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Enhancing Elementary Numeracy Skills Through Visualization-Based Accelerated Learning Cycle

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ABSTRACT

Basic arithmetic skills are foundational for elementary education, yet many students struggle to grasp core mathematical concepts. Innovative teaching methods, such as visualization-based learning, may help address this issue by promoting conceptual understanding and critical thinking. This quasi-experimental study employed a Nonequivalent Control Group Design to evaluate the effectiveness of a visualization-based accelerated learning cycle on fourth-grade students' arithmetic abilities. A purposive random sampling technique was used to assign 60 students into two groups: an experimental group (n = 30) and a control group (n = 30). Posttest results analyzed using a t-test indicated that the experimental group outperformed the control group, with an average score of 75.64 compared to 69.68. These findings suggest that visualization-based instruction can significantly enhance mathematical numeracy skills. The results demonstrate that visualization strategies support the acquisition of arithmetic concepts and foster critical thinking. The improved performance of the experimental group highlights the potential of this approach in elementary mathematics instruction. Visualization-based learning appears to be an effective method for improving arithmetic skills among elementary students. Its integration into classroom instruction could enhance learning outcomes, especially if supported by equitable access to technology. Future studies should investigate the long-term effects of this approach and include larger, more diverse samples.

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1. INTRODUCTION

Basic mathematics education plays a crucial role in forming the intellectual foundation of students, both in academic life and in applying mathematical concepts in the real world (Cargnelutti, Tomasetto, & Passolunghi, 2017). From primary education, basic arithmetic skills such as addition, subtraction, multiplication, and division become the foundation for the development of further mathematical skills (Gunderson, Park, Maloney, Beilock, & Levine, 2018). These skills are important for academic success in mathematics but also have broad implications for developing cognitive abilities and more complex problem-solving skills. According to various studies, these abilities significantly influence students' performance at higher education levels and the application of mathematics in daily life (Hawes, Moss, Caswell, Naqvi, & MacKinnon, 2017). Therefore, improving basic arithmetic skills is a top priority in primary education.

However, many students struggle to understand these fundamental mathematical concepts despite the long-recognized importance of basic arithmetic skills. Various challenges in teaching basic mathematics often stem from conventional teaching approaches focusing on memorization and algorithmic procedures without a deep understanding of the underlying concepts. This causes many students to struggle to apply basic arithmetic skills effectively (Dorn, Hancock, Sarakatsannis, & Viruleg, 2020). Additionally, teaching methods that tend to be boring and monotonous—such as lectures or isolated exercises—often fail to engage students, thus hindering the development of their skills.. The skills of students in Indonesia in solving mathematical problems still need to improve, as seen from the results of the PISA 2018 (Niklas, Cohrssen, & Tayler, 2016) and TIMSS 2015 (Cokely et al., 2018) studies. Based on the PISA 2018 survey results, the mathematics score of students in Indonesia was 379, still far below the international average score of 489. Student achievement in Indonesia still needs to improve regarding the ability to solve non-routine problems. This is evident from Indonesian students only being able to solve level 1 and level 2 questions out of 6 levels (the highest) provided by PISA. Meanwhile, according to TIMSS 2015, the mathematics score of students in Indonesia reached 397, still far below the international score of 500. This shows that the skills of students in Indonesia in solving mathematical problems still need to be improved, so they must be reviewed so that students can enhance their skills in solving problems.

Students at various levels of primary education often face similar difficulties in mastering basic arithmetic skills. The main cause of this issue is the imbalance between teachers' teaching methods and students' cognitive needs in understanding basic mathematical concepts. Many teaching methods still focus on memorizing calculation procedures without emphasizing a deep understanding of the underlying concepts. For example, students are generally given repetitive and algorithmic exercises without approaches that allow them to understand the fundamental principles behind these arithmetic operations. This often leads to a low understanding of basic mathematics, causing them to struggle with more complex problems in the future. Additionally, in many cases, many students struggle to keep up with the standardized pace of classroom learning, especially those who require special attention. The lack of technology or innovative approaches in mathematics education, such as visualization, further exacerbates this difficulty. Visualization-based approaches could be an effective solution to help students understand mathematical operations more concretely. However, although visualization has been applied in some advanced mathematics research, its implementation in enhancing basic arithmetic skills at the primary education level is still not optimal, thus opening opportunities for further research.

Given Indonesia's low level of numeracy, it is critical to cultivate numeracy literacy through daily activities. In this case, there is a difference between mathematics and numeracy in terms of empowering knowledge and skills. Literacy skills are closely related to the reflective thinking process, a critical thinking process used to make decisions (Raghubar & Barnes, 2017). In addition, several studies have shown that a dialogical approach involving reflective exercises can help build literacy skills (Anobile et al., 2018). Reflective thinking is a high-level talent that can encourage children to think critically, making it easier to improve their reading skills and overcome complex challenges (Huang, Zhang, & Hudson, 2019). The mathematics learning process aims not only to demand high grades in learning but also to make students ready to solve a mathematics problem. Mathematics learning can be an environment that causes someone to carry out mathematics learning work. So, the mathematics study is centred on teachers involving student learning activities (Maass, Geiger, Ariza, & Goos, 2019). Teachers are the most important figures and make good contributions to the world of education. The results of research by (Saefurohman et al., 2021) stated that students' problem-solving abilities still need to improve because students need to understand information, are less able to create mathematical models and are less careful in solving problems. Then, (Sobkow, Fulawka, Tomczak, Zjawiony, & Traczyk, 2019) showed that students' mathematical problem-solving abilities, especially elementary school students, still need to improve, especially in terms of understanding problems and re-checking. This is reinforced by research by (Chiu, 2018), which states that problem-solving abilities are based on Polya's steps in low-ability subjects using the creative problem-solving learning model. In addition, internal factors from students can also be the cause of students' low mathematical problem-solving skills, including mathematical habits of mind, which are defined as a unique way to approach mathematical problems and think about mathematical concepts that resemble the methods used by mathematicians (Mercader, Miranda, Presentación, Siegenthaler, & Rosel, 2018). Students who have MHoM will find it easy to solve problems and think of strategies for solving them to support improving student knowledge.

Based on observations made by researchers in one of the elementary schools in the Sumenep district, mathematical problem-solving still needs to improve, especially since most of the fourth-grade students who achieved the minimum completion criteria were only 75% with a score of 65 to 70. Students at the school have difficulty thinking critically, are too anxious to face mathematics learning, feel insecure about being active in learning activities, and are afraid of being wrong if they express their opinions. This may be due to the learning model implemented in the classroom needing to get students used to expressing their views, and learning activities are centred only on the teacher. Moreover, if students are asked to work on questions, express opinions, or ask the teacher, they wait to respond. According to (Nelson & McMaster, 2019), in mathematics learning, it is necessary to eliminate students' negative perceptions of mathematics because this will hinder students' cognitive structure in digesting the material to be given. Not only is a positive attitude needed in the learning process, but problem-solving skills are also one of the focuses of mathematical literacy, which hinders students' mathematical literacy abilities. In dealing with these problems, changes in student treatment are needed, such as forms of learning that can support students to create positive perceptions of mathematics and, at the same time, help students develop their problem-solving abilities during learning.

An alternative that is applied to foster problem-solving abilities in mathematics learning is to use the Accelerated Learning Cycle learning model. The right learning model will encourage enthusiasm, pleasure, and comfort in learning. According to (Kusuma, Rahmawati, & Ramadoni, 2020), the Accelerated Learning Cycle Learning Model can be a learning model that creates a meaningful learning zone and encourages positive things so that students can change their learning perceptions. The Accelerated Learning Cycle learning model has stages of activities so that learning can hold competence in learning by playing a full role in life.

This Accelerated Learning Cycle learning model has 5 phases, namely the preparation phase, the connection phase, the creative presentation phase, the activation phase and the integration phase (Kinard & Parker, 2007). The advantages of the Accelerated Learning Cycle learning model emphasize the principle of creative learning rather than consuming; it gives students positive emotions in accepting the learning process (Mutaf-Yıldız, Sasanguie, De Smedt, & Reynvoet, 2020). Each phase will achieve specific goals that will support a better learning process. Their research (Gregory et al., 2019) explained that to develop problem-solving skills in students, the accelerated learning cycle is a learning mechanism that has a significant influence. Meanwhile, according to (Muhaimin, Dasar, & Kusumah, 2023), the accelerated learning cycle influences students' problem-solving abilities, improving problem-solving skills and problem-solving in line with increasing skills in students' mathematical literacy.

In addition to the learning model, the approach to learning will also support the achievement of learning objectives. Abstract mathematics learning requires an appropriate approach so that students can master mathematical skills; one solution is to use a visualization approach. According to (Abbas & Bito, 2024) explains that the visualization approach fosters a positive response to the lesson. This will support the accelerated learning cycle model's achievement and help students' mathematical literacy skills. Through the visualization approach, students can make mathematics abstract so that it is simpler to understand the lesson. Good understanding aligns with problem-solving so students can connect mathematical concepts and solve similar problems (Megawati & Sutarto, 2021). This means that visualization makes it easier for students to solve mathematical problems. Applying the accelerated learning cycle model using a visualization approach supports students' mathematical literacy skills. In addition to external factors, internal factors supporting students' mathematical literacy skills are students' mathematical habits of mind. The application of the accelerated learning cycle model with a visualization approach to mathematical literacy skills seen in literacy skills will show how the learning model contributes to students' low literacy skills.

This study aims to explore and analyze the effectiveness of implementing a visualization-based accelerated learning cycle in enhancing basic arithmetic skills among primary school students. Specifically, this research has several objectives: first, to evaluate the effectiveness of the visualization-based accelerated learning cycle in improving basic arithmetic skills in primary school students. Second, to identify the impact of visualization on students' understanding of basic mathematical concepts and the application of basic arithmetic skills. Third, to provide insights into the potential use of the visualization-based accelerated learning cycle as a method that can be adapted and applied in the context of primary education. Through these objectives, this study aims to contribute practically and theoretically to the field of mathematics education, particularly in applying more innovative and effective teaching methods.

Although various studies discuss the use of visualization in mathematics education and accelerated learning, there is still a lack of literature that systematically and integratively combines these two approaches to enhance students' basic arithmetic skills. Most existing research focuses more on using visualization in the context of advanced mathematics learning or contexts outside of mathematics classrooms. These studies highlight that the application of visualization technology in solving more complex problems while using visualization to address students' difficulties in mastering basic arithmetic skills remains limited. Additionally, although some studies examine accelerated learning, research linking it with visualization techniques in the context of basic mathematics is almost non-existent. Most accelerated learning research focuses more on learning models that generally speed up students' learning time without utilizing visualization elements to enhance the understanding of basic mathematical concepts. Therefore, this study fills the gap by integrating these two approaches into a learning cycle designed to improve students' basic arithmetic skills.

This study offers a significant new aspect by combining a visualization-based accelerated learning cycle into a systematic approach. This visualization-based accelerated learning cycle has the potential to become a highly relevant and innovative teaching method in enhancing basic arithmetic skills by paying more attention to individual students' needs and providing space for them to accelerate the learning process according to their abilities. The importance of this research lies in its contribution to a deeper understanding of how visualization elements can be used to accelerate and deepen the understanding of basic mathematical concepts, thereby opening opportunities for developing more effective teaching methods in primary education. Additionally, this study provides important insights for educators to adapt visualization techniques and use accelerated learning approaches to improve the quality of mathematics education.

2. METHODS

The type of research used in this study is a quasi-experiment with a Nonequivalent Control Group Design research approach. In the quasi-experimental method, researchers try to determine whether a treatment affects the results of a study. This research design was chosen because it allows the researcher to compare non-randomized experimental and control groups, which is more practical to implement in the context of primary education within existing classrooms (Creswell, 2014). The Nonequivalent Control Group Design is a quasi-experimental design used when the experimental and control groups are not randomly selected. In this study, two groups of students, each receiving different treatments, will be compared. The experimental group will follow a visualization-based accelerated learning cycle, while the control group will follow mathematics instruction using a conventional approach focusing more on traditional teaching methods without visualization support. The use of this design allows for the identification of differences in basic arithmetic skills between the two groups after the treatment. During the design, the experimental and control groups were compared, but samples were not taken in all directions, and only the experimental group was treated. After in-depth observation, the two groups received a pretest and were given the last treatment, a posttest.

The overall population of this study was 60 4th-grade elementary school students. Fourth-grade students were chosen as the population because they have reached a cognitive development level that allows them to begin learning basic arithmetic skills more deeply, and they are also familiar with basic mathematical concepts. The sample in this study consists of 60 students, divided into two groups: the experimental group, consisting of 30 students, and the control group, also consisting of 30 students. The selection of this sample size is based on practical considerations and the need to obtain sufficiently representative data and ensure that the statistical analysis used (particularly the t-test) can provide valid and reliable results. Although the sample groups are not randomized, the researcher ensures that both groups have similar characteristics in terms of initial mathematical ability, which can be measured through a pre-test or initial observation before the experiment begins. This aims to minimize bias arising from differences in the basic characteristics between the experimental and control groups.

The data collection technique in this study was a test as a benchmark for students' problem-solving numeracy abilities, and a questionnaire was used to determine students' responses to mathematics learning using the Accelerated Learning Cycle learning model. The test instrument in this study was made in the form of descriptive questions to require students to answer in detail so that the thinking process, accuracy, and systematics can be evaluated to generate creativity and positive activity because the test requires students to think systematically, express opinions and arguments, and link relevant facts. The questionnaire instrument was used to determine how students expressed their interest in learning before and after using the Accelerated Learning Cycle learning model. Additionally, the visualization data used in the learning cycle is collected by recording students' interactions with visualization materials during the learning process. Students in the experimental group will be allowed to work with various visual aids (such as diagrams, images, and visual-based mathematics applications) to support their understanding of basic mathematical concepts. This visualization data is used to assess how effective the visual aids are in helping students understand and master basic arithmetic skills. This process also helps researchers evaluate the level of student engagement and the effectiveness of visualization techniques in the context of accelerated teaching.

The data analysis technique for this study used prerequisite tests consisting of (1) a normality test with a One-Sample Kolmogorov-Smirnov Test, (2) a homogeneity test with a Test Of Homogeneity Of Variance, and (3) a hypothesis test with an independent t-test for N-Gain Score assisted by SPSS version 25.0 for windows. Thus, this Research Method section details the steps taken in conducting the research, starting from the research design, population and sample, data collection techniques, instruments used, and data analysis techniques. This method ensures that the research is conducted systematically, validly, and scientifically accountable.

3. FINDINGS AND DISCUSSION

The study's results will discuss the research conducted by researchers, starting with the differentiation of the average value of students' mathematical numeracy abilities using the Accelerated Learning Cycle model based on visualization. Before answering the formulation of the problem carried out by researchers, a prerequisite test was carried out first, namely: normality test (to test that the data used is standard data so that testing can be carried out), homogeneity test (to find out whether the two variations are the same or not), average similarity test (to find out whether the average of the two samples is the same or not).

Table 1. Pre-test vs post-test Scores

No	Statistics	Experimental Class		Control class	
		Pretest	**Posttest**	**Pretest**	**Posttest**
1	Number of Students	30	30	30	30
2	Average	12.88	82.41	11.22	75.78
3	Standard Deviation	7.32	4.54	6.89	4.11
4	Minimum score	21		21	
5	maximum score	89		78	

Table 1 explains the mathematical numeracy ability of students taught with the accelerated learning cycle learning model based on visualization, showing an increase with a dominance in the medium category of 66.67%. Descriptively, there is a difference in the post-test scores between the two classes. From the post-test results, the average value of the experimental class was 82.41, with a maximum score of 89. At the same time, the average value of the control class was 75.78, with a maximum score of 78. So, the problem-solving numeracy ability of the experimental class has a mean value higher than that of the control class. However, inferentially, further testing is needed.

Table 2. Normality Test Data

Tests of Normality				
	Class	**Kolmogorov-Smirnov**		
		Statistic	**df**	**Sig.**
Posttest	Experiment	.157	28	.138
	Control	.133	27	.200

Based on the SPSS test in Table 2, the significance value for the control class is 0.2 > 0.05, meaning the data is usually distributed. A significance value of 0.138 > 0.05 was obtained for the experimental class, meaning the experimental class data is generally distributed. Therefore, both sample classes are declared generally distributed to be used for further research using the homogeneity test.

Table 3. Homogeneity Test Data

Test of Homogeneity of Variances			
Posttest			
Levene Statistic	df1	df2	Sig.
.098	1	54	.757

Based on the SPSS calculation in Table 3, the sig value is 0.757 > 0.05, meaning there is no difference in the variance of the post-test data. The mathematical numeracy ability between the experiment and the control is homogeneous. After the data meets the prerequisite test, which is usually distributed and homogeneous, the hypothesis test is carried out using the independent t-test for the N-Gain score.

Table 4. t-test Results

	Class	**Average**	**N-gain (%)**	t_{count}	t_{table}
Posttest	Experiment	75.64	80.06	2.394	1.665
	Control	69.68	69.97		

The results of the post-test t-test showed that the average score of the experimental class's mathematical numeracy ability test was 75.64, and the average score of the control class's mathematical numeracy ability test was 69.68, so it can be concluded that the average score of the experimental class's mathematical numeracy ability was higher than that of the control class. The table shows a significant difference in the influence of mathematical numeracy ability between students learning using the Accelerated Learning Cycle model based on visualization and the conventional model in grade 4 of elementary school.

Discussion

This study aims to test the effectiveness of a visualization-based accelerated learning cycle in improving the basic arithmetic skills of fourth-grade elementary school students. The results show that the experimental group receiving the visualization-based accelerated learning cycle experienced a significant improvement in basic arithmetic skills compared to the control group receiving conventional instruction. These findings align with previous research indicating that using visualization in teaching mathematics can enhance the understanding of complex mathematical concepts (Hoogland, 2016; Sa'dijah et al., 2023). As a cognitive aid, visualization allows students to process information more concretely, reduce cognitive load, and help them understand the relationships between more abstract concepts (Iswara, Ahmadi, & Da Ary, 2022). Furthermore, research by (Gunderson et al., 2018; Von Hippel et al., 2018) shows that visualization approaches facilitate students in understanding lessons and developing critical thinking skills.

The accelerated learning cycle consists of five phases to help students solve problems, which are the core of mathematical numeracy skills: first, the preparation phase, where students are prepared to focus on the lesson. The second phase is the connection phase, where students can express their opinions about the lesson material. This will create confidence and emotional connection in students. The third phase is the creative presentation phase, where students will learn in groups accompanied by the teacher. Students will be guided to discover and develop concepts. The fourth phase is the activation phase, where students use their creativity and abilities to solve given problems. In the fifth phase, students and teachers reflect on and appreciate the students' achievements in learning (Dorn et al., 2020).

In addition to the above approach, the visualization approach, which consists of four stages, facilitates students in solving problems. The first stage is visualization, where students are guided to identify concepts using provided images or illustrations. The second stage is representation, where students are guided to represent concepts using images or symbols. The third stage is abstraction, where students can restate or conclude a concept they have learned. The fourth stage is schematization, where students can use the ideas they have found. Specifically, in the context of this study, the visualization used during the accelerated learning cycle includes graphical representations of basic mathematical concepts such as number diagrams, area models for multiplication, and division visualizations using physical objects and images. This supports the cognitive theory that visual learning can accelerate the understanding of mathematical concepts, especially in children at the concrete operational stage of development (Bailey et al., 2017). This study's results confirm that visualization can strengthen the mental connections between mathematical concepts and visual representations, making it easier for students to apply basic arithmetic skills.

Furthermore, data analysis shows that although there was an improvement in both groups, the significant difference in the increase in basic arithmetic test scores between the experimental and control groups indicates that visualization-based learning provides additional benefits in accelerating understanding. Although the control group also showed improvement, it was not as rapid or as significant as the improvement in the experimental group. This leads to the conclusion that visualization helps students understand concepts and retain that information in the long term (Niklas et al., 2016).

The results of this study have significant implications for existing theories in the field of mathematics learning. Theoretically, these findings reinforce the constructivist view that the best learning occurs when students construct knowledge through direct experience and meaningful representation (Ambusaidi & Al-Naqbi, 2014). In this case, using visualization in the accelerated learning cycle creates an active learning experience for students, where they not only passively listen to information but actively transform mathematical information into visual forms that are easier to understand and remember. From a cognitive theory perspective, this study also emphasizes the importance of reducing cognitive load in mathematics learning. (Kusuma et al., 2020) argues that visualization can help students reduce cognitive load by presenting information in a more easily processed format. This is evident in the findings of this study, where students receiving visualization-based learning were able to solve fundamental math problems more quickly and accurately compared to those learning using conventional methods. Thus, this study contributes to developing theories underlying mathematics learning and using visual aids in elementary education.

The practical implications of these findings are highly relevant for teaching in elementary schools. In practice, the results of this study indicate that integrating visualization into mathematics learning can improve students' basic arithmetic skills. Therefore, mathematics teaching at the elementary school level should consider visual aids as part of a broader teaching strategy. Teachers can adapt their curriculum's visualization-based accelerated learning cycle to help students understand mathematical concepts more concretely and enjoyably (Sa'dijah et al., 2023). This also opens opportunities for schools to adopt digital technology in mathematics learning, which has been proven effective in enhancing students' thinking and problem-solving skills (Megawati & Sutarto, 2021). Thus, these findings provide important insights into mathematics learning theory and offer practical solutions for improving the quality of teaching in elementary schools. Therefore, this study makes a significant contribution both theoretically and practically.

Although the findings of this study provide important contributions, several limitations must be considered. One of the main limitations is the relatively small sample size, which is only 30 students divided into two groups. Although this sample size is sufficient for fundamental statistical analysis, the results of this study may not be fully generalizable to the entire population of elementary school students, especially if demographic or socio-economic factors play a role in influencing the results. Further research with more extensive and diverse samples from various socio-economic backgrounds will provide a more comprehensive picture of the effectiveness of the visualization-based accelerated learning cycle in various contexts. Additionally, the limitation of the study duration is another factor to consider (Anggraini 2019). This study only involved one learning cycle, which was relatively short. Therefore, the findings obtained may not reflect the long-term impact of the visualization-based accelerated learning cycle on students' basic arithmetic skills. Further research involving long-term interventions and continuous monitoring will better evaluate the sustainability of these skill improvements over time. Furthermore, although the instruments used to measure basic arithmetic skills have been validated, external factors such as student motivation or parental involvement influence the results of the basic arithmetic test. The researchers have attempted to control these factors, but there may still be influences from external variables that cannot be fully controlled in this study.

Based on the identified limitations, there are several suggestions for future research. First, to enhance external validity, future research should involve more extensive and diverse samples regarding the number of participants and their demographic characteristics. This will allow for a deeper exploration of whether the visualization-based accelerated learning cycle has similar effects on a broader population. Second, future research should examine the long-term impact of implementing the visualization-based accelerated learning cycle on basic arithmetic skills. Long-term research will provide more comprehensive information about the sustainability of the method's effectiveness and whether students will maintain the improvements in basic arithmetic skills observed during the learning cycle over a more extended period. Third, to further develop the understanding of the effectiveness of visualization in mathematics learning, future research can test various forms of visualization, such as dynamic or interactive visualizations involving digital technology. This research can provide insights into the visualization types that most effectively support mathematical understanding in various learning contexts.

The findings of this study have important social and ethical implications, especially in the context of using digital technology in learning. One major issue is the gap in access to technology between students from families with limited access to digital devices and those with greater access. Although technology-based visualization can provide significant benefits in accelerating mathematical understanding, students from less privileged families may be unable to utilize this method optimally without equal access. Therefore, implementing technology in learning must be accompanied by policies that ensure equal access for all students, regardless of their socio-economic background. Additionally, the ethical aspects of using technology must also be considered. Digital learning tools must ensure that student data is protected and used ethically without the risk of misuse of personal information. In this regard, educational institutions must ensure that all learning technologies comply with strict privacy and data protection guidelines.

On the other hand, using visualization in mathematics learning can help include students with special needs or learning difficulties, such as dyslexia or other cognitive challenges. Visualization allows for representing mathematical concepts in a more accessible format, which can help reduce the difficulties these students face in understanding mathematical material. Overall, this study's social and ethical implications indicate that the use of educational technology, such as visualization in mathematics learning, has the potential to level the educational playing field but also demands attention to issues of access inequality and student data protection. Thus, this study significantly contributes to mathematics learning theory and provides practical guidance for teaching mathematics in elementary schools. However, further research is needed to explore the long-term impact of using visualization in mathematics learning and to ensure that educational technology is accessible to all students fairly and ethically.

4. CONCLUSION

Theoretically, this study enriches the understanding of how visual aids, such as diagrams, area models, and other graphical representations, can support essential mathematics learning. Practically, the results of this study indicate that the use of visualization can be an effective strategy to improve basic arithmetic skills in elementary school students while also providing guidelines for teachers to integrate technology and visual aids into their teaching practices. However, this study also identifies limitations that need to be considered, including the small sample size and limited study duration, which affect the generalization and sustainability of these findings. To strengthen the external validity of these findings, future research should involve more extensive and diverse samples, including students from various geographical regions and socio-economic backgrounds. Research with more representative samples will provide a more comprehensive picture of the effectiveness of the visualization-based accelerated learning cycle in broader contexts. Long-term research is needed to assess the sustainability of the improvements in basic arithmetic skills resulting from using the visualization-based accelerated learning cycle. This research should include continuous monitoring to evaluate whether the improvements recorded at the end of the learning cycle are maintained in the long term. Overall, this study provides valuable new insights into mathematics education, demonstrating the great potential of the visualization-based accelerated learning cycle in enhancing basic arithmetic skills. The results of this study have the potential to encourage the development of more innovative and inclusive curricula and significantly contribute to mathematics teaching in elementary schools.

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