementation, and evaluation. In the analysis stage, two stages are carried out: problem analysis and curriculum analysis. In the analysis stage, the researcher conducted two activities: problem analysis and curriculum analysis. It is imperative to identify any potential issues with the objective of acquiring pertinent information and conducting a thorough analysis of the challenges encountered (Herawati et al., 2024). At the problem analysis stage, there are some students who have a little difficulty operating laptops/computer, students need some time to be able to work on questions from digital-based number bag media, some students lack mastery of addition and subtraction. Solutions that can be used to problems during learning activities are the habit of students using laptops/computers, maximizing time well during learning, providing assistance gradually to students who have difficulty in understanding the concept of addition and subtraction. Curriculum analysis is carried out on learning components, namely learning outcomes (CP) and learning objectives (TP) to be implemented (Aulya et al., 2024). In the curriculum analysis, there are learning outcomes (CP) phase A of the number elements developed by the researcher into several learning objectives, including through the explanation of digital-based number pocket media, students can calculate the addition and subtraction of the arrangement correctly (C3). The presentation given by the teacher enables students to analyze various methods of solving addition and subtraction problems correctly (C4). The discourse facilitated by the instructor enables students to employ strategies for solving addition and subtraction problems with confidence (P2) through the utilization of digital number pocket media. Digital media has been demonstrated to facilitate the presentation of mathematical concepts in a concrete, interactive, and adaptable manner, aligning with the demands of learning outcomes (Mardati, 2021).

During the design stage, the product is conceptualized as an interactive web comprising multiple primary pages, including instructional menus, exercises, interactive questions, downloadable worksheets, and an "About the Compiler" section. This media employs a visual approach, utilizing drag-and-drop elements in the form of number sticks into tens and units pockets. This method facilitates comprehension of the concept of place values in addition and subtraction operations for students. The question design is structured in stages of 10 questions, 5 for addition and 5 for subtraction. The utilization of interactive media in the educational environment has been demonstrated to facilitate comprehension of abstract concepts for students. This is achieved through the use of visual displays, engaging exercises, and active involvement during the learning process (Fiani et al., 2024). The interface has been rendered both responsive and aesthetically pleasing, employing a color scheme and illustrations characteristic of children's literature, accompanied by clear instructions for use. The visual design

is intended to be aesthetically pleasing and responsive. It employs children's illustrations and vibrant colors to align with the characteristics of elementary school students. The utilization of engaging and thematically congruent learning media has been demonstrated to facilitate accelerated comprehension of the subject matter among students (Mahesti & Koeswanti, 2021). The scoring system has been meticulously engineered to provide automatic final score feedback, which is transmitted to Google Sheets and graphically displayed using Firebase and Chart.js. This feature enables educators to closely monitor the progress of student learning outcomes in real time. The utilization of digital platforms enables educators to directly observe students' learning progress and swiftly adapt learning strategies, irrespective of time and location (Rahma & Mufidah, 2025). The design of the number bag media can be seen in Table 2.

Table 2. Digital-based Number Pocket Game Media Design

Information	Design
Home An initial view of the interactive media "Digital Number Pocket" that provides navigation to various key features such as Instructions, Exercises, Interactive Questions, Download Worksheets, and About Compilers	
Instructions Provides interactive media usage guides, including how to use number bags, usage rules, and includes examples in PDF and video formats.	 
Exercise Displays interactive simulations to get acquainted with the concepts of addition and subtraction with number bags. Students can manipulate sticks and see the results of calculations automatically.	

Information	Design
Interactive Questions Menu to select the type of question you want to work on, namely addition or subtraction. Each question is equipped with drag and drop stick interaction, answer columns, and automatic assessment buttons.	 Steps on how to work on interactive questions a. Hover over the stick, then press and put it in the bag, if it is green then the stick is already in. b. Put in the top pocket of the unit as many as 2 sticks and tens as many as 2 sticks, then the result of the number in orange shows 22. c. Put it in the bottom pocket of the unit as many as 3 sticks and tens as many as 3 sticks, then the result of the number in orange shows 33. d. Add the sticks at the top of the unit and the bottom of the unit by lowering them into the bottom pocket which is combined to 5, the same as the tens pocket because the number is the same, which is 2 + 3, then the result is 5. e. Result 22 + 33 = 55. Subtraction (45 - 22) = a. Hover over the stick, then press and put it in the bag, if it is green then the stick is already in. b. Put in the top pocket of 5 sticks and 4 tens of sticks, then the result of the number in orange shows 45. c. Put 2 sticks in the bottom pocket of the unit and 2 sticks in the ten, then the number in orange shows 22. d. Reduce the top stick by the unit with the lower unit stick and the result is lowered into the bottom pocket which results in 3. e. Reduce the top stick to the tens with the top ten stick, which is 4 minus 2 the result is 2, then put the result of the 2 sticks into the bottom tens pocket. f. Result 45 -22 = 23.
Download Worksheets Provides access to download supporting worksheets in PDF form via an external Google Drive link as offline exercise materials.	
About the Compiler Contains information on the identity of the media compiler (name, institution, year) and the purpose of making the media, which is to help 2nd grade elementary school students understand basic calculation operations in a concrete way	

Link: https://drive.google.com/drive/folders/1iLmX_fsK0oxV7d6FRVA1rG3csIKnwPo1?usp=drive_link

In the development stage, researchers developed digital-based number pocket media using HTML5, CSS3, JavaScript, Firebase, and Google Apps Script. The development process begins with creating a child-friendly user interface, compiling question content, integrating interactive features, and an automatic assessment system that records student scores directly into Google Spreadsheet and displays them in graphical form. Web-based learning media also excels in terms of easy access and flexibility of time and place in its use (Rani et al., 2024). The researcher validates media experts and material experts and then revises them. In this case, to find out the feasibility of digital-based number pocket media. The results obtained can be seen in Table 3.

Table 3. Assessment Results of Media Expert and Material Expert Validators

No.	Validator	Presentase	Category
1	Media Expert	90,91%	Very Feasible
2	Material Expert	85%	Very Feasible
Mean		87,96%	Very Feasible

Based on Table 3, the validation results from media experts obtained 90.91% data which is included in the "Very Feasible" category. Validation from material experts obtained 85% data in the "Very Feasible" category. To get input and assessment, validation was carried out by material experts and media experts and obtained an assessment with a very feasible category (Maulida et al., 2023) Validation by experts shows that the media is considered very worthy of being seen in terms of content, design appearance, and level of interactivity (Putricia et al., 2025). In addition, improvements were also made based on input from validators, such as adding backgrounds, adding sound to video instructions to clarify instructions, and replacing large numbers with small ones to suit the abilities of lower-grade students. The use of audio-visual elements helps students remember the material more easily because it creates a lasting impression in the learning process (Khulaifatuzzahra et al., 2024).

At the implementation stage, it was carried out by providing practicality questionnaires to grade 2 teachers and carrying out learning outcome tests on 14 2nd grade students of SD Negeri 2 Belung who were the subjects of the research. The results of the teacher's practicality assessment can be seen in Table 4.

Table 4. Results of Teacher Practicality Assessment

No.	Respond	Presentase	Category
1	Grade 2 Teacher	94%	Very Practical
Mean		94%	Very Practical

Based on the results of the practicality questionnaire filled out by grade 2 teachers, 94% of the data was obtained which was categorized as "Very Practical". Practicality refers to the situation in which the learning media developed can be easily used by users, both students and teachers, so that the learning process carried out becomes more meaningful and interesting (Milala et al., 2021).

Pre-test and post-test are given to determine the improvement of student learning outcomes before and after using digital number bags. The results of improving student learning outcomes through pre-test and post-test can be seen in Figure 2.

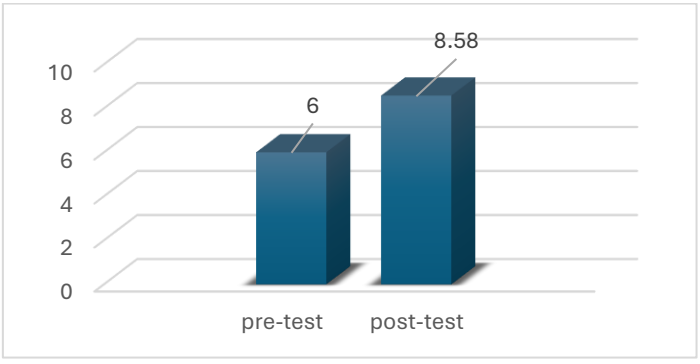


Figure 2. Student Effectiveness Outcomes

Based on Figure 2, student learning outcomes seen from the pre-test and post-test results increased by 2.58 with an average N-gain of 0.645. The categorization of the average effectiveness of N-gain with $0 < g < 0.3$ was included in the low category, $0.3 \leq g \leq 0.7$ was included in the medium category, and $g > 0.7$ was included in the high category. Based on the analysis of the improvement of student learning outcomes, the average

effectiveness of N-gain was obtained of 0.645 which is included in the medium category. The effectiveness of digital-based number bags to improve learning outcomes can be seen in Figure 3.

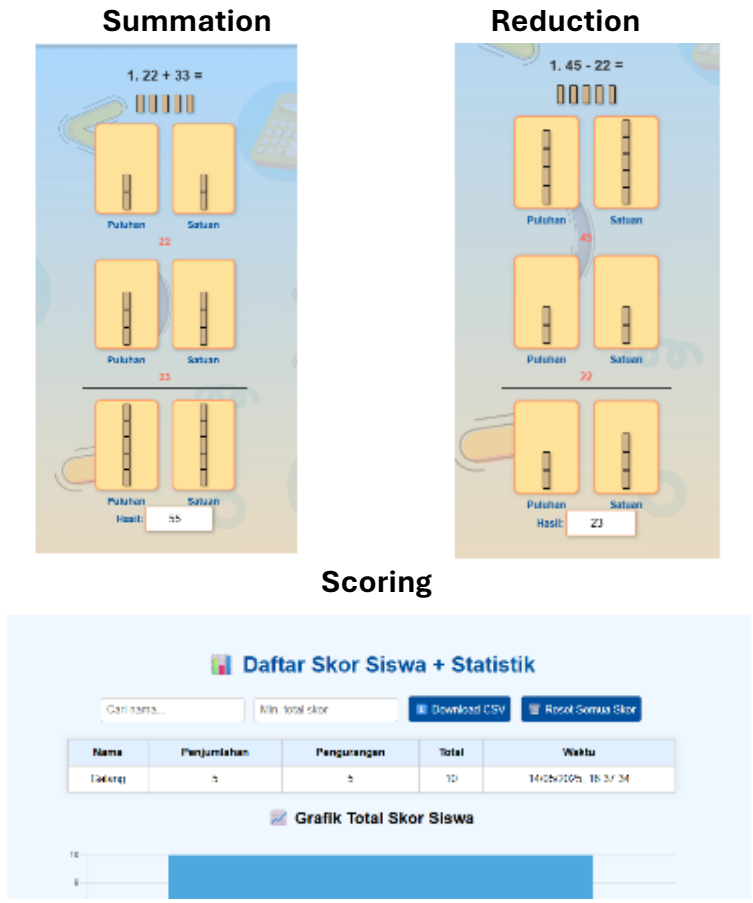


Figure 3. The level of digital number pocket media work

Based on Figure 3, students can learn the addition and subtraction operations of two-digit numbers through digital number pocket media designed to provide an interactive experience in learning mathematics. The stages in working on this media begin with the presentation of instructions for use, where students are asked to understand the rules on how to use the media and the steps for solving problems. In the second stage, students begin to try the digital number pocket on the practice feature by dragging and dropping the stick and starting to count as desired by the student, then the results will automatically appear when clicked. The drag and drop technique has been recognized as one of the effective and feasible methods in developing learning media (Sudeka & Setiawan, 2024). In the third stage, work on interactive questions with the selection of addition or subtraction material presented on two separate pages. Each question does not automatically display the answer, so students must calculate independently with the help of digital visualization. After completing all the questions, students will get a final score with a maximum of 10. This score describes the number of correct answers obtained by students. Students compete with each other to answer quickly and correctly so that their names can occupy the top position on the leaderboard (Sitorus & Santoso, 2022). In the fourth stage, you can download worksheets that can be done anywhere according to the student's wishes. Learners' worksheets serve as a means to deepen their understanding of the learning material and provide ample opportunities for them to demonstrate mastery of concepts and hone their process skills optimally (Darmawan & Nawawi, 2020).

At the evaluation stage, it is carried out to assess the effectiveness of media in improving student learning outcomes. Evaluation is carried out in two forms, namely formative and summative. Formative evaluation is carried out at the validation stage and limited trials, while summative evaluation is carried out through pre-tests and post-tests given before and after the use of media. The results of the analysis showed a significant increase in student learning scores, with an average increase reaching the high category. In addition to the test results, students' responses to the media also showed a positive response. Students find the media easy to use and fun, and can help them understand the addition and subtraction material gradually. Digital media provides opportunities for students to learn independently and adapt the learning process to their individual needs (Novela et al., 2024). Evaluation was also carried out on the score reporting system connected to Google Spreadsheet, which makes it easy for teachers to carry out continuous and targeted assessments. The digital platform has the opportunity to observe the learning process in real time (Rahma & Mufidah, 2025).

4. Conclusion

This research develops digital-based number pocket media. The application of this media is declared feasible, practical, and effective when applied at SDN 2 Belung. This is supported by the results of media expert validation by obtaining data in the category of "Very Feasible". The results of the validation of material experts obtained data in the "Very Feasible" category. In addition, the results of the teacher's practicality assessment obtained data in the "Very Practical" category. Then the effectiveness analysis was carried out with a pretest and posttest by students by obtaining average results in the "medium" category which can be said to be "Effective". Suggestions for teachers, especially in elementary schools, can use digital-based number pocket media to help students understand the concept of addition and subtraction of stacks, as well as practice periodically so that students can understand how to use them. The suggestion for the next researcher is to develop this media to other materials and make it an application for android or iOS so that it is more accessible on students' smartphones so that it can increase the flexibility of use both at school and at home.

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