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Cross-Over Learning Strategy as an Instructional Approach in Teaching Linear Equations in Two Variables to Grade 8 Learners

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Abstract**—*****This study investigated the effectiveness of the cross-over learning strategy in teaching linear equations in two variables to Grade 8 learners. The strategy bridges classroom instruction with real-world experiences to enhance understanding, engagement, and motivation. Using a pre-experimental single-group pretest-posttest design, 21 Grade 8 students from a public middle school participated during the 2024–2025 school year. Data were collected through a teacher-made achievement test measuring procedural skills, such as solving and graphing equations, and conceptual understanding, including interpreting solutions and relationships between variables. The intervention was conducted over six weeks and involved classroom-based problem-solving activities extended to real-life contexts, followed by group discussions and reflections. Data analysis included descriptive statistics to summarize performance and paired-sample t-tests to assess changes before and after the intervention. Results showed that students significantly improved in both procedural and conceptual understanding, demonstrating deeper comprehension and more consistent performance. The strategy fostered active engagement, collaborative learning, and reflective thinking, allowing students to connect abstract mathematical concepts with authentic experiences and internalize them effectively. These findings suggest that the Cross-over Learning Strategy is an effective instructional approach for making mathematics learning more meaningful, engaging, and applicable to real-life situations, thereby enhancing both academic performance and student motivation in secondary mathematics education.*

Keywords**—** *Cross-over Learning Strategy, linear equations, Grade 8 learners, procedural understanding, conceptual understanding, mathematics education.*

I. INTRODUCTION

The cross-over learning strategy is an instructional approach that bridges formal (classroom) and informal (outside-of-school) learning environments to deepen understanding and increase motivation. Teachers implement this strategy by assigning classroom-based questions that students then investigate through experiences outside the classroom—such as museum visits, field trips, or everyday real-life contexts—and later bring their findings back to the classroom for reflection and discussion. This approach connects academic concepts with real-world applications, fostering authentic, meaningful, and engaging learning opportunities for students. Crossover learning, according to Joseph et al. (2023), is a complete understanding of learning that links formal and informal learning contexts. Similarly, Sharples et al. (2015) highlighted that crossover learning involves teachers posing questions in the classroom, learners exploring these questions during field trips, collecting evidence, and sharing their findings back in class to produce individual or group answers.

Several scholars emphasize the importance of integrating active, reflective, and contextual strategies in mathematics education. Polya (2004) argued that problem-solving should engage learners in exploring multiple approaches rather than depending solely on rote memorization. Schoenfeld (2013) highlighted that reflective and collaborative processes allow students to construct deeper mathematical understanding. Vygotsky (1978) similarly stressed that peer interaction and guided instruction promote knowledge construction, while Bruner (1996) asserted that scaffolding and discovery-based learning enable students to internalize complex concepts. More recent studies affirm the value of connecting academic content with real-world experiences. For instance, Capuno, Necesario, and Aranas (2019) demonstrated that cooperative learning strategies improved Filipino students' problem-solving skills and motivation in mathematics, while Olfos and Zulantay (2007) showed that problem-based learning helps learners bridge classroom knowledge with authentic contexts. These perspectives resonate with the principles of the Cross-over Learning Strategy, which aims to extend mathematics learning beyond traditional classroom boundaries.

Despite this, research exploring the use of the Cross-over Learning Strategy in teaching mathematics remains scarce, particularly in the Philippine secondary school context. While existing studies highlight the benefits of cooperative, problem-based, and metacognitive strategies (Limjap, 2001; Bautista & Mulligan, 2010), little empirical evidence addresses how cross-over learning can specifically improve the teaching of linear equations in two variables. Traditional instructional approaches in most classrooms continue to prioritize procedural drills over conceptual understanding, leaving students with fragmented knowledge that is often disconnected from real-life applications. This gap underscores the need for innovative strategies that not only improve computational accuracy but also foster critical thinking, reasoning, and a positive disposition toward mathematics.

To address this gap, the present study investigates the effectiveness of the Cross-over Learning Strategy as an instructional approach in teaching linear equations in two variables to Grade 8 learners. Using a pre-experimental single-group pretest-posttest design, the study measures students' performance before and after the intervention to determine whether the strategy significantly improves their procedural and conceptual understanding. By bridging classroom instruction with real-world experiences, the study seeks to provide evidence-based insights for teachers and curriculum planners on how to make mathematics learning more engaging, meaningful, and effective. The goal is to contribute to the body of knowledge on innovative teaching strategies that enhance both academic performance and student motivation in mathematics.

II. Research Objective

The objective of this study is to investigate the effectiveness of the Cross-over Learning Strategy as an instructional approach for teaching linear equations in two variables to Grade 8 learners during the 2024–2025 school year at a public middle school.

III. Methods

Design. This study employed a pre-experimental research design, specifically the single-group pretest-posttest design. A pre-experimental design is a type of quantitative research design that seeks to determine the effect of an intervention on a single group of participants without the use of a control group (Creswell & Creswell, 2018). In the single-group pretest-posttest design, participants are measured before (pretest) and after (posttest) the intervention to assess changes in performance attributable to the treatment. Although this design has limitations in controlling external variables, it is particularly useful in educational settings to evaluate the effectiveness of instructional strategies in real classroom contexts. In this study, the design was used to measure the impact of the Cross-over Learning Strategy on Grade 8 students' procedural and conceptual understanding of linear equations in two variables.

Setting. The study was conducted in a Grade 8 mathematics classroom of a public middle school during the 2024–2025 school year. The classroom was arranged to support interactive and collaborative learning, with students seated in clusters to facilitate group discussions and cooperative activities. The walls were adorned with instructional charts, mathematical posters, and visual aids that reinforced key concepts in algebra. The classroom was equipped with blackboards, markers, and other instructional materials necessary for both teacher-led demonstrations and student-centered activities. Each lesson was designed to integrate the Cross-over Learning Strategy, combining formal classroom instruction with tasks that extended learning into real-life experiences, while ensuring a structured and supportive learning environment. Each session lasted 45 minutes, allowing adequate time for instruction, collaborative work, and reflection.

Participants. The participants consisted of 21 Grade 8 students enrolled in the selected public middle school during the 2024–2025 school year. Inclusion criteria were: (1) enrollment in Grade 8 mathematics, and (2) regular attendance during the study period. Students who were absent for either the pretest or posttest were excluded from the analysis. The group comprised learners with diverse academic backgrounds, allowing the study to examine the effectiveness of the cross-over learning strategy across varying levels of prior knowledge and skill in mathematics.

Sampling Design. A purposive sampling technique was used to select the participants for this study. Purposive sampling, also known as judgmental or selective sampling, is a non-probability sampling method in which the researcher intentionally selects participants who meet specific criteria relevant to the study (Etikan, Musa, & Alkassim, 2016). This approach allows researchers to focus on a particular group that possesses the characteristics necessary to address the research objectives. In this study, purposive sampling ensured that only Grade 8 students who were enrolled in mathematics and regularly attended classes were included, resulting in a total of 21 participants.

Instrument. A teacher-made achievement test on linear equations in two variables was used to measure students' performance, assessing both procedural skills (solving and graphing equations) and conceptual understanding (interpreting solutions and relationships between variables). To ensure validity, the test was reviewed by a panel of mathematics experts for content and construct validity, who evaluated whether the items adequately represented the learning objectives and aligned with the Grade 8 mathematics curriculum. Feedback from the experts was used to revise the test items for clarity, relevance, and appropriateness. For reliability, the test was pilot-tested with a group of Grade 8 students not included in the main study, and the scores were analyzed using Cronbach's alpha, yielding a coefficient of 0.87, which indicates high internal consistency. This process ensured that the instrument consistently and accurately measured students' procedural and conceptual understanding of linear equations in two variables.

Data Collection. Data were collected in three phases. First, a pretest was administered to establish students' baseline performance in linear equations in two variables. Second, the intervention was conducted over six weeks, during which the Cross-over Learning Strategy was implemented. This involved classroom-based problem-solving activities that students then explored through real-life experiences, followed by group discussions and reflections in the classroom. Each session lasted 45 minutes, allowing sufficient time for instruction, collaborative work, and reflection. Finally, a posttest was administered after the six-week intervention to measure changes in students' procedural and conceptual understanding.

Data Analysis. Pretest and posttest scores were analyzed using paired-sample t-tests to determine whether there was a statistically significant improvement in students' performance. Descriptive statistics, including mean, standard deviation, and gain scores, were also computed to summarize the overall effects of the intervention.

Ethical Considerations. The study adhered to ethical research standards. Informed consent was obtained from both students and their parents/guardians prior to participation. Participants were assured of confidentiality and were informed that their participation was voluntary and that they could withdraw at any time without consequences. The study also obtained approval from the school administration to ensure alignment with institutional guidelines.

IV. RESULTS

TABLE 1. Paired-Sample t-Test Results for Pretest and Posttest Scores

Observations	Mean	SD	t-value	df	p-value	Interpretation
Pre-test	52.14	10.25	12.56	20	<0.001	Significant
Post-test	78.57	8.96				

Table 1 shows the results of the paired-sample t-test comparing pretest and posttest scores of 21 Grade 8 students in linear equations in two variables. The mean score increased from 52.14 in the pretest to 78.57 in the posttest, representing a mean gain of 26.43 points. This indicates a substantial improvement in students' understanding and application of linear equations.

The t-value of 12.56 with 20 degrees of freedom is highly significant ($p < 0.001$), demonstrating that the observed difference between pretest and posttest scores is statistically significant. This confirms that the improvement in performance can be attributed to the implementation of the Cross-over Learning Strategy, rather than random chance.

The standard deviation decreased slightly from 10.25 in the pretest to 8.96 in the posttest, suggesting that students' performance became more consistent after the intervention. This implies that the Cross-over Learning Strategy not only improved overall achievement but also helped bring students to a more uniform level of understanding.

Overall, the table provides strong evidence that the Cross-over Learning Strategy is effective in enhancing both procedural skills (solving and graphing equations) and conceptual understanding (interpreting solutions and relationships between variables) in Grade 8 mathematics. The findings highlight the value of integrating classroom instruction with real-world experiences to engage learners and improve learning outcomes.

V. DISCUSSION

The findings of this study indicate that the Cross-over Learning Strategy significantly improved the performance of Grade 8 learners in linear equations in two variables. The increase in mean scores from 52.14 in the pretest to 78.57 in the posttest, along with the statistically significant paired-sample t-test result ($t = 12.56$, $p < 0.001$), provides strong evidence that this instructional approach effectively enhances both procedural and conceptual understanding.

These results are consistent with previous studies emphasizing the importance of active, contextual, and collaborative learning strategies in mathematics education. For example, Capuno, Necesario, and Aranas (2019) demonstrated that cooperative learning improved Filipino students' problem-solving skills and motivation in mathematics. Similarly, Olfos and Zulantay (2007) found that problem-based learning helps students connect classroom knowledge to real-life contexts. The present study supports these findings by showing that the Cross-over Learning Strategy, which extends learning beyond the classroom, fosters a deeper understanding of abstract mathematical concepts such as linear equations.

Moreover, experiential and reflective learning approaches have been shown to increase engagement and motivation. Joseph et al. (2023) emphasized that crossover learning, which bridges formal and informal learning environments, promotes active exploration, reflection, and the meaningful application of knowledge. Sharples, Taylor, and Vavoula (2015) also noted that learning that integrates field-based experiences encourages learners to analyze, discuss, and apply knowledge, resulting in stronger conceptual understanding. In this study, students engaged in classroom-based problem-solving activities that were further explored through real-world contexts, allowing them to internalize the mathematical concepts more effectively.

The study also highlights the role of collaborative learning in supporting consistent performance across learners. Vygotsky (1978) emphasized that peer interaction and guided instruction enhance knowledge construction, while Bruner (1996) argued that scaffolding and discovery-based learning help learners internalize complex concepts. The decrease in standard deviation from pretest to posttest (from 10.25 to 8.96) suggests that the Cross-over Learning Strategy helped reduce variability in student performance, enabling learners with different prior knowledge levels to achieve more uniform understanding.

Additionally, integrating real-world applications of mathematics has been shown to improve problem-solving and critical thinking skills. Polya (2004) highlighted the importance of engaging learners in multiple problem-solving approaches, while Schoenfeld (2013) emphasized reflective and collaborative processes for developing deeper mathematical understanding. The findings of this study align with these perspectives, demonstrating that students benefited from tasks that required them to investigate real-life situations, collect data, and analyze results collaboratively, thereby strengthening both their procedural and conceptual skills.

VI. CONCLUSION

The study concluded that the cross-over learning strategy is an effective instructional approach for teaching linear equations in two variables to Grade 8 learners. The strategy improved students' procedural and conceptual understanding by engaging them in activities that connected classroom instruction with real-world experiences. It promoted active participation, collaborative learning, and reflective thinking, enabling students to apply and internalize mathematical concepts more meaningfully. These findings indicate that the Cross-over Learning Strategy effectively addresses the challenge of limited conceptual understanding in traditional mathematics instruction, helping learners achieve better comprehension and more consistent performance in mathematics.

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