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ORIGINAL RESEARCH ARTICLE

Effect of a Structuralist-Based Geometry Instructional Approach on the Mathematical Literacy of Grade 9

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ABSTRACT

This research note was conducted to determine the effects of a structuralist-based geometry instructional approach on the mathematical literacy of Grade 9 public junior high school students. Mathematical literacy remains a recurring issue among junior high school students, especially in geometry, as learners find it difficult to reason mathematically, represent mathematical information, and solve mathematical problems. The structuralist-based intervention was based on Structural Learning Theory, which focused on recognizing patterns, connecting concepts, visualizing mathematical ideas, and using manipulatives to increase comprehension of geometric concepts. This investigation used a quantitative pre-experimental research design involving a one-group pretest–posttest method. The respondents were 40 Grade 9 students from a public junior high school in Nabunturan, Davao de Oro, chosen using purposive sampling. Descriptive statistics such as mean, standard deviation, and a paired samples t-test were used. Findings revealed that students' mathematical literacy improved from a low level during the pretest (M = 37.73, SD = 3.99) to a high level during the posttest (M = 57.18, SD = 8.91). Statistical analysis further revealed a significant difference between pretest and posttest scores, t (39) = -13.079, $p < .001$, indicating that students performed significantly better after exposure to the structuralist-based instructional approach. The computed effect size (d = 2.07) indicated an extremely large educational effect. The findings suggest that integrating structuralist-based instructional strategies may enhance students' mathematical literacy in geometry through meaningful conceptual engagement and structured learning experiences.

Keywords: *Geometry, mathematical literacy, pretest, posttest, structuralist-based geometry*

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INTRODUCTION

Poor mathematics literacy is an issue of great concern for many countries across the globe. Mathematics students in the 21st century come to mathematics classes with a negative attitude, with a marked lack of fluency and confidence in numerical manipulation, simplification, and problem-solving (Chand et al., 2021). In addition, the study of Nurwahid (2022) stated that there is a range of factors that contribute to the problem of poor mathematics literacy. These include teacher-centered learning, lack of practice with literacy questions, and difficulty in applying mathematical models to real-world problems. This problem is further exacerbated by the lack of variation in teaching models, lack of motivation, and appropriate learning strategies (Kurniawati, 2020).

Mathematical literacy is defined by the PISA (2022), as an individual's capacity to formulate, employ, and interpret mathematics in a variety of contexts. It involves mathematical reasoning and the use of mathematical concepts, procedures, facts, and tools to explain, describe, and predict phenomena. Mathematical literacy enables individuals to recognize the role of mathematics in everyday life and to make sound judgments and decisions as constructive and reflective citizens. Consequently, the development of mathematical literacy is considered a fundamental objective of quality mathematics education and an essential component of 21st-century competencies (Rizki and Priatna, 2019). It is also one of the necessary components of building 21st-century capabilities. The research on mathematics education has shown that mathematical literacy is a serious issue and a growing challenge in the teaching of basic mathematics (Haara, 2018).

In the Philippines, the study of Layug et al. (2021) stated that at Baguio City National High School it has been found that Filipino students had lower numeracy skills and students find it extremely difficult to learn mathematics. The low mathematics ability of Filipino students can be attributed to various factors. One of the main reasons is the inadequate teaching of mathematics in schools, which affects the effectiveness of teaching mathematics concepts to students. (Gallano, 2023).

Meanwhile, based on the exam survey conducted by the researcher as the practicum teacher in public basic education in Nabunturan, Davao de Oro, the findings revealed that 10 out of 40 students, or 25% of the students have passed in the passing score. Moreover, 30 out of 40 students, or 75%

displayed failure to pass in the passing score. These findings emphasize that students have low performances in mathematics in examinations and have low mathematical literacy in the grading period.

One instructional approach that may address this issue is the structuralist-based geometry instructional approach grounded in Structural Learning Theory proposed by Scandura (1970). Structural Learning Theory emphasizes that learning becomes more meaningful when learners recognize patterns, relationships, and underlying structures within concepts. In mathematics education, this approach encourages students to identify relationships among geometric concepts through visual representations, manipulatives, structured problem-solving activities, and conceptual connections rather than relying solely on procedural memorization. The structuralist-based geometry instructional approach in this study operationally refers to a teaching strategy that integrates manipulatives, pattern recognition tasks, visual-spatial representations, and guided conceptual analysis to help students understand geometric relationships and solve mathematical literacy tasks. Through this approach, students are encouraged to construct meaning from geometric concepts by identifying structural relationships among figures, formulas, and problem situations.

In contrast to traditional teacher-centered instruction, where knowledge is often presented directly and students primarily practice procedural exercises, a structuralist-based geometry instructional approach actively engages learners in examining patterns, relationships, and conceptual connections. The approach utilizes visual representations, manipulatives, structured investigations, pattern-recognition activities, and guided problem-solving experiences to facilitate deeper conceptual understanding. Through these learning experiences, students are encouraged to construct mathematical meaning, develop reasoning skills, and apply their knowledge to authentic problem situations.

Several studies support the effectiveness of structured and manipulative-based instructional approaches in mathematics learning. In the study of Mulligan et al. (2020) found that pattern and structure interventions significantly improved students' mathematical reasoning and problem-solving abilities. In addition, Carbonneau et al. (2020) also reported that manipulative-based learning positively influences mathematical problem-solving performance. These findings suggest that structured instructional approaches may contribute to improved mathematical literacy outcomes. This study aimed to determine the effect of a structuralist-based geometry instructional approach on the mathematical literacy of Grade 9 students. Specifically, the study sought to answer the following research questions: What is the level of students' mathematical literacy in geometry before the implementation of the structuralist-based geometry instructional approach? Then is there a significant difference between the students' pretest and posttest mathematical literacy scores in geometry after exposure to the structuralist-based geometry instructional approach?

This study employed a quantitative pre-experimental research design using a one-group pretest–posttest approach. The design was selected to determine whether exposure to a structuralist-based geometry instructional approach would result in changes in students' mathematical literacy scores in geometry. The respondents of the study consisted of 40 Grade 9 students enrolled in a public junior high school in Nabunturan, Davao de Oro (Figure 1). Respondents were selected using purposive sampling because the identified section demonstrated low mathematical literacy performance based on prior geometry assessment results. It utilized a researcher-developed mathematical literacy test in geometry designed to measure students' ability to interpret, analyze, and solve geometry-related mathematical problems. The test included items focusing on geometric reasoning, representation, interpretation, and application of concepts in contextualized

Figure 1. Photo documentation of the Grade 9 students during the conduct of examination.

situations. The structuralist-based geometry instructional approach was implemented during geometry instruction sessions. The intervention emphasized; a) identification of geometric patterns andrelationships, b) use of manipulatives and visual representations, c) guided conceptual analysis of geometric properties, d) collaborative problem-solving activities, and e) structured learning tasks promoting mathematical reasoning. Students participated in instructional activities designed to help them construct conceptual understanding of geometry through exploration of relationships among mathematical structures. In addition, mathematics instructor's experts evaluated the instrument. Pilot testing was also conducted to determine the reliability and clarity of the instrument. Descriptive statistics, including mean and standard deviation, were employed to assess students' mathematical literacy before and after the intervention. In addition, the Shapiro-Wilk test was used to verify whether the data distribution was normal. Because the data were normally distributed, a paired samples t-test was used to see if there was a statistically significant difference between the pretest and posttest results.

From the findings, it is evident that the students had low mathematical literacy prior to undergoing the structuralist-based instruction program. The mean scores obtained from the pre-test were 37.73 (SD = 3.99), suggesting that the students did not demonstrate adequate competence in solving mathematics literacy tasks. Upon implementation of the study program, there was an improvement in scores, rising to 57.18 (SD = 8.91). This was viewed as an indication of high levels of mathematical literacy. The improvement in the students' scores indicates that the structuralist-based geometry instructional approach program positively impacted the students' comprehension of geometric principles and the application of mathematical skills to solve mathematical tasks.

These findings support the study of Mulligan et al. (2020), who found that instructional approaches emphasize patterns and structures improved mathematical reasoning and achievement. Similarly, Carbonneau et al. (2020) emphasized that manipulative-based learning enhances students' problem-solving performance and conceptual understanding. The result showed that the paired samples t-test revealed a statistically significant difference between students' pretest and posttest scores, t (39) = -13.079, $p < .001$. The negative t-value indicates that posttest scores were significantly higher than pretest scores because the analysis computed the difference using pretest minus posttest values. Furthermore, the computed effect size of d = 2.07 indicates an extremely large effect based on Cohen's effect size interpretation guidelines. This finding suggests that the intervention produced a substantial improvement in students' mathematical literacy performance. The findings imply that the structuralist-based geometry instructional approach was effective in improving students' mathematical literacy in geometry. Conceptual learning activities in a well-structured manner could help the students develop their reasoning skills, visualization skills, and conceptual knowledge about the geometric relationships. In addition, these results can be seen as a confirmation of Structural Learning Theory introduced by Scandura (1970), which holds that learning is considered to be meaningful only if the students understand the structure of the information. Through this intervention, the students were able to interact meaningfully with the concepts of geometry. From the results of this research, it was determined that the geometry instruction based on structural learning theory had a positive influence on the mathematical literacy of Grade 9 learners regarding their geometric abilities. Learners made significant progress between the pre-test and the post-test because of instructional activities that involved relational concepts, visual aids, manipulation, and problem solving. The large difference in the post-test scores and extremely large effect size suggest that this form of instruction had a positive impact on the reasoning skills and mathematical literacy abilities of the learners.

CONCLUSION

The findings of this study suggest that mathematics educators may enhance students' mathematical literacy and conceptual understanding in geometry through structuralist-based geometry instructional approach. This approach emphasizes the identification of patterns, relationships, and underlying structures in mathematical concepts rather than reliance on rote procedural learning. The integration of manipulatives (realia) defined as concrete, hands-on instructional materials such as geometric solids, fraction models, counting objects, and other physical or digital tools that allow learners to directly explore and represent mathematical ideas along with visual representations and concept-based activities, can support students in making abstract concepts more concrete and understandable. Moreover, School administrators can assist math teachers by enrolling them into training programs in conceptual and literacy-based math teaching. Additionally, Future researchers can undertake similar studies but using a real experimental or quasi-experimental methodology, along with control groups, to improve internal validity. Further, Other areas of mathematics can be used as topics for future research.

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