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THE EFFECT OF THE SIMPLE SOROBAN APPLICATION ON STUDENTS' MATHEMATICS LEARNING OUTCOMES

Rima Agustina[1], Nina Ikhwati Wahidah[2], Irma Ayuwanti[3*], Tim Bordasch[4]
[1,2,3] *Universitas Nahdlatul Ulama Lampung, Indonesia*
[4]*University Bielefeld, Germany*
Email: [1]*rimaagustinn1@gmil.com*, [2]*Ninaikhwatiwahidah19@gmail.com*, [3]*irmaayuwanti@gmail.com*, [4]*bordasch_tim@gmail.com*

ABSTACT

Mathematics learning in junior high schools is predominantly dominated by conventional, teacher-centered instruction, which often limits students' active participation and inhibits meaningful conceptual understanding. As a result, many students experience persistent difficulties in mastering basic arithmetic concepts. To address the issue, the study introduces the Simple Soroban application as a digital abacus-based learning medium that provides visual, interactive, and concrete representations of integer operations. Therefore, the study aims to examine the effect of using the Simple Soroban application on seventh-grade students' mathematics learning outcomes, particularly in the integer operations study, which employed a quantitative approach using a posttest-only control group design. The population consisted of all seventh-grade students of SMP Negeri 2 Purbolinggo. Samples were selected through stratified random sampling, resulting in an experimental group taught using the Simple Soroban application and a control group taught using conventional teaching methods. Data were collected using a multiple-choice test that had been tested for validity, reliability, difficulty level, and discrimination index. The data were analyzed using normality tests, homogeneity tests, and an independent sample t-test with SPSS 26 and Microsoft Excel 2010. The findings revealed a statistically significant difference in mathematics learning outcomes between the two groups, indicated by a calculated t-value of −2.742 exceeding the critical t-value of 2.002 at a significance level of 0.05. These results suggest that digital abacus-based learning media can serve as an effective instructional alternative to improve students' understanding of integer operations. However, this study was limited to one school and one mathematical topic, which may restrict the generalizability of the findings.

Keywords: Integer Operations, Learning Outcomes, Mathematics Learning, Learning Media, Simple Soroban

*** Corresponding Author Email:** irmaayuwanti@gmail.com

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INTRODUCTION

Education plays a crucial role in shaping students' cognitive abilities, character, and competencies in accordance with national educational objectives (Murtiningsih et al., 2024). Through education, students are expected not only to acquire knowledge but also to develop critical thinking, logical reasoning, creativity, and problem-solving skills that are essential for facing the challenges of the twenty-first century. Among various school subjects, mathematics holds a central position because it functions as a foundational discipline that supports the development of analytical thinking, systematic reasoning, and decision-making skills. Mathematics learning enables students to understand patterns, relationships, and structures, which are fundamental to scientific and technological advancement. Therefore, the quality of mathematics instruction significantly influences students' overall academic development and cognitive growth.

Despite its importance, mathematics is often perceived by students, particularly at the junior high school level, as a difficult and abstract subject. Many mathematical concepts are presented symbolically and procedurally, making them challenging for students to understand meaningfully. One topic that frequently causes learning difficulties is integer operations, which include addition, subtraction, multiplication, and division involving positive and negative numbers. According to (Maryanti & Asmara, 2025) students often struggle with integer operations due to misconceptions, lack of conceptual understanding, and difficulties in visualizing numerical relationships. These challenges are further exacerbated when instruction relies heavily on rote learning and memorization rather than conceptual exploration.

This perception of mathematics as a difficult subject has a direct impact on students' learning outcomes. Low motivation, anxiety toward mathematics, and passive learning behaviors frequently emerge when students fail to grasp basic concepts. Empirical evidence from SMP Negeri 2 Purbolinggo illustrates this issue clearly. Based on school assessment data, 52% of seventh-grade students did not achieve the Minimum Completeness Criteria (Kriteria Ketuntasan Minimal/KKM) of 75 in daily assessments on integer operations. This condition indicates that a substantial proportion of students have not yet mastered fundamental arithmetic concepts, which may hinder their ability to learn more advanced mathematical topics in subsequent grades.

In response to these challenges, national education policy emphasizes the importance of innovative and technology-based learning approaches to enhance the quality of instruction. The Regulation of the Minister of National Education No. 41 of 2007 explicitly highlights the need for learning processes that promote students' creativity, independence, and active participation. This policy encourages teachers to move beyond traditional teacher-centered instruction and to adopt learning strategies and media that actively involve students in constructing their own understanding. In the context of mathematics education, this means transforming abstract concepts into learning experiences that are more concrete, contextual, and meaningful for students.

The integration of instructional media is one of the key strategies recommended to achieve these goals. Instructional media serve as tools that mediate the interaction between teachers, students, and learning content. Appropriate media can help clarify abstract ideas, stimulate students' interest, and support deeper conceptual understanding. In mathematics learning, especially for topics such as integer operations, instructional media play a vital role in bridging the gap between abstract symbols and students' cognitive representations. Visual, manipulative, and interactive media are particularly effective in helping students understand numerical relationships and operational rules.

However, in practice, mathematics instruction in many schools remains dominated by conventional methods, such as lecturing, textbook-based exercises, and repetitive problem-solving. These approaches often position students as passive recipients of information rather than active participants in the learning process. As a result, classroom interactions are limited, opportunities for exploration and discussion are minimal, and students may rely on memorization without truly understanding underlying concepts. This condition often leads to superficial learning and low retention, especially for abstract mathematical topics.

Innovative and interactive learning media are expected to address these shortcomings by fostering active learning environments. Media that incorporate visual representations, handson activities, and digital interactivity can increase students' engagement and motivation. When students are actively involved in manipulating objects, observing patterns, and receiving immediate feedback, they are more likely to develop meaningful understanding. Consequently, the selection and use of appropriate learning media become crucial factors in improving mathematics learning outcomes.

One instructional medium that aligns with technological advancements and educational needs is the Simple Soroban application. Simple Soroban is a digital simulation of the Japanese abacus, designed to help students perform arithmetic operations through the manipulation of virtual beads. Unlike conventional calculators, which often provide results without revealing underlying processes, the Simple Soroban application emphasizes procedural understanding and visualization. Students can observe how numbers are represented and transformed during operations, allowing them to understand the logic behind arithmetic procedures.

The use of the Simple Soroban application is grounded in constructivist learning theory, which posits that knowledge is actively constructed by learners through interaction with learning objects and experiences. By engaging with the digital abacus, students can explore integer operations concretely and interactively. The visual movement of beads helps students internalize concepts such as positive and negative values, place value, and the relationships between numbers. Moreover, the application's interactive features are expected to enhance students' motivation and concentration, making mathematics learning more enjoyable and less intimidating.

Previous studies have provided empirical support for the effectiveness of abacus-based learning media in improving mathematics achievement. (Nova Fitrianingsih et al., 2023) reported that the implementation of discovery learning assisted by the Simple Soroban application resulted in 85.18% classical learning mastery among elementary school students. Their findings suggest that the combination of inquiry-based learning and digital abacus media can significantly enhance students' understanding of arithmetic concepts. Similarly, Aripen, (2021), Hasibuan, (2022)., and Wang, (2021), found a significant improvement in students' mathematics learning outcomes through the use of abacus media, as indicated by a t-value of 19.09. These results demonstrate that abacus-based instruction, whether conventional or digital, has a positive impact on students' numeracy skills.

Despite these encouraging findings, most existing studies have focused on elementary school students and basic arithmetic skills. Empirical research examining the effectiveness of the Simple Soroban application at the junior high school level remains limited. This gap is particularly notable given that junior high school students are at a developmental stage where abstract thinking begins to mature, and digital technology becomes an integral part of their daily lives. Students at this level often show high interest in digital tools and applications, yet the integration of such technology into mathematics instruction has not been optimally implemented.

The lack of research at the secondary education level raises important questions regarding the applicability and effectiveness of digital abacus-based media for more complex mathematical content. Integer operations at the junior high school level involve not only procedural skills but also conceptual understanding of number systems and operational rules. Therefore, it is necessary to investigate whether digital tools such as the Simple Soroban application can effectively support students' cognitive development and learning outcomes in this context.

Preliminary observations conducted at SMP Negeri 2 Purbolinggo further highlight the need for such research. Many seventh-grade students were observed to experience difficulties in understanding integer operations, particularly when dealing with negative numbers and mixed operations. Classroom observations and informal interviews with teachers revealed that learning activities were still predominantly teacher-centered, with limited use of interactive or technology-based media. Consequently, student participation was relatively low, and many students struggled to follow lessons or complete assignments independently.

These conditions suggest that the limited use of engaging instructional media may be one of the contributing factors to students' low learning outcomes. Without adequate visual and interactive support, students may find it difficult to internalize abstract concepts and develop confidence in their mathematical abilities. Therefore, introducing alternative instructional media that align with students' learning needs and technological interests is essential to improve the quality of mathematics instruction.

Based on the theoretical considerations, empirical evidence, and contextual problems identified, this study aims to investigate the effect of using the Simple Soroban application on the mathematics learning outcomes of seventh-grade students at SMP Negeri 2 Purbolinggo. This study focuses on comparing learning outcomes between students who are taught using the Simple Soroban application and those who receive conventional instruction, specifically on the topic of integer operations. The scope of the study is limited to one junior high school to allow for in-depth analysis and controlled implementation of the intervention.

Although previous studies have examined the use of Simple Soroban-based learning media in elementary education, empirical research investigating the effectiveness of the Simple Soroban application at the junior high school level remains limited. Therefore, this study aims to fill this research gap by examining the effect of the Simple Soroban application on students' mathematics learning outcomes in integer operations.

The research question addressed in this study is: Is there a significant effect of the Simple Soroban application on students' mathematics learning outcomes? By answering this question, the study seeks to provide empirical evidence on the effectiveness of digital abacus-based learning media at the junior high school level. The findings are expected to contribute theoretically to the literature on educational technology and mathematics education by extending previous research to a new educational context. Practically, the results are anticipated to offer teachers an alternative instructional medium that can be used to enhance students' engagement, conceptual understanding, and learning outcomes in mathematics.

METHOD

This study employed a quantitative quasi-experimental method using a posttest-only control group design (kory listia at al, 2025). The research was conducted during the first (odd) semester of the 2025/2026 academic year at SMP Negeri 2 Purbolinggo, East Lampung Regency. This design was selected because it allows researchers to compare learning outcomes between groups after treatment while minimizing potential testing effects that may arise from pretest exposure. The experimental framework involved two intact groups: an experimental group that received instruction using the Simple Soroban application and a control group that was taught using conventional teaching methods commonly implemented by the classroom teacher.

The population of this study consisted of all seventh-grade students at SMP Negeri 2 Purbolinggo, totaling 240 students distributed across eight classes (VII A–H). From this population, a sample of 60 students was selected, with 30 students assigned to the experimental group and 30 students to the control group. The sampling technique used was stratified random sampling to ensure representation across different academic strata, including accelerated and regular classes (Mardati et al., 2025). This approach was intended to maintain group equivalence and reduce sampling bias, thereby strengthening the internal validity of the study.

The independent variable in this research was the use of the Simple Soroban application, which was implemented through several of its main features, namely free mode, challenge mode, and offline tutorial (Noviyana, 2025). These features were integrated into the learning process to support interactive and student-centered instruction. Meanwhile, the dependent variable was students' cognitive learning outcomes in mathematics, specifically on the topic of integer operations. Learning outcomes were measured using a posttest consisting of 10 multiple-choice items scored on a 100-point scale. Researchers used 10 questions considering efficiency and time constraints, so that the data collection process could be carried out more optimally. The Minimum Completeness Criteria (KKM) applied in this study was 75, in accordance with the school's academic standards.

The research instrument was developed based on a detailed test blueprint covering five indicators of integer operations: addition, subtraction, multiplication, division, and mixed operations. The cognitive levels assessed ranged from C1 (remembering) to C3 (applying) in Bloom's taxonomy. Before its implementation, the instrument was piloted on 20 students using a 20-item test. The item analysis results indicated that 14 items met the validity requirements, with item validity coefficients exceeding the critical value ($r > 0.4438$) (Mejía-clavo et al., 2024). Furthermore, the instrument demonstrated high reliability, as indicated by a Cronbach's alpha coefficient of 0.872. The selected items were categorized as having moderate difficulty levels (0.30–0.70) and good discriminating power ($D \geq 0.30$), indicating that the test was suitable for measuring students' cognitive achievement (Pendidikan & P-issn, 2025).

Content validity of the instrument was evaluated by two mathematics education experts, Ummi Rosidah, S.Pd., M.Pd., and Yeni Wulandari, S.Pd., M.Pd., who concluded that the instrument was feasible for use with minor revisions. In addition, language validity was assessed by Ismun Ali, M.Pd.I., and Agus Winarsih, S.Pd., Gr., and the instrument was judged to be linguistically appropriate and understandable for junior high school students.

The research procedure began with preliminary observation and interviews with the mathematics teacher to identify classroom conditions and students' initial difficulties. This was followed by the implementation of the treatment over eight lesson hours. The instructional stages included learning orientation, demonstration of the Simple Soroban application, guided and competitive group practice, and evaluation activities (Mansour & Wardat, 2025). After the completion of the treatment, both the experimental and control groups were administered the same posttest to measure students' learning outcomes objectively.

Data analysis was conducted using both descriptive and inferential statistics. Descriptive statistics were used to calculate mean scores, standard deviations, and classical mastery percentages. Inferential analysis included the Kolmogorov–Smirnov test to assess the normality of the data distribution and Levene's test to examine the homogeneity of variance (Sipahutar, 2023). Finally, an independent samples t-test was performed at a significance level of $\alpha = 0.05$ with 58 degrees of freedom to determine whether there was a statistically significant difference between the two groups. All statistical analyses were carried out using SPSS version 26 and Microsoft Excel 2010 (Sugiono, 2021).

RESULT

The data analysis in this study consisted of descriptive analysis, prerequisite assumption testing, and hypothesis testing.

Descriptive Statistics

The descriptive analysis of the posttest scores shows that students in the experimental group achieved better learning outcomes than those in the control group. The experimental group obtained a mean posttest score of 82.67 (SD = 8.45), with 86.67% of students achieving mastery. In contrast, the control group achieved a mean score of 65.90 (SD = 10.23), with only 60.00% of students reaching the mastery criterion. The difference in mean scores between the two groups was 16.77 points, while the difference in mastery levels reached 26.77%. These results indicate that students who learned using the Simple Soroban application demonstrated higher mathematics learning outcomes compared to those who received conventional instruction.

In addition, the distribution of scores in the experimental group showed a relatively narrower range compared to the control group. The minimum score obtained by students in the experimental group was 70, while the highest score reached 95. In contrast, the control group recorded a wider variation of scores, ranging from 55 to 85. This pattern suggests that the learning outcomes in the experimental group were not only higher on average but also more consistently distributed among students. The results of the statistical description are written in Table 1.

Table 1. Posttest Descriptive Statistics

Grup	N	Mean	SD	Min	Max
Experimental	30	82.67	8.45	70	95
Control	30	65.90	10.23	55	85

Prerequisite Assumption Tests

Before hypothesis testing, normality and homogeneity tests were conducted. The Kolmogorov–Smirnov test showed that the posttest scores of both the experimental group (Sig. = 0.200) and the control group (Sig. = 0.150) were normally distributed (Sugiono, 2021), as the significance values were greater than 0.05. Furthermore, the Levene homogeneity test yielded a significance value of 0.120, indicating that the variances of the two groups were homogeneous. Thus, the data met the assumptions required for parametric statistical testing.

These results indicate that the distribution of posttest scores in both groups followed a normal distribution pattern and that the variance between the two groups was statistically homogeneous. Therefore, the use of parametric statistical analysis, particularly the independent samples t-test, was considered appropriate for examining differences in learning outcomes between the experimental and control groups. The results of the normality and homogeneity calculations are presented in Table 2.

Table 2. Normality and Homogeneity Test Results

Test	Grup	Statistic	Sig
Kolmogorov – Smirnov	Exsperimen	0.112	0.200
	Control	0.135	0.150
Leven	Combined	1567	0.120

Hypothesis Testing

Hypothesis testing was conducted using an independent samples t-test to examine differences in posttest scores between the experimental and control groups. The results showed a calculated t value (t_h) of −2.742 with 58 degrees of freedom and a significance value of 0.004. At a significance level of 0.05, the critical t value (t_t) was 2.002. Since the absolute value of the calculated t was greater than the critical value ($|-2.742| > 2.002$) and the significance value was less than 0.05, the null hypothesis (H_0) was rejected (Kadir, 2021). This indicates a statistically significant difference in mathematics learning outcomes between the two groups.

The negative sign of the calculated t value indicates that the mean score of the experimental group was higher than that of the control group when the comparison order was reversed in the statistical output. This difference confirms that students who learned using the Simple Soroban application achieved better results than those who received conventional instruction.

In addition, the effect size analysis yielded a Cohen’s d value of 1.78, which falls into the large effect category. This result suggests that the use of the Simple Soroban application had a strong effect on students’ mathematics learning outcomes.

According to Cohen’s classification criteria, an effect size greater than 0.80 is considered large. Therefore, the effect size obtained in this study indicates a very strong practical impact of the Simple Soroban application on students’ mathematics learning outcomes. This finding suggests that the intervention not only produced statistically significant results but also demonstrated substantial educational significance. The results of the hypothesis test using the independent sample t-test are presented in Table 3.

Table 3. Independent Samples *t*-Test Results

Variable	t_h	Df	Sig	Mean Difference	t_t
Posttest	−2.742	58	0.004	−16.77	2.002

DISCUSSION

The findings of this study indicate that the use of the Simple Soroban application has a significant positive effect on students’ mathematics learning outcomes, particularly in integer operations. Based on the statistical analysis of the posttest results, students in the experimental group demonstrated better achievement compared to those in the control group who experienced conventional learning. The experimental group not only achieved higher mean scores but also showed a notable increase in classical learning mastery, with an improvement of 26.77%. This result suggests that the integration of digital abacus-based learning media can meaningfully support students’ understanding of mathematical concepts and improve their learning performance.

The improvement observed in the experimental group can be interpreted as the result of the visual and interactive learning environment provided by the Simple Soroban application. Integer operations are often perceived as abstract and difficult by junior high school students because they involve symbolic manipulation and conceptual reasoning related to positive and negative numbers. When students rely solely on conventional explanations or procedural rules, they may memorize steps without fully understanding the underlying numerical relationships. The use of digital manipulatives, such as the virtual beads in the Simple Soroban application, allows students to observe numerical changes directly and connect symbolic operations with visual representations. This visual support helps reduce cognitive load and enables students to construct meaning more effectively when solving integer problems.

Another possible explanation for the improved learning outcomes is the opportunity for active exploration provided by the application. During the learning process, students in the experimental group were not merely passive recipients of information but were actively involved in manipulating the digital soroban to perform calculations and verify their answers. This interactive engagement allows students to experiment with different numerical operations and immediately observe the consequences of their actions. As a result, students can gradually develop a deeper conceptual understanding of integer relationships rather than relying exclusively on memorized procedures. This interpretation is consistent with the view that visual manipulatives can strengthen conceptual understanding in mathematics learning(Wardanu et al., 2025)

The learning activities supported by the Simple Soroban application also reflect important cognitive processes described in Bloom’s taxonomy (Program & Pendidikan, 2022). Students initially recall basic number concepts (C1), then interpret the relationships between numbers through bead manipulation (C2), and finally apply these concepts to solve structured mathematical problems (C3). The application, therefore, facilitates a learning process that moves beyond simple memorization toward meaningful understanding and application. In addition, the learning environment created during the intervention encouraged students to participate actively, explore numerical relationships, and correct their own errors. Such learning conditions are consistent with constructivist learning principles, which emphasize that knowledge is actively constructed through interaction with learning materials and experiences.

The findings of this study are also consistent with previous research reporting positive effects of abacus-based learning media on students' mathematical performance. For example, Pahmi et al., (2023) reported that abacus-based instructional approaches could improve students' achievement in mathematics learning. Similarly, Nova Fitrianingsih et al. (2023) found that the integration of discovery learning assisted by the Simple Soroban application achieved 85.18% classical mastery among elementary school students. Research conducted by Aripen (2021) also reported a significant improvement in students' numeracy skills using abacus media, with a t value of 19.09 indicating strong statistical significance. These studies provide supporting evidence that abacus-based learning tools can enhance students' mathematical understanding and performance.

However, the present study contributes additional insight by demonstrating that the effectiveness of soroban-based learning media is not limited to elementary school contexts. While many previous studies focused on basic arithmetic learning in primary education, this research shows that the Simple Soroban application can also support learning at the junior high school level, particularly for integer operations. At this level, students encounter more complex mathematical concepts that require stronger conceptual understanding. The positive results obtained in this study indicate that digital soroban media can help bridge the gap between concrete representations and abstract mathematical reasoning.

The effectiveness of the application may also be influenced by several learning features embedded in the system. One feature that appeared to play an important role is the challenge mode, which integrates game-like elements such as levels, scores, and timed tasks into the learning process. These elements may increase students' motivation and encourage them to practice repeatedly to achieve better results. Increased motivation and engagement can lead to longer practice time and greater persistence when solving mathematical problems, which ultimately contributes to improved learning outcomes.

Another feature that supports learning effectiveness is the availability of an offline tutorial function. This feature allows students to access instructional materials and practice activities even in environments with limited internet connectivity. In many educational contexts, especially in semi-rural areas, technological infrastructure may still present challenges for fully online learning. The offline accessibility of the Simple Soroban application, therefore, provides a practical advantage by ensuring that students can continue learning independently without technological interruptions. This accessibility may have contributed to the consistent practice observed during the intervention period.

In addition, the application provides immediate feedback for each student's response. Immediate feedback plays an important role in effective learning because it enables students to quickly identify errors and adjust their strategies when solving problems. During the implementation of the intervention, students in the experimental group were observed to be more willing to attempt multiple solutions and to refine their answers after receiving feedback from the application. This process of trial, correction, and reflection may help strengthen students' procedural accuracy as well as their conceptual understanding.

From a theoretical perspective, the results of this study also support the Technological Pedagogical Content Knowledge (TPACK) framework, which emphasizes the integration of technology, pedagogy, and subject matter knowledge in effective teaching(Maulida, 2026). In this study, the Simple Soroban application was not used merely as a technological supplement but was integrated into the instructional process as a tool to facilitate conceptual exploration of integer operations. The teacher guided students in using the application, encouraged discussion of problem-solving strategies, and reinforced key mathematical ideas. This alignment between technological tools and pedagogical strategies illustrates how digital media can be effectively integrated into mathematics instruction.

In practical terms, the findings of this study have important implications for mathematics teachers, particularly within the implementation of the Merdeka Curriculum Phase D. Teachers are encouraged to adopt learning media that promote active student engagement and conceptual understanding. The Simple Soroban application offers an accessible and user-friendly digital learning medium that can complement conventional instructional approaches. Its use is especially relevant for topics such as integer operations, where students frequently experience conceptual difficulties (Erawati & Wulan, 2025). By integrating this application into classroom activities, teachers can create learning experiences that are more interactive, engaging, and aligned with student-centered learning principles.

Despite these positive findings, several limitations should be acknowledged. The study employed intact classes without full randomization, which may influence internal validity. In addition, the research was conducted in a single school context, which may limit the generalizability of the results. Differences in educational environments, student characteristics, and technological resources in other schools may produce different outcomes.

Another limitation is that this study primarily examined cognitive learning outcomes, while other important aspects, such as students' motivation, attitudes toward mathematics, collaboration skills, and digital literacy, were not analyzed in detail (Maryanti & Asmara, 2025). These dimensions are important components of comprehensive learning and may also be influenced by the use of digital learning applications.

Future research is therefore recommended to expand the scope of investigation by involving multiple schools and more diverse student populations. Longitudinal studies may also provide valuable insight into the long-term retention of mathematical understanding developed through the use of the Simple Soroban application. In addition, future studies may explore the integration of adaptive learning systems or artificial intelligence to personalize learning experiences according to students' individual needs.

Overall, the results of this study provide empirical evidence that the Simple Soroban application can serve as an effective digital learning medium for improving students' understanding of integer operations. By providing visual representations, interactive learning experiences, and immediate feedback, the application supports meaningful mathematical learning and encourages more active student engagement. These findings contribute to the growing body of research on technology-enhanced mathematics education and highlight the potential of digital manipulatives to support conceptual learning in secondary school contexts.

CONCLUSION AND SUGGESTIONS

This study concludes that the Simple Soroban application has a significant positive effect on seventh-grade students' mathematics learning outcomes, particularly in the topic of integer operations. Using a posttest-only control group design, the independent samples t-test revealed a statistically significant difference ($p < 0.05$) between the experimental group that used the application and the control group that received conventional instruction. The experimental group achieved a higher mean posttest score (82.67) compared to the control group (65.90), with an improvement in classical learning mastery of 26.77%. These results indicate that visual digital learning media can effectively support students' conceptual understanding of mathematical concepts. The effectiveness of the Simple Soroban application lies in its visual, manipulative, and interactive features, which help students understand abstract number concepts more concretely. In the context of this study conducted at SMP Negeri 2 Purbolinggo, the application not only increased students' active participation but also facilitated computational processes through digital bead representations.

Based on these findings, mathematics teachers are encouraged to integrate the Simple Soroban application into classroom instruction through structured learning modules that support interactive and student-centered learning. Schools are also recommended to provide adequate digital devices and infrastructure to support the effective implementation of digital learning. Future research is recommended to examine the implementation of the Simple Soroban application across different mathematical topics and educational levels using larger and more diverse samples. Further studies may also explore hybrid instructional approaches that combine conventional and digital media, investigate long-term learning effects, and examine students' affective and motivational aspects alongside cognitive learning outcomes.

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