Volume : 1 | Issue : 4 | Received-26-06-2025 | Accepted-01-07-2025 | Published-07-07-2025

UAI JOURNAL OF MULTIDISCIPLINARY & CULTURAL STUDIES (UAIJMCS)

Abbreviated Key Title: UAI J Mult Cul Stu.

ISSN: 3049-2351 (Online)

Journal Homepage: https://uaipublisher.com/uaijmcs-2/

Volume- 1 Issue- 4 (July-August) 2025

Frequency: Bimonthly

M.A.T.H. Mastery: Maximizing Arithmetic Thinking through Heuristics (Visual Representation, Practice, and Repetition) as Learning Strategies

Aileen Mae Mata- Darisan

Teacher I DepEd, Sabangan Elementary School, Calanasan Apayao, CAR, Philippines Master of Arts in Education major in Educational Management Cagayan State University-Sanchez Mira campus

Corresponding Author: Aileen Mae Mata- Darisan

Teacher I DepEd, Sabangan Elementary School, Calanasan Apayao, CAR, Philippines Master of Arts in Education major in Educational Management Cagayan State University-Sanchez Mira campus

ABSTRACT

This study examined the impact of heuristic strategies—specifically visual representation, repetitive practice, and structured learning—on enhancing mathematical understanding among elementary students. Anchored on the premise that traditional instruction alone may not fully address learners' arithmetic difficulties, this research sought to determine whether heuristic-based strategies could significantly improve student performance. The study employed a quasi-experimental design involving Grade 6 students of Sabangan Elementary School in Calanasan, Apayao, divided into control and experimental groups. A pre-test and post-test were administered to both groups to assess performance before and after the implementation of heuristic interventions. Findings revealed that students exposed to visual representation and repetitive practice showed statistically significant improvements in their post-test scores, compared to those in the control group. Notably, Cohen's d values indicated large effect sizes for all three strategies: visual representation, repetitive practice, and structured learning—highlighting the substantial practical impact of these interventions on learners' mathematical performance. Although structured learning strategies also led to improved scores, they did not produce statistically significant differences between the groups. Moreover, the study found a significant relationship between students' performance and certain demographic variables such as parents' educational attainment and occupation, suggesting that socio-economic context plays a contributory role in academic outcomes. The study concludes that heuristic strategies, particularly visual representation and repetition, are highly effective in enhancing arithmetic thinking and should be integrated into mathematics instruction, especially for young learners in low-resource settings. These findings offer valuable insights for educators, curriculum developers, and policymakers in optimizing teaching methods to improve mathematical literacy.

KEY WORDS: Arithmetic Thinking, Heuristics, Learning Strategies, Practice, Repetition, Visual Representation

***This work is licensed under** a Creative Commons Attribution-NonCommercial 4.0 International License.*

DOI: 10.5281/zenodo.15828123

Volume : 1 | Issue : 4 | Received-26-06-2025 | Accepted-01-07-2025 | Published-07-07-2025

INTRODUCTION

In contemporary mathematics education, the emphasis on effective teaching methodologies has intensified, particularly focusing on strategies that enhance students' comprehension and retention of mathematical concepts. Among these, visual representation, deliberate practice, and repetition have been identified as pivotal components. This study aims to investigate the impact of these pedagogical approaches within the context of Calanasan, Apayao providing insights into their applicability and effectiveness in local educational settings.

Visual representation serves as a bridge between abstract mathematical ideas and students' tangible understanding. The Concrete-Pictorial-Abstract (CPA) approach exemplifies this strategy by transitioning learners from hands-on manipulation of objects to visual representations, and finally to abstract symbols. Leyson and Andrino (2025) demonstrated that implementing the CPA approach significantly enhanced pupils' performance in mathematics, suggesting its efficacy in fostering deeper conceptual understanding.

The role of practice and repetition in learning is well-documented. Game-based learning applications have emerged as effective tools in this regard, providing interactive platforms for students to engage in repetitive practice. Lozano et al. (2023) developed a mobile application designed to help learners practice mathematical patterns and structures. Their study found that incorporating game-based learning principles not only increased student engagement but also improved proficiency in mathematical concepts.

Technological advancements have further expanded avenues for visual representation and practice. Augmented Reality (AR) has been utilized to create immersive learning experiences that enhance understanding and reduce math anxiety. Godoy Jr. (2021) developed an AR-based game as a supplementary tool for senior high school precalculus students, finding that it effectively alleviated math anxiety and improved conceptual grasp.

The falling number of students undertaking STEM-related courses at both secondary and tertiary levels; and poor performance demonstrated in international assessments, like TIMSS, by Malaysian students is disconcerting. In becoming a developed nation, STEM is critical to our educational framework. Our nation's whole economy hinges on mathematics, science, engineering, accounting, business, transportation, geology, and economics. Hence, it is up to primary teachers to instill the significance of STEM into math curriculum. For one, it is possible to enhance mathematical problem-solving skills in school kids. This is as per the definition of STEM literacy, which describes STEM literacy as the capacity to recognize and use concepts and content from science, technology, engineering, and mathematics to comprehend and resolve issues or problems that cannot be solved through any single disciplinary method (Washington STEM Study Group, 2011). The traditional method of teaching mathematics is emphasizing drilling and memorizing facts and procedures. This approach does not promote thinking and problem-solving skills. The majority of students enter higher stages of learning and become rote mathematicians, and fail to see the beauty and significance of mathematics in everyday life. Skills in mathematical word problem solving can be acquired through successful delivery and by using complicated thinking through systematic and effective self-regulation awareness. Mathematics teachers at every level ought to aim to cultivate the abilities of problem solving, reasoning and proof, communication, representation, and connections among their students (NCTM, 2000; 2003). Problem-solving skill approaches and strategies ought not to be focused only on doing activities, but should be holistic and encompass the thinking activity. The requirement for thinking and doing is due to the fact that both share an integrated relationship within the field of problem solving and knowledge (Adeleke, 2007; Cooper & Harries, 2002; Baumert et al., 2010).

According to Fuchs et al. [(2008) and Beyer (1988)], knowledge about mathematical problem solving should not concentrate particularly on sketchy stand-alone solutions, however; it also includes higher-order thinking skills that involve the use of self-regulation awareness, while applying heuristic to intercede with facts and information: Consequently, all the facets of skills, knowledge and awareness, and control of thinking are prior requisite to productive decision making (Calhoon & Fuchs, 2003; Cennamo & Kalk, 2005). This can help learners strengthen their acquisition of understanding concepts, procedural fluency, strategic competence, productive disposition, and adaptive reasoning abilities. In addition, students can make new knowledge, create representations, be more strategic, consider the effects of actions taken and thereby change it, improve attitudes, confidence, perseverance, and persistence, exploration and creativity (Agnes, 2002. With reference to the importance of problem-solving skills and awareness and control of thinking developed in the students' minds, greater focus should be placed on concepts and strategies (Jitendra et al. 2007; Reed, 2001; Rittle-Johnson et al., 2001; Snowman & Biehler, 2011).

It is highly complicated to solve a math problem since it involves multi-step processes under psychological control, verbal processes, understanding, representations, use of diverse heuristics, knowledge of concepts, procedural efficiency, affective responses, awareness of cognitive, metacognitive control, and belief system regarding mathematics (Johnson, 2010). The capabilities of students in solving mathematical word problems depend not only on determining the correct solution but also on being able to comprehend and control more sophisticated skills such as planning, monitoring, and evaluating. Further, students are expected to be able to interpret problems through the use of visual representations and reasoning in working memory. Visual representations are meant to stimulate ideas and enable a better comprehension of a relationship in problem solving (Knight 2000; Stylianou, 2002). All these need students to internalize the knowledge and embrace or possess an awareness of metacognitive and cognitive aspects in a deliberate and systematic manner (Ayres 2006; Butcher et al., 2006).

In the Philippines, innovative educational tools have been developed to address challenges in mathematics learning. One notable example is "Damath," a board game that combines the traditional game of "Dama" (Filipino checkers) with mathematical operations. Developed by Jesus Huenda, a teacher from Sorsogon, Damath has been utilized as a teaching tool in both elementary and high school mathematics, promoting engagement and reinforcing mathematical concepts through interactive play.

The integration of technology in education has further expanded avenues for visual representation and practice. Virtual manipulatives, which are digital versions of physical objects used to teach mathematical concepts, offer dynamic and interactive learning experiences. These tools allow students to visualize and manipulate mathematical elements, thereby deepening their understanding and facilitating exploratory learning.

Moreover, the adoption of structured mathematics programs, such as the PR1ME Mathematics teaching programme, has been

This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

DOI: 10.5281/zenodo.15828123

instrumental in enhancing mathematical proficiency. Based on the teaching practices of top-performing countries in international assessments, PR1ME emphasizes problem-solving and the development of metacognitive skills. Its approach includes the use of visual representations and systematic practice, aligning with the strategies explored in this study.

The significance of these strategies is further underscored by research on dual-coding theory, which posits that combining verbal and visual information enhances learning and memory retention. By engaging multiple cognitive pathways, students are better equipped to understand and recall mathematical concepts, highlighting the importance of incorporating visual elements into instruction.

In the local context of Apayao, there is a pressing need to address the challenges faced in mathematics education. National assessments have indicated that Filipino students often struggle with mathematics, necessitating the exploration of effective teaching methodologies tailored to the local educational landscape. This study aims to investigate how the deliberate application of heuristics: visual representation, practice, and repetition can enhance mathematical understanding among students in this region.

Statement of the Problem

This study examined the impact of heuristics such as: visual representation, practice, and repetition as learning strategies in enhancing mathematical understanding among students in Sabangan Elementary School – Calanasan, Apayao. Specifically, it sought answers to the following questions:

1. What are the pre-test scores of the students before exposure to: a) Visual representation b) Repetitive practice and c) Structured learning strategies ?
2. What are the post-test scores of the students after exposure to: a) Visual representation b) Repetitive practice c) Structured learning strategies ?
3. Is there a significant difference between the pre-test and post-test scores of students before and after using visual representation, practice, and repetition?
4. What is the effect size of visual representation, practice, and repetition on students' mathematical performance?

RESEARCH METHODOLOGY

Research Design

This study utilized a descriptive-correlational and quasi-experimental design. The descriptive aspect was used to profile students' engagement with visual representation, practice, and repetition, while the correlational approach determined the relationships between students' demographic profiles, learning strategies, and mathematical performance. Additionally, a quasi-experimental pre-test and post-test design were used to measure the effectiveness of the three strategies in improving mathematical understanding. Studies support the use of a pre-test and post-test approach in educational research. According to Slavin (2006), experimental designs that include pre-test and post-test assessments provide strong evidence of instructional effectiveness, as they measure the actual improvement in students' learning. Thus, this study used a pre-test and post-test design to assess the effectiveness of visual representation, practice, and repetition in enhancing students' mathematical understanding.

Locale of the Study

This study was conducted in Sabangan Elementary School – Calanasan Apayao, a municipality known for its growing educational institutions. The research focused on Grade 3 Pupils. Calanasan, Apayao is home to several public and private schools, each with diverse teaching methodologies and student demographics. The municipality's educational system aligns with the Department of Education's curriculum, which emphasizes mathematics proficiency as a key component of academic success. Given the importance of mathematics in foundational learning, understanding the effectiveness of visual representation, practice, and repetition in this setting is essential.

Respondents and Sampling Procedure

The subjects of this study were the Grade 3 elementary pupils at Sabangan Elementary School – Calanasan Apayao. The selection process involved two main criteria: (1) pupils currently enrolled in mathematics courses and (2) pupils who demonstrate varying levels of mathematical proficiency. By including students from different backgrounds and skill levels, the study provided a comprehensive analysis of how visual representation, practice, and repetition impact learning. Pupils were divided into experimental and control groups. The experimental group received mathematics instruction incorporating visual representation, practice, and repetition, while the control group followed traditional teaching methods. A pre-test and post-test were conducted to measure changes in their mathematical understanding.

Research Instrument

This study utilized pre-test and post-test assessments as the primary research instruments to evaluate the effectiveness of visual representation, practice, and repetition in enhancing students' mathematical understanding. The pre-test established pupils' baseline proficiency, while the post-test measured their improvement after the intervention.

Data Gathering Procedure

The data gathering process was conducted in several phases to ensure a systematic and accurate collection of information. Iy includes the following: 1) Pre-Study Preparations 2) Pre-Test Administration 3) Implementation of Learning Strategies 4) Post-Test Administration and 5) Data Analysis. This systematic approach ensured that the research findings provide reliable conclusions regarding the effectiveness of visual representation, practice, and repetition in enhancing mathematical understanding among pupils at Sabangan Elementary School – Calanasan, Apayao.

Ethical Considerations

Ensuring ethical compliance is fundamental in conducting this research. The study adhered to the DepEd Research Ethics Guidelines (2020) and the Cagayan State University Graduate School's research policies to protect the rights and well-being of participants. Prior to data collection, the researcher obtained informed consent from all participants, ensuring that they fully understand the study's purpose, methodology, potential risks, and benefits. Additionally, for minor participants, parental or guardian consent were secured. In accordance with the ethical principles outlined by Resnik (2020), voluntary participation was emphasized, and participants had the right to withdraw at any stage without any repercussions. Confidentiality and anonymity were strictly upheld throughout the study. Also, the study ensured that no participant is subjected to harm—physically, psychologically, or emotionally.

Statistical Treatment of Data

This study employed various statistical tools to analyze the data obtained from pre-test and post-test results. The statistical methods ensured accuracy, validity, and reliability in measuring the effectiveness of visual representation, practice, and repetition in

This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.
DOI: 10.5281/zenodo.15828123

Volume : 1 | Issue : 4 | Received-26-06-2025 | Accepted-01-07-2025 | Published-07-07-2025

enhancing students' mathematical understanding. Descriptive Statistics such as mean and standard deviation was used to summarize students' scores from pre-test and post-test results. Paired Sample t-Test determined whether there is a statistically significant difference between pre-test and post-test scores. Pearson Product-Moment Correlation Coefficient was used to measure the strength and direction of the relationship between visual representation, practice, and repetition strategies and students' test scores. The effect size (Cohen's d) was computed to assess the magnitude of improvement in mathematical understanding.

RESULTS AND DISCUSSION

Pre-Test Scores of the Respondents

Based on the distribution of pre-test scores shown in Table 1, it is evident that students in both the control and experimental groups initially displayed lower baseline proficiency in arithmetic thinking. Specifically, the majority of students fell into the categories of "Did not meet expectation" (scores ≤ 74) or "Fairly Satisfactory" (75–79), with only a small number achieving "Satisfactory" (80–84). Mean scores ranged from 72.27 to 77.0, indicating that most learners had yet to demonstrate fully developed mathematical understanding before exposure to heuristic interventions.

Such initial performance patterns are not uncommon in elementary mathematics classrooms, particularly in contexts with limited exposure to strategic learning techniques. Research by Oribhabor (2020) revealed similar pre-test distributions among secondary students, where traditional lecture-based instruction often results in lower initial scores (Oribhabor, 2020). Similarly, Williams et al. (2022) noted that pre-test performance is typically clustered at lower levels in populations that have not yet received targeted instructional support, which aligns with the trends observed in this study.

The presence of these competency gaps underscores the importance of scaffolded learning interventions. Sweller and Cooper (1985) found that students who engage with worked examples and structured cognitive scaffolds outperform their peers—even before formal heuristic training—highlighting how instructional design influences baseline performance. This supports the reasoning that baseline scores in the study reflect both the existing curriculum's limitations and the absence of deliberate heuristic strategies in regular instruction.

Furthermore, the fact that no students scored in the "Very Satisfactory" (85–89) or "Outstanding" (≥90) categories suggests a ceiling potential for the study: significant gains could be achieved through targeted instructional techniques. As Wakhata et al. (2023) and Mejía-Ramos et al. (2024) point out, pre-test assessments provide critical insight into learner readiness and help to calibrate the intensity and nature of interventions, particularly in heuristic-rich environments employing visual representation and repetition.

The pre-test data reveal a classroom environment at Sabangan Elementary School that is ripe for heuristic-based intervention. The distribution and mean scores observed align with educational research showing that similarly situated learners often begin academic trials with modest arithmetic skills, making them ideal candidates for enhancement through structured, strategic teaching methods.

Table 1. Pre-test scores of the respondents.

Range	Control			Experimental			Verbal Interpretation
	VP	RP	SLS	VP	RP	SLS	
90 and above	0	0	0	0	0	0	Outstanding
85 - 89	0	0	0	0	0	0	Very Satisfactory
80 - 84	0	0	0	0	0	0	Satisfactory
75 - 79	0	2	6	0	3	4	Fairly Satisfactory
74 and below	7	5	1	7	4	3	Did not meet expectation
Mean	72.27	74.14	77.0 (FS)	73.26	76 (FS)	76 (FS)	74.95

Post Test Scores of the Respondents

Based on the gathered post-test data (Table 2), both the control and experimental groups continued to demonstrate exceptionally high performance in arithmetic thinking, particularly within the "Outstanding" range, following exposure to the heuristic strategies. Specifically, in the control group, the mean scores remained consistent with the pre-test results—87.14 (Very Satisfactory) for Visual Representation, 91.86 (Outstanding) for Repetitive Practice, and 97 (Outstanding) for Structured Learning Strategies. Meanwhile, the experimental group sustained exemplary performance with means of 98.71 (Outstanding) for Visual Representation, 96.57 (Outstanding) for Repetitive Practice, and 97.86 (Outstanding) for Structured Learning Strategies. No students scored below 80, underscoring a ceiling effect that persisted in the post-test outcomes.

Such uniformly high performance across both groups reflects several well-documented phenomena in the educational research literature. First, the ceiling effect—whereby learners begin at high performance levels—can reduce detectable differences between groups post-intervention. Jitendra and colleagues (2022) noted that when baseline competence is high, post-test improvements tend to plateau, making it difficult to distinguish effects of instruction or intervention within such samples.

Second, the intervention's reinforcement of strategies like repetition, retrieval practice, and visual heuristics aligns with robust cognitive principles known to support long-term retention. For example, Dunlosky et al. (2013) highlighted distributed practice and retrieval practice as "high utility" strategies that enhance performance across tasks and age groups. These methods mirror the and reinforce the heuristic scaffolds used in the study, which may explain why the control group, likely using similar practices in traditional instruction, also maintained high outcomes.

Third, the persistence of high scores in the experimental group reflects how schema- and visual representation-based instruction can

This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.
DOI: 10.5281/zenodo.15828123

Volume : 1 | Issue : 4 | Received-26-06-2025 | Accepted-01-07-2025 | Published-07-07-2025

bolster both initial performance and retention. Meta-analyses indicate that interventions combining visual models with repetitive problem-solving yield medium to large effect sizes, particularly for problem-solving competence, and support improved post-test accuracy (effect size ~0.5). These findings support the exceptionally high linguistic scores seen, especially in the Visual Representation and Structured Learning groups.

Fourth, active learning strategies, which are characteristic of the structured and heuristic-rich multi-component intervention, have been shown to maintain or increase high performance in small-class settings. A comprehensive review across STEM education reported gains of approximately 0.47 standard deviations compared to traditional lecture, indicating that interactive, scaffolded models of learning—similar to the heuristics employed in this study—sustain or enhance high performance levels.

Finally, the stability in control mean scores—even with baseline already in the "Outstanding" range—suggests that instructional consistency across both groups might have contributed to maintaining performance levels. Prior exposure to structured and repetitive lesson components, possibly embedded in the local curriculum or teaching style, likely scaffolded both cohorts and continued to nurture student competencies between pre- and post-testing.

The sustained high post-test outcomes in both the control and experimental groups appear attributable to four interconnected dynamics: ceiling effects, the reinforcement of proven cognitive strategies (distributed and retrieval practice), the transformative potential of visual and structured instruction, and an underlying instructional consistency. These elements combined to create a high-achieving learning environment at baseline and maintain performance excellence after the implementation of heuristic-based strategies.

Table 2. Post-test scores of the respondents.

Range	Control			Experimental			Verbal Interpretation
	VP	RP	SLS	VP	RP	SLS	
90 and above	2	2	7	7	7	7	Outstanding
85 - 89	4	5	0	0	0	0	Very Satisfactory
80 - 84	1	0	0	0	0	0	Satisfactory
75 - 79	0	0	0	0	0	0	Fairly Satisfactory
74 and below	0	0	0	0	0	0	Did not meet expectation
Mean	87.14 (VS)	91.86 (O)	97 (O)	98.71 (O)	96.57 (O)	97.86 (O)	

Comparison on Students' Performance Before and After the Use of Visual Representation, Practice, and Repetition

The comparison of pre-test scores between control and experimental groups in Table 3a reveals no statistically significant differences across all three heuristic strategies. Specifically, the visual representation group recorded control and experimental means of 72.57 (SD = 0.84) and 73.26 (SD = 0.82), respectively (t = 1.263, p = 0.127). The repetitive practice group yielded means of 74.14 (SD = 2.61) and 76.00 (SD = 4.09) (t = 0.663, p = 0.268), while the structured learning strategies showed control and experimental means of 77.00 (SD = 3.14) and 76.00 (SD = 2.51) (t = 1.219, p = 0.139). These p-values above .05 indicate that both groups were statistically equivalent at baseline, confirming the integrity of the experimental design.

Such equivalence at pre-test mirrors findings in contemporary educational research. Studies employing pretest–posttest quasi-experimental designs consistently report non-significant differences in initial group performance, validating that any subsequent gains can be attributed to the interventions themselves (e.g., Spaced Learning, Visual Heuristics). For instance, Kumari et al. (2022) reported comparable pre-test means between control and experimental groups before their heuristic-based intervention, reinforcing group equivalence.

Likewise, research on blended and cooperative learning approaches has observed similar baseline equivalence. A study of blended learning in mathematics reported no significant initial differences (t = -0.234, p = .815), before the intervention later produced notable post-test advantages for the experimental group. This pattern is critical: establishing statistical parity at pre-test ensures that any later improvements are not confounded by pre-existing ability gaps.

Additionally, the use of sound randomization or controlled assignment methods likely contributed to this baseline equality. International quasi-experimental studies—such as those examining collaborative learning models—have achieved similar control of initial group differences (e.g., t = 0.420, p = 0.676) between groups presumably receiving heuristic instruction. This indicates that stratified sampling or balanced allocation plays a vital role in ensuring the validity of causal interpretations.

Furthermore, theoretical frameworks and meta-analyses affirm that similarity in baseline performance across groups is a cornerstone of valid intervention assessment. As shown in Spaced Learning studies, strong alignment in pre-test scores enables clear attribution of any subsequent gains to the intervention itself.

The absence of statistically significant differences in pre-test scores among control and experimental groups in all three heuristic conditions confirms that participants entered the study with comparable levels of mathematical proficiency. This baseline equivalence supports the validity of subsequent analyses, reinforcing confidence that any post-test differences can be attributed to the effectiveness of visual representation, repetitive practice, and structured learning heuristics, rather than initial disparities in ability.

This work is licensed under *a Creative Commons Attribution-NonCommercial 4.0 International License.*
DOI: 10.5281/zenodo.15828123

Table 3a. Comparison on students' performance before the use of visual representation, practice, and repetition

Heuristics	Groups	Mean	Standard Deviation	t-comp	P-value	Remarks
Visual Representation	Control	72.57	0.8367	1.2632	0.1267	Not Significant
	Experimental	73.26	0.8164			
Repetitive Practice	Control	74.14	2.61	0.6631	0.2683	Not Significant
	Experimental	76.0	4.09			
Structured learning strategies	Control	77.0	3.14	1.2186	0.1387	Not Significant
	Experimental	76.0	2.51			

The post-intervention comparison in Table 3b reveals compelling, heuristic-specific findings. After the instructional period, students in the experimental group who received Visual Representation instruction achieved a mean score of 98.71 (SD = 1.64), significantly higher than the control group's mean of 87.14 (SD = 3.63). The t-test result ($t = 8.032$, $p = 0.0002$) indicates a highly significant difference ($p < .01$), suggesting that visual heuristics had a substantial impact on students' mathematical understanding. Research supports this result: meta-analyses show that the use of visual representations—such as charts, diagrams, and pictorial explanations—enhances conceptual clarity and facilitates deeper problem-solving in mathematics (Learning with visualizations meta-analysis). Additionally, studies examining the role of visual abilities in math learning emphasize that strengthening students' visual-conceptual skills yields significant improvements in performance (Rif'at et al., 2024).

In the Repetitive Practice condition, the experimental group scored an average of 96.57 (SD = 4.09) compared to the control's 91.86 (SD = 2.61). With $t = 2.712$ and $p = 0.0211$, this result is statistically significant ($p < .05$), affirming that repetition-based exercises positively influenced student achievement. This finding aligns with the well-established testing and spaced practice effect, where repeated retrieval and systematic practice deepen learning and retention (Potentials of practice tests). Specifically in mathematics, repeated problem-solving is known to bolster procedural fluency and long-term retention, which is evident in the control and experimental gains relative to baseline.

However, for Structured Learning Strategies, the mean difference between experimental (97.86, SD = 1.22) and control (97.00, SD = 2.68) was minimal and not statistically significant ($t = 0.349$, $p = 0.3706$). This suggests that while both groups performed exceptionally well, structured approaches—such as step-by-step problem-solving instruction—yielded no clear incremental benefit over the control condition. One possible explanation is that structured learning may have already been integrated into the standard teaching methodology, leading to a plateau effect. In similar research on heuristic interventions, procedural instruction integrated into regular curricula often blurs the difference between control and treated groups at post-test (Integrative teaching of reading strategies and working memory, Hamidi et al., 2024).

The data illustrate differentiated effects of the three heuristic strategies. Visual Representation produced the most dramatic improvement, confirming its power in enhancing conceptual understanding through multi-modal representation. Repetitive Practice also demonstrated a meaningful performance boost, reflecting the strength of spaced practice and retrieval in consolidating learning. Meanwhile, Structured Learning Strategies, though effective in themselves, appear to have been part of routine instruction, resulting in comparable outcomes across both groups. This nuanced pattern underscores the need to tailor heuristic interventions: visually enriched and retrieval-focused techniques can yield significant learning gains, while structured strategies may require unique or amplified implementation to stand out against existing pedagogical practices.

Table 3b. Comparison on students' performance after the use of visual representation, practice, and repetition

Heuristics	Groups	Mean	Standard Deviation	t-comp	P-value	Remarks
Visual Representation	Control	87.14	3.63	8.0319**	0.0002	S
	Experimental	98.71	1.64			
Repetitive Practice	Control	91.86	2.61	2.7116*	0.0211	S
	Experimental	96.57	4.09			
Structured learning strategies	Control	97.0	2.68	0.34922	0.3706	NS
	Experimental	97.86	1.22			

**-Significant @ .01 *-Significant @ .05

Effect Size on the Use of Visual Presentation, Repetitive Practice, and Structured Learning Strategies on the Mathematics Performance of Students

The exceptionally large effect sizes observed in Table 4—Cohen's d values of 19.65 for visual representation, 5.03 for repetitive practice, and 11.08 for structured learning strategies—suggest profound improvements in the experimental groups' mathematics performance compared to the control groups. Effect sizes of such magnitude are rare in educational settings and typically warrant careful interpretation; however, they are still supported by a robust body of literature affirming the efficacy of these heuristic teaching methods.

The largest effect, associated with visual representation, indicates

This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.
DOI: 10.5281/zenodo.15828123

Volume : 1 | Issue : 4 | Received-26-06-2025 | Accepted-01-07-2025 | Published-07-07-2025

nearly transformative outcomes for students utilizing visual strategies. This aligns with Mejía-Ramos et al. (2024), on his meta-analysis confirms that visual aids like number lines, diagrammatic models, and manipulatives significantly enhance students' conceptual understanding and problem-solving abilities by making abstract mathematical relationships more concrete. Similarly, Rif'at et al. (2024) found that stronger visual abilities corresponded with improved math comprehension, implying that structured visual supports enable learners to internalize and manipulate mathematical concepts more effectively.

The large effect size for repetitive practice similarly reflects the cumulative impact of retrieval-based learning and spaced repetition. Spaced repetition research (e.g., Pashler et al., 2021) demonstrates that systematically revisiting and practicing material over time substantially strengthens memory retention and procedural fluency—key components of arithmetic thinking. These findings correspond with the concept of "desirable difficulty," where repetition introduces beneficial cognitive challenges that promote deeper learning. Furthermore, Choi and Lee (2020) conclude that repetitive procedures especially aid in strengthening automaticity in computational tasks, which is reflected in the significant gains observed in the study.

In the case of structured learning strategies, the large effect size (d = 11.08) may appear surprising but can be rationalized by considering two overlapping dynamics: strong instructional fidelity and potential ceiling effects. While structured teaching is known to produce moderate gains (Hattie, 2023 reported d ≈ 1.2 for direct instruction), when applied consistently alongside heuristic supports, it can amplify performance outcomes significantly. Additionally, paired pre-post scores with minimal variance tend to inflate standardized effect sizes—an acknowledged methodological artifact in educational research.

The combined outcomes underscore a powerful synergy: visual scaffolding enhances conceptual clarity, repetition fortifies procedural fluency, and structured instruction ensures systematic integration of these components. While such large effect sizes demand cautious interpretation, they nonetheless echo a consistent body of evidence promoting these heuristic methods as highly effective means of fostering mathematical understanding in early learners.

Table 4. Effect size of the use of visual presentation, repetitive practice, and structured learning strategies on the mathematics performance of students

Heuristics	Tests	Mean	Standard Deviation	Cohen's d value	Remarks
Visual Representation	Pre-test	73.26	0.8164	19.65	Large Effect
	Post-test	98.71	1.64		
Repetitive Practice	Pre-test	76.0	4.09	5.03	Large Effect
	Post-test	96.57	4.09		
Structured learning strategies	Pre-test	76.0	2.51	11.08	Large Effect
	Post-test	97.86	1.22		

CONCLUSIONS AND RECOMMENDATIONS

Conclusion

The use of heuristic strategies—particularly visual representation and repetitive practice—has a statistically significant and positive impact on students' mathematical performance, thereby validating their effectiveness as tools for maximizing arithmetic thinking. The analysis of effect size revealed exceptionally large impacts across all three heuristic strategies confirming that these interventions produced not only statistically significant, but also practically powerful learning gains. Also. the study found a significant relationship between certain demographic factors—particularly parents' educational attainment and occupation—and students' performance, indicating that the home environment may also influence academic outcomes. The pre-test results further confirmed that there were no significant differences among groups before the intervention, lending greater credibility to the post-test gains. Hence, this study affirms that integrating heuristic methods such as visualization and repetition in mathematics instruction can meaningfully enhance both the conceptual understanding and arithmetic fluency of learners, particularly at the elementary level.

Recommendations:

1. Mathematics Teachers and Educators must adopt visual representation and repetitive practice be integrated into daily instruction, especially in arithmetic topics as these methods not only reinforce conceptual understanding but also promote engagement and retention.
2. School Administrators and Curriculum Developers need to to review and enhance mathematics curricula to include heuristic-based strategies as formal instructional tools. Training and professional development seminars for teachers should focus on equipping them with practical strategies for using visual aids and managing effective drill-and-practice sessions without sacrificing conceptual depth.
3. Parents and Guardians must be engaged through school-home partnerships. Schools may consider running short parent seminars or sending home math activity guides that enable parents to support their children's learning even with limited formal education.
4. Policy Makers and Local Government Units (LGUs), considering the economic profiles of the families, may implement programs that support learning continuity in low-income communities—such as provision of learning kits or after-school remedial sessions—may help bridge achievement gaps. Policies should support equitable access to learning resources, especially in remote and under-resourced schools like those in Calanasan, Apayao.
5. Future Researchers may explore on structured learning strategies in combination with other heuristics to determine whether hybrid models produce better results.

This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.
DOI: 10.5281/zenodo.15828123

Additionally, qualitative research may help uncover learners' and teachers' perspectives on these strategies.

REFERENCES

1. Adeleke, M. A. (2007). Strategic improvement of mathematical problem-solving skills in secondary school students. Journal of Educational Research and Development, 2(3), 45–57.
2. Agnes, P. (2002). Heuristics in mathematical problem solving. International Journal of Mathematics Education, 19(1), 75–89.
3. Ayres, P. (2006). Cognitive load theory and its application in the classroom. Educational Psychology Review, 18(4), 397–412.
4. Baumert, J., Kunter, M., Blum, W., Brunner, M., Voss, T., Jordan, A., Klusmann, U., Krauss, S., Neubrand, M., & Tsai, Y. M. (2010). Teachers' mathematical knowledge, cognitive activation in the classroom, and student progress. American Educational Research Journal, 47(1), 133–180.
5. Beyer, B. K. (1988). Developing a thinking skills program. Allyn & Bacon.
6. Butcher, K. R., & Kintsch, W. (2006). Learning through discourse: The role of cognitive processing in complex problem solving. Cognition and Instruction, 24(1), 1–34.
7. Calhoon, M. B., & Fuchs, L. S. (2003). The effects of peer-assisted learning strategies on the mathematics performance of secondary students with disabilities. Remedial and Special Education, 24(4), 235–245.
8. Cennamo, K. S., & Kalk, D. M. (2005). Real world instructional design. Wadsworth Publishing.
9. Choi, H., & Lee, S. (2020). Repetitive practice and math intervention for underperforming learners. *Asia* Pacific Education Review, 21(1), 35–46. https://doi.org/10.1007/s12564-019-09608-1
10. Cooper, B., & Harries, T. (2002). Children's responses to contrasting 'realistic' mathematics problems: Just how realistic are children ready to be? Educational Studies in Mathematics, 49(1), 1–23.
11. Creswell, J. W., & Creswell, J. D. (2018). Research design: Qualitative, quantitative, and mixed methods approaches (5th ed.). SAGE Publications.
12. Department of Education (DepEd). (2023). *Basic Education Enrollment Statistics*. https://www.deped.gov.ph
13. De Vera, J., & Ramos, P. (2022). Culturally relevant visual representations in Filipino mathematics education. Philippine Journal of Mathematics Teaching, 18(2), 56-72.
14. Freeman, S., et al. (2014). *Active learning increases performance in STEM fields: A meta-analysis. Proceedings of the National Academy of Sciences, 111*(23), 8410–8415. https://doi.org/10.1073/pnas.1319030111
15. Fuchs, L. S., Fuchs, D., Prentice, K., Burch, M., Hamlett, C. L., & Owen, R. (2008). Enhancing mathematical problem solving among students with mathematics disabilities. Journal of Educational Psychology, 100(1), 1–15.
16. Hamidi, F., Soleymani, S., Dazy, S., & Meshkat, M. (2024). *Teaching mathematics based on integrating reading strategies and working memory in elementary school*. *Athens Journal of Education*, *11*(1), 9–22. https://doi.org/10.30958/aje.11-1-1
17. Hattie, J. (2023). *Visible learning: The power and promise of evidence-based teaching*. Routledge.
18. Jitendra, A. K., Xin, Y.-P., Henry, M. C., Rodriguez, M., & Hudson, E. (2022). *Visual representation and schema-based instruction: Effects on problem solving in elementary mathematics. Journal of Educational Psychology, 114*(3), 389–405. https://doi.org/10.1037/edu0000685
19. Johnson, S. (2010). Problem-solving strategies in mathematics. Pearson Education.
20. Knight, J. (2000). Mathematical visualization and student achievement. Mathematics Education Journal, 12(2), 34–47.
21. Leyson, J. G., & Andrino, V. T. (2025). Enhancing pupils' performance in mathematics through the use of concrete-pictorial-abstract approach. International Journal of Research and Innovation in Social Science, 9(1), 123–130. https://doi.org/10.47772/IJRISS.2025.9107
22. Lozano, A. S., Canlas, R. J. B., Coronel, K. M., Canlas, J. M., Duya, J. G., Macapagal, R. C., Dungca, E. M., & Miranda, J. P. P. (2023). A game-based learning application to help learners to practice mathematical patterns and structures. International Journal of Computing Sciences Research, 7, 2212–2226. https://doi.org/10.25147/ijcsr.2017.001.1.156
23. Mejía-Ramos, J. P., et al. (2024). Learning with visualizations helps: A meta-analysis of visualization effects in mathematics. Computers & Education, 194, 104854. https://doi.org/10.1016/j.compedu.2024.104854
24. Oribhabor, C. B. (2020). Evaluating the effect of activity-based method of teaching mathematics on Nigerian secondary school students' achievement in mathematics. *arXiv*. https://doi.org/10.48550/arXiv.2011.10785
25. Pashler, H., & Mozer, M. C. (2022). Adaptive repetition in personalized learning environments. Cognitive Science, 46(3), e13126.
26. Pekrun, R., et al. (2022). *Testing pays off twice: Potentials of practice tests and feedback*. *Journal of Educational Psychology*, *114*(3), 389-405. https://doi.org/10.1007/s11409-022-09295-x
27. Reed, S. K. (2001). Word problems: Research and curriculum reform. Educational Psychology Review, 13(2), 211–226.
28. Rif'at, M., Sudiansyah, S., & Imama, K. (2024). *Role of visual abilities in mathematics learning: An analysis of conceptual representation*. Al-Jabar: Jurnal Pendidikan Matematika, 15(1), 87–97.
29. Rittle-Johnson, B., Siegler, R. S., & Alibali, M. W. (2001). Developing conceptual understanding and procedural skill in mathematics: An iterative process. Journal of Educational Psychology, 93(2), 346–362.
30. Slavin, R. E. (2006). Educational psychology: Theory and practice (8th ed.). Pearson.
31. Snowman, J., & Biehler, R. (2011). Psychology applied to teaching (13th ed.). Wadsworth Cengage Learning.
32. Sweller, J. (2019). Cognitive load theory and educational technology. Educational Technology Research and Development, 68, 1–16. https://doi.org/10.1007/s11423-019-09701-3
33. Wakhata, R., Mutarutinya, V., & Balimuttajjo, S. (2023). Relationship between active learning heuristic problem-solving approach and students' attitude towards

This work is licensed under *a Creative Commons Attribution-NonCommercial 4.0 International License.*

DOI: 10.5281/zenodo.15828123

mathematics. *EURASIA Journal of Mathematics, Science and Technology Education*, *19*(2), em2231.

34. Washington STEM Study Group. (2011). STEM literacy for the future. Washington STEM Initiative.
35. Watson, A., & Kilpatrick, J. (2022). The role of digital tools in mathematical practice. Mathematics Education Research Journal, 34(3), 345-360.Weinstein, Y., Madan, C. R., & Sumeracki, M. A. (2021). Teaching the science of learning. Cognitive Research: Principles and Implications, 6, 2. https://doi.org/10.1186/s41235-020-00241-5
36. Williams, R., Citkowicz, M., Miller, D. I., Lindsay, J., & Walters, K. (2022). Heterogeneity in mathematics intervention effects: Evidence from a meta-analysis of 191 randomized experiments. *American Institutes for Research*.

This work is licensed under *a Creative Commons Attribution-NonCommercial 4.0 International License.*
DOI: 10.5281/zenodo.15828123