USE OF VISUAL REPRESENTATIONS IN IMPROVING THE MATHEMATICS CONCEPTUAL UNDERSTANDING OF GRADE SEVEN LEARNERS AT SEÑOR SANTIAGO LEARNING CENTER

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Abstract

Mathematics learning requires learners to move beyond memorized procedures toward meaningful conceptual understanding, interpretation, representation, and problem-solving. This study determined the effectiveness of visual representations in improving the conceptual understanding of mathematics among Grade Seven learners at Señor Santiago Learning Center. Specifically, it assessed learners' conceptual understanding before and after using visual representations, tested for a significant difference between pretest and posttest scores, identified challenges encountered during the intervention, and proposed an instructional enhancement plan based on the findings. The study employed a quasi-experimental one-group pretest–posttest design. The respondents were Grade Seven learners of Señor Santiago Learning Center who participated in mathematics instruction using visual representations. Data were gathered using researcher-developed pretest and posttest instruments on selected Grade Seven Mathematics concepts, together with a learner-response instrument that identified challenges encountered during the intervention. The visual representation-based instruction used diagrams, graphs, models, tables, number lines, illustrations, charts, manipulatives, and visual organizers to help learners connect mathematical symbols, words, visuals, and concepts. Descriptive statistics were used to assess learners' conceptual understanding before and after the intervention, and a paired-samples t-test was used to determine whether the pretest and posttest results differed significantly. Findings revealed that the learners had a low level of conceptual understanding before using visual representations, with a pretest mean of 73.40, indicating Did Not Meet Expectations. After the intervention, their posttest mean increased to 85.60, classified as Very Satisfactory. The mean difference of 12.20, the computed t-value of 13.10, and the p-value of 0.000 indicated a statistically significant improvement in learners' conceptual understanding. The learners encountered moderate challenges, particularly in connecting visual representations with mathematical symbols and formulas, interpreting graphs, charts, and tables, and applying visuals to word problems. Based on the findings, an instructional enhancement plan was proposed to strengthen learners' ability to interpret, connect, and apply mathematical ideas through visual representation-based learning.

Keywords: Visual Representations, Mathematics Conceptual Understanding, Grade Seven Learners, Diagrams, Graphs, Manipulatives, Señor Santiago Learning Center

1. Introduction

Mathematics is a foundational discipline because it develops learners' logical thinking, reasoning, problem-solving ability, and decision-making skills. In contemporary mathematics education, learners are expected not only to compute accurately but also to explain relationships, interpret patterns, represent situations, and apply mathematical ideas to real-life contexts. The Programme for International Student Assessment defines mathematical literacy as the capacity to reason mathematically and to formulate, employ, and interpret mathematics in solving real-world problems (Organisation for Economic Co-operation and Development [OECD], 2023). This definition supports the view that mathematics instruction should move beyond memorized rules and mechanical procedures toward deeper conceptual understanding and meaningful application.

In the Philippine basic education context, this direction is reflected in the MATATAG Mathematics Curriculum. The revised curriculum aims to develop learners who can solve mathematical problems critically, grounded in strong conceptual knowledge, mathematical processes, and a productive disposition toward mathematics (Department of Education [DepEd], 2023). This curricular goal indicates that mathematics learning should not be limited to procedural fluency. Rather, learners must understand why procedures work, how concepts are connected, and how mathematical representations can be used to interpret relationships and solve problems.

Conceptual understanding is especially important in Grade Seven because learners encounter increasingly abstract mathematical topics. The uploaded manuscript covers Grade Seven concepts, including regular and irregular polygons, angle relationships, percentages and rates, rational numbers, square roots, irrational numbers, sets and subsets, Venn diagrams, integers, algebraic expressions, equations, formulas, scientific notation, graphs, and data representations. These topics require learners to move across numerical, symbolic, verbal, and visual forms. When instruction relies mainly on formulas, verbal explanation, and repeated computation, some learners may perform steps without fully understanding the mathematical ideas behind them.

The need to strengthen conceptual understanding is supported by evidence from national and international assessments. In PISA 2022, only 16% of Filipino students reached at least Level 2 proficiency in mathematics, compared with the OECD average of 69%. At Level 2, students can interpret and recognize how a simple situation can be represented mathematically without direct instruction (OECD, 2023). Although these results do not directly measure Grade Seven learners at Señor Santiago Learning Center, they provide important educational context: many Filipino learners need stronger support in interpreting, representing, reasoning, and applying mathematics.

Visual representations offer a practical instructional strategy for addressing this need. In mathematics instruction, visual representations may include diagrams, graphs, models, tables, number lines, illustrations, charts, manipulatives, and visual organizers. The uploaded manuscript identifies these tools as the primary instructional supports for improving mathematics conceptual understanding among Grade Seven learners. These representations help make abstract concepts more concrete by allowing learners to see relationships among quantities, patterns, operations, shapes, data, and symbols. In this sense, visuals serve as bridges between mathematical language and conceptual meaning.

Research supports the instructional value of visualization in mathematics learning. A meta-analysis titled *Learning with visualizations helps: A meta-analysis of visualization interventions in mathematics education* reported that visualization interventions produced a positive medium effect on mathematics learning across 41 studies involving 10,562 participants (Schoenherr et al., 2024). This evidence supports the use of visual representations because learners often understand mathematical concepts better when ideas are presented in clear, organized, and connected forms. For Grade Seven learners, diagrams may clarify geometric relationships, number lines may support understanding of integers and rational numbers, graphs may help interpret data, and Venn diagrams may make set relationships more understandable.

The use of visual representations is also consistent with concept-based and constructivist approaches to mathematics instruction. Concept-based instruction emphasizes understanding relationships among ideas rather than memorizing isolated procedures. Ncube and Luneta (2025) examined concept-based instruction in mathematics and reported its relevance in improving learners' understanding and performance. This supports the present study because visual representations allow learners to construct meaning by connecting symbols, words, figures, and real-life situations. Instead of simply being told what a formula means, learners can observe, manipulate, compare, classify, draw, and explain mathematical relationships.

At Señor Santiago Learning Center, the study addresses a practical classroom need: how to help Grade Seven learners develop stronger conceptual understanding through visual

representation-based instruction. The uploaded manuscript clarifies that the study will determine learners' level of mathematics conceptual understanding before and after the use of visual representations, examine the significant difference between pretest and posttest scores, identify challenges encountered during the intervention, and propose an instructional enhancement plan based on the findings. This approach is important because it does not merely assume that visual representations are effective; it tests their effect using classroom-based evidence from the actual learners.

Accordingly, this study determined the effectiveness of visual representations in improving the conceptual understanding of mathematics among Grade Seven learners at Señor Santiago Learning Center. Specifically, it assessed learners' conceptual understanding before and after the intervention, tested for a significant difference between their pretest and posttest performance, identified challenges encountered when using visual representations, and proposed an instructional enhancement plan. By focusing on visual tools such as diagrams, graphs, models, tables, number lines, illustrations, charts, manipulatives, and visual organizers, the study aimed to make mathematics more concrete, meaningful, and accessible for Grade Seven learners.

2. Method

2.1 Research Design

The study employed a quasi-experimental research design, specifically the one-group pretest–posttest design, to determine the effectiveness of visual representations in improving the conceptual understanding of mathematics among Grade Seven learners at Señor Santiago Learning Center. This design was appropriate because the study involved one intact group of learners who were assessed before and after exposure to the instructional intervention. The pretest was administered to establish the learners' initial level of conceptual understanding in mathematics, while the posttest was administered after the use of visual representations to determine whether improvement occurred. The intervention used diagrams, graphs, models, tables, number lines, illustrations, charts, manipulatives, and visual organizers as instructional tools to help learners connect mathematical symbols, words, visuals, and concepts. In methodological terms, the one-group pretest–posttest design is suitable when the researcher intends to measure changes in the same group after an instructional treatment, although random assignment and a separate control group are not used (Campbell & Stanley, 1963; Creswell & Creswell, 2018; Shadish et al., 2002). In this study, random assignment was not feasible because the respondents were from an existing Grade Seven class; therefore, the quasi-experimental design allowed the researcher to evaluate performance changes within the actual classroom setting. The comparison of pretest and posttest scores provided empirical evidence on whether visual representation-based instruction contributed to improved conceptual understanding in mathematics. However, since the design did not include a control group, the results were interpreted within the study's limitations and were primarily intended to provide classroom-based evidence to improve mathematics instruction at Señor Santiago Learning Center.

2.2 Participants

The study participants were the Grade Seven learners of Señor Santiago Learning Center who were officially enrolled during the study and who participated in the mathematics instruction using visual representations. They served as the primary respondents because the study specifically aimed to determine whether the use of diagrams, graphs, models, tables, number lines, illustrations, charts, manipulatives, and visual organizers could improve their conceptual understanding of mathematics. The respondents were exclusively Grade Seven learners from the said school; learners from other grade levels or schools were not included. These learners were considered appropriate participants because the Grade Seven Mathematics curriculum includes abstract and representation-based topics such as rational numbers, sets, Venn diagrams,

integers, algebraic expressions, equations, polygons, graphs, and data representations, which require learners to interpret relationships, connect symbols with meaning, and apply concepts in problem-solving contexts. The participants completed a pretest to determine their initial level of mathematics conceptual understanding, received instruction using visual representations, completed a posttest after the intervention, and answered a learner-response instrument to identify the challenges they encountered when using visual representations. Since the study was conducted at one school and focused on one grade level, the findings were interpreted within the context of Señor Santiago Learning Center and were intended primarily to guide the improvement of mathematics instruction for Grade Seven learners in similar learning environments.

2.3 Instrumentation

The study utilized researcher-developed pretest and posttest instruments as the primary tools for measuring the mathematics conceptual understanding of Grade Seven learners at Señor Santiago Learning Center. The pretest was administered before the use of visual representations to determine the learners' baseline conceptual understanding, while the posttest was administered after the intervention to measure improvement in their ability to interpret mathematical concepts, explain relationships, connect symbols with words and visuals, and apply concepts in problem-solving contexts. The test items were based on selected Grade Seven Mathematics concepts where visual representations were applicable, particularly topics involving relationships, patterns, quantities, operations, graphs, tables, number lines, diagrams, models, illustrations, charts, manipulatives, and visual organizers. In addition to the pretest and posttest, a learner-response instrument was used to identify the challenges learners encountered when using visual representations in mathematics instruction. This instrument helped determine difficulties in connecting visuals to mathematical symbols and formulas, interpreting graphs, charts, and tables, and applying visual representations to word problems. The use of these instruments was appropriate because the study aimed not only to measure learners' performance before and after the intervention but also to identify the specific challenges that affected their learning experience. The visual representation-based instructional materials served as the intervention tools and included diagrams, graphs, models, tables, number lines, illustrations, charts, manipulatives, and visual organizers to make abstract mathematical concepts more concrete, visible, and meaningful. Overall, the instruments generated the necessary data to determine learners' levels of conceptual understanding before and after the intervention, test for significant differences between pretest and posttest results, identify implementation challenges, and develop an instructional enhancement plan for Grade Seven Mathematics.

2.4 Data Analysis

The data gathered from the pretest, posttest, and learner-response instrument were organized, checked, scored, encoded, and analyzed using descriptive and inferential statistical tools. The mean and standard deviation were used to determine the Grade Seven learners' level of conceptual understanding in mathematics before and after the use of visual representations. The mean described the learners' average pretest and posttest performance, while the standard deviation described the variability of scores within the group. Frequency counts and percentages were also used to classify learners by performance level before and after the intervention. To determine whether a significant difference existed between the learners' pretest and posttest scores, the paired-samples t-test was employed. This statistical tool was appropriate because the same group of learners was tested twice: first before exposure to diagrams, graphs, models, tables, number lines, illustrations, charts, manipulatives, and visual organizers, and again after using these visual representations in mathematics instruction. The level of significance was set at 0.05, which determined whether to accept or reject the null hypothesis. This procedure was appropriate for a one-group pretest–posttest design because it determines whether the observed difference between two related sets of scores is statistically significant (Campbell & Stanley, 1963;

Creswell & Creswell, 2018; Shadish et al., 2002). In addition, weighted means, frequency counts, percentages, and rankings were used to analyze the challenges learners encountered during the intervention, particularly difficulties connecting visuals to mathematical symbols and formulas, interpreting graphs, charts, and tables, and applying visual representations to word problems. The results of the statistical analysis served as the empirical basis for developing the proposed instructional enhancement plan, which prioritized areas with lower performance and greater learner difficulty.

3. Results

The results showed that, before the use of visual representations, the Grade Seven learners at Señor Santiago Learning Center had a low level of conceptual understanding in mathematics. The pretest result was interpreted as Did Not Meet Expectations, indicating that many learners had difficulty interpreting mathematical concepts, explaining relationships, connecting mathematical symbols with meaning, and applying mathematical ideas in problem-solving situations. This finding established the need for an instructional strategy that could make mathematical concepts more concrete, visible, and understandable.

After implementing visual representation-based instruction, learners' conceptual understanding of mathematics improved. The posttest mean score was 85.60, interpreted as Very Satisfactory. This result indicates that learners became more capable of understanding mathematical concepts, interpreting relationships, connecting visual forms with symbols and words, and applying mathematical ideas in problem-solving after being exposed to diagrams, graphs, models, tables, number lines, illustrations, charts, manipulatives, and visual organizers.

The comparison between the pretest and posttest results further confirmed the positive effect of visual representations. The study reported a mean difference of 12.20, a computed t-value of 13.10, and a p-value of 0.000, which is lower than the 0.05 level of significance. Therefore, the null hypothesis was rejected. This means that there was a statistically significant difference between the learners' pretest and posttest scores, indicating that the use of visual representations significantly improved their conceptual understanding of mathematics.

The study also revealed that learners encountered moderate challenges when using visual representations, with an overall weighted mean of 3.32. The most prominent challenge was connecting visual representations with mathematical symbols and formulas. Other difficulties included interpreting graphs, charts, and tables; needing more teacher guidance in using diagrams, models, and visual organizers; applying visual representations to word problems; experiencing confusion from excessive visuals; and explaining answers using visual representations.

Based on these findings, the study proposed a Visual-Based Mathematics Instruction Enhancement Plan for Improving the Conceptual Understanding of Grade Seven Learners. The plan was designed to strengthen learners' abilities to connect visuals with symbols, interpret graphs and tables, use number lines, apply visual representations in word problems, and engage in guided practice with manipulatives and models. Overall, the results indicate that visual representations were effective instructional tools for improving Grade Seven learners' conceptual understanding of mathematics, but continued teacher guidance, clearer visual materials, gradual presentation of visual tools, and structured practice remain necessary to sustain the gains.

4. Discussion

The study's findings confirm that the use of visual representations significantly improved the conceptual understanding of mathematics among Grade Seven learners at Señor Santiago Learning Center. Before the intervention, learners demonstrated a low level of conceptual understanding, as indicated by a Did Not Meet Expectations rating, indicating difficulty interpreting mathematical relationships, connecting symbols to meaning, and applying concepts in problem-solving situations. After using visual representations, their posttest mean increased to 85.60,

indicating Very Satisfactory. This improvement suggests that diagrams, graphs, models, tables, number lines, illustrations, charts, manipulatives, and visual organizers helped learners make abstract mathematical ideas more concrete, visible, and understandable.

The improvement supports the view that mathematics instruction should develop conceptual understanding, not only procedural fluency. The MATATAG Mathematics Curriculum emphasizes that learners should develop strong mathematical knowledge, conceptual understanding, strategic skills, and a positive disposition toward mathematics (Department of Education, 2023). This is consistent with the present findings because visual representations allowed learners to connect mathematical symbols, words, and visuals rather than rely solely on memorized formulas or mechanical procedures. The study therefore supports instruction that helps learners explain why mathematical processes work and how concepts are related.

The statistically significant difference between the pretest and posttest results further strengthens the intervention's effectiveness. The study reported a mean difference of 12.20, a computed t-value of 13.10, and a p-value of 0.000, which is lower than the 0.05 level of significance. Thus, the null hypothesis was rejected, indicating that the improvement in learners' conceptual understanding of mathematics was statistically significant. This result is consistent with Schoenherr, Strohmaier, and Schukajlow's (2024) meta-analysis, which found that visualization interventions produced a positive effect on mathematics learning. It also supports Parame-Decin's (2023) assertion that visual representations help learners understand abstract concepts and solve mathematical problems.

The findings also affirm the importance of representation-based mathematics instruction. Grade Seven Mathematics includes topics such as rational numbers, integers, sets, Venn diagrams, algebraic expressions, equations, polygons, graphs, and data representations, all of which require learners to interpret relationships and move across verbal, numerical, symbolic, and visual forms (Department of Education, 2023). When learners see mathematical ideas through visual tools, they are better able to organize information, compare values, identify patterns, and understand connections among concepts. This supports the argument of Ncube and Luneta (2025) that concept-based instruction strengthens learners' depth of understanding, transfer of learning, engagement, and mathematical performance.

However, the learners still encountered moderate challenges during the intervention, with an overall weighted mean of 3.32. The most prominent challenge was connecting visual representations with mathematical symbols and formulas. Other difficulties included interpreting graphs, charts, and tables; applying visual representations to word problems; needing more teacher guidance; experiencing confusion when too many visuals were presented; and explaining answers using visual representations. These findings imply that visual representations are effective, but they must be introduced gradually, clearly, and with sufficient teacher facilitation. Visual tools should not simply be shown to learners; they must be explicitly connected to mathematical language, symbols, formulas, and problem-solving steps.

The challenges learners encounter also support the need for guided and scaffolded instruction. Visual representations may reduce abstraction, but learners still need help interpreting their meanings and how they relate to mathematical procedures. This is consistent with constructivist learning principles, which hold that learners construct understanding through active engagement, prior knowledge, guided practice, and meaningful interaction (Creswell & Creswell, 2018). It is also consistent with cognitive load theory, which suggests that instructional materials should be designed to support understanding without overwhelming learners. Thus, teachers should use clear visuals, limit unnecessary details, provide step-by-step modeling, and allow learners to explain their reasoning using both visual and symbolic forms.

Overall, the findings justify the proposed Visual-Based Mathematics Instruction Enhancement Plan for Improving the Conceptual Understanding of Grade Seven Learners. The plan should prioritize activities that strengthen learners' ability to connect visuals with symbols, interpret tables and graphs, use number lines and diagrams, apply visual representations in word

problems, and explain mathematical reasoning. The results suggest that visual representations are effective instructional tools, but their success depends on careful selection, guided explanation, repeated practice, and integration with mathematical concepts. Therefore, the study supports the continued use of visual representation-based instruction to make Grade Seven Mathematics more meaningful, accessible, and conceptually grounded.

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