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Impact of Problem-Solving Instruction on Grade 10 Math Achievement in a Secondary School in Jamaica

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Abstract: ***This study examined the impact of problem-solving instruction on the mathematics achievement and attendance of Grade 10 students at a rural secondary school in Jamaica. A quasi-experimental pre-test and post-test design compared students receiving traditional instruction with students receiving problem-solving instruction during a three-week algebra intervention. Both groups improved academically, with the experimental group recording a larger mean increase. However, a significant baseline difference between the groups limits attribution of the post-test difference solely to problem-solving instruction. Attendance in the experimental group also increased significantly during the intervention, although other factors affecting attendance were not controlled. The findings suggest that problem-solving instruction is promising for supporting mathematics learning, but further studies with better baseline equivalence and control of potential confounding variables are recommended.***

Keywords: problem-solving instruction, mathematics achievement, rural secondary school, Jamaica

1. Introduction

Mathematics is essential in shaping students' educational paths and future career opportunities. However, many high school students struggle to grasp mathematical concepts, which often results in poor performance. The primary objective of mathematics education is to develop students' critical thinking and problem-solving skills [1]. In Jamaica, mathematics is a compulsory subject at both the primary and secondary levels, and proficiency in mathematics is crucial for those pursuing careers in science, technology, engineering, and mathematics (STEM). Unfortunately, traditional rote learning methods often hinder students' ability to apply mathematical concepts effectively to everyday situations. Research indicates that problem-solving approaches allow students to engage more deeply with mathematical concepts, improving their understanding and leading to better outcomes. [2].

This research was conducted at a non-traditional secondary school located in a rural area of Jamaica. The investigator identified the necessity of this study, driven by a commitment to addressing persistent challenges related to students' mathematics performance within the institution. Over the past eight years, the school's success rate in passing the Caribbean Secondary Education Certificate (CSEC) Mathematics examination has consistently fallen below ten students annually. As the mathematics instructor responsible for both classes involved in this research, the researcher deemed it appropriate to focus the study on these student populations to explore potential strategies for improvement.

2. Problem Statement

Despite its importance, students in the Caribbean have historically struggled with mathematics. The 2023 Caribbean Secondary Education Certificate (CSEC) performance report showed that Jamaican students, along with many of their Caribbean counterparts, scored below the regional average in mathematics. In 2025, Jamaica's CSEC Mathematics pass rate (44 % passing grades) showed a 5% improvement from 2024, but was below the regional average, which was not explicitly reported but typically slightly higher than Jamaica's performance. Jamaica's performance was roughly in line with the Caribbean trend of struggling with math, with the overall regional pass rate in math hovering around 40-50% for that period [3]. Based on observations at a local high school, students appeared to have challenges with mathematics. The school's data show that many students have not met the expected standards, especially in applying mathematical concepts to solve problems. The overall pass rate for the critical national examination, the Caribbean Secondary Education Certificate (CSEC), has remained relatively low over several years. While the school's pass rate for an alternative certification, City and Guilds, appears relatively better and closer to the national average, this alternative is not typically accepted for entry into tertiary education. Difficulty in mathematics can significantly affect Jamaican students' futures, limiting their job prospects and opportunities for advancement and thereby hindering their ability to achieve their goals.

Past studies revealed that traditional teaching methods, such as extensive lecturing and memorization, often fail to develop the problem-solving skills needed for real-world situations [4]. In response to this ongoing challenge, the Ministry of Education, Skills, Youth & Information has enhanced teacher training and instructional strategies to address low achievement in mathematics. A study conducted in 2015 by the Ministry found that students using a problem-solving-focused approach significantly improved their mathematics skills, especially in the areas of reasoning and problem-solving [5].

3. Purpose of the Study

This study aimed to evaluate the effect of problem-solving instruction on the mathematics achievement of Grade 10 students at a secondary school in Jamaica. The emphasis will be centred on the development of critical thinking, conceptual understanding, and real-world problem-solving skills.

4. Significance of the Study

The study will provide key insights for teachers, students, and policymakers. Investigating Problem-Solving Instruction (PSI) could help teachers understand how this instructional approach affects students' mathematics performance. Additionally, it may indicate whether students demonstrate increased attendance and class participation when confronted with real-world challenges. This study may enable teachers to collect and evaluate data on student performance, thereby informing instructional decisions that adapt lessons to address learners' diverse needs.

Understanding the impact of Problem-Solving Instruction (PSI) on mathematics achievement is essential for informing policymakers about effective teaching methodologies. If Problem-Solving Instruction (PSI) demonstrates a positive effect, resources and curriculum development should be directed toward teacher training and the widespread implementation of Problem-Solving Instruction (PSI) strategies, which may enhance student performance in mathematics, a critical component of success in Science, Technology, Engineering, and Mathematics (STEM). Consequently, policymakers can prioritize its adoption as part of broader initiatives to ensure equitable access to high-quality education, thereby fostering social and economic mobility. Furthermore, this knowledge enables policymakers to make informed decisions about the allocation of educational resources, funding, and professional development opportunities.

Therefore, studying the impact of problem-based instruction on mathematics achievement not only supports teachers' professional development but also improves student learning and benefits the broader education sector.

5. Research Questions

This study sought to answer the following research questions:

1) Is there any difference in the performance of Grade 10 students taught using traditional teaching methods compared to those taught using the problem-solving instruction method?
2) How does the Problem-Solving Instruction (PSI) method impact student attendance, as measured by changes in average attendance rates before and after implementation?

6. Limitations

1) Since the sample is drawn from just one school, with only 64 students, the findings may not be generalized because this narrow context might not adequately represent the broader population of Grade 10 students.
2) Factors such as students' prior knowledge, socioeconomic status, or learning disabilities can affect the results [6]. These elements can strongly influence students' math performance, regardless of the teaching methods used. However, the pre-test might offer some insight into these influences.
3) Short-Term vs. Long-Term Effects: The immediate outcomes of problem-based instruction may differ from its long-term effects on mathematical understanding and retention. Some students may become interested and excited when introduced to Problem-Solving Instruction (PSI) over a short period, but may lose interest if the exposure is prolonged, especially if they find it too challenging.
4) Resistance to Change: Some students might oppose problem-based learning because of their preconceptions. When they hear about problem-solving, they may perceive it as challenging, which can deter them from trying.

Definition of Terms

Problem-solving instruction in math education: Problem-solving instruction in mathematics education refers to teaching methods and strategies that equip students with the skills and techniques necessary to comprehend, analyse, and address mathematical challenges. This approach actively engages students in a range of problems, including real-world applications, mathematical puzzles, and complex scenarios that require critical thinking and reasoning [7].

Secondary Mathematics Achievement: Secondary Mathematics Achievement refers to the level of proficiency and performance that students demonstrate in mathematics during their secondary education, typically spanning grades 7 through 11 (approximately ages 12 to 17). This term covers various metrics and indicators used to assess students' understanding, skills, and abilities related to mathematical concepts and their applications at this educational stage [8].

Low-achieving schools and math performance: Mathematics performance refers to an individual's or group's ability to comprehend, apply, and create mathematical concepts, processes, and skills. It is commonly assessed using standardized tests, classroom assessments, and various measures that encompass problem-solving, mathematical reasoning, and the application of mathematics in practical contexts [9].

Impact of teaching methods on math learning: The impact of teaching methods on the learning of mathematical concepts concerns how different instructional strategies influence students' understanding, engagement, and performance. This includes approaches such as direct instruction, inquiry-based learning, problem-solving, collaborative activities, and technology use, all of which affect students' understanding of mathematical concepts, application of skills, and academic success. Piaget [10] emphasized that active engagement and hands-on exploration are vital for cognitive development, suggesting that methods promoting active learning and problem-solving can significantly enhance students' grasp of mathematics.

7. Literature Review

This section contains a thorough review of the literature on problem-solving instruction (PSI) in mathematics education and its effects on students' learning outcomes. It explores the theoretical foundations of structured problem-solving instructions, highlighting how well-ordered guidance fosters meaningful engagement with mathematical concepts. The chapter also discusses the proven effectiveness of problem-solving instruction (PSI) in improving students' mathematical skills, critical thinking, and reasoning. It emphasizes effective teaching strategies for applying problem-solving instruction (PSI) in various classroom contexts and identifies characteristics of practical problems that support learning and comprehension. Additionally, the chapter addresses common challenges in implementing problem-solving instruction and highlights research gaps that require further exploration.

Mathematics education has long acknowledged that problem-solving is essential for developing mathematical skills, critical thinking, and reasoning. Over the years, research has consistently highlighted the importance of structured problem-solving instructions (PSI) in promoting meaningful learning and enhancing students' math achievement. These instructions employ pedagogical strategies that systematically guide students in solving mathematical problems, emphasizing reasoning, exploration, and strategic thinking rather than memorizing procedures. They typically include clear steps, such as understanding the problem, planning, executing, and reviewing the solution, that support student efforts and foster independent problem-solving skills. This review examines the theoretical foundations of problem-solving instruction, its demonstrated effectiveness, effective teaching strategies for implementation, the characteristics of practical problems, common obstacles in practice, and existing research gaps.

The significance of problem-solving in mathematics education can be traced to the influential work of George Polya [11], who emphasized the use of heuristic strategies and a structured approach to problem-solving. Polya proposed a four-step process: understanding the problem, devising a plan, carrying out the plan, and reflecting on the outcome, which has served as a foundational framework for teaching problem-solving across various educational levels. His approach underscored the importance of developing students' strategic thinking and metacognitive skills, rather than focusing solely on procedural fluency. Since then, constructivist learning theories have further supported the use of problem-solving instructions. Lev Vygotsky's [12] social constructivism emphasizes active learner engagement in constructing knowledge through meaningful tasks, including complex problems that require exploration and reasoning. Vygotsky also introduced the concept of the Zone of Proximal Development (ZPD), emphasizing the importance of scaffolding, supporting learners just beyond their current level of competence, to facilitate learning.

Building on these foundations, the cognitive apprenticeship model [13] advocates guided learning in which teachers serve as mentors, modelling problem-solving strategies and gradually releasing responsibility to students. This approach aligns with the idea that students learn best when they actively participate in solving authentic problems within a supportive environment. These theoretical perspectives collectively justify the integration of structured problem-solving instructions as a practical pedagogical approach in mathematics classrooms.

Hiebert and Grouws [14], in their comprehensive review, concluded that students who participate in problem-solving tasks develop deeper conceptual understanding, greater engagement, and improved problem-solving skills. Similarly, Liu & Xiong [15] conducted a meta-analysis that found that explicit instruction in problem-solving strategies significantly enhances students' understanding and ability to apply mathematical concepts across diverse contexts. The findings suggest that problem-solving instructions not only improve immediate achievement but also foster transferable skills that benefit students in future learning endeavours. Empirical research supports the positive impact of problem-solving instructions on students' mathematical achievement. Numerous studies and meta-analyses have demonstrated that students engaged in problem-solving activities outperform their peers in both procedural and conceptual assessments [16,17,18,19,20].

Boaler [21] further supported this view, emphasizing that students taught through problem-solving approaches demonstrate greater conceptual understanding and exhibit higher levels of motivation and perseverance. These students tend to approach mathematics with curiosity and resilience, which are critical for overcoming challenges and developing a growth mindset. Schoenfeld [22] argued that problem-solving instruction promotes mathematical reasoning, flexibility, and strategic competence, traits essential for success in higher mathematics and real-world problem contexts. Importantly, these benefits are not limited to specific student populations; diverse learners, including those with learning difficulties or from marginalized backgrounds, also benefit from problem-solving approaches [23]. Lesh and Doerr [24] along with Van de Walle, et al. [25], emphasize that well-designed problem-solving instruction can serve as an equitable pedagogical strategy that supports the mathematical growth of all students.

The rationale for adopting a problem-solving approach in mathematics education is multifaceted [26]. First, it fosters meaningful learning by encouraging students to understand underlying mathematical principles rather than merely memorizing procedures [21]. Authentic problems that require reasoning and exploration motivate students to engage deeply with concepts, leading to durable understanding and better transfer of skills to new problems [22]. Secondly, problem-solving approaches foster the development of higher-order thinking skills, including analysis, synthesis, evaluation, and metacognition [24]. As students grapple with complex problems, they learn to strategize, evaluate their solutions, and reflect on their thinking processes, cultivating independence and resilience.

Moreover, problem-solving instruction enhances motivation and engagement. Authentic and challenging problems are often more relevant and stimulating for learners, motivating perseverance and curiosity [24]. This increased motivation contributes to improved academic achievement and fosters a positive attitude towards mathematics. Additionally, problem-solving strategies align with educational standards that emphasize reasoning, modelling, and communication skills vital for success beyond the classroom. Consequently, integrating problem-solving instructions into curricula is seen as a pathway to developing not only procedural fluency but also conceptual understanding and mathematical literacy.

Implementing problem-solving instructions involves a variety of pedagogical strategies tailored to scaffold student learning and promote independence. Inductive and discovery-based teaching, for example, encourages students to explore specific problems, identify patterns, and derive general principles. Van de Walle, et al. [25] advocate inquiry-based learning in which students investigate problems to discover mathematical relationships. This approach fosters active engagement and ownership of learning, aligning with constructivist principles.

Guided problem solving and scaffolding are also central to effective instruction. Teachers provide hints, prompts, or partial solutions to support students in developing strategies, gradually withdrawing assistance as competence increases [24]. This process enables learners to build confidence and competence in problem-solving. Open-ended problems, which often have multiple solutions or approaches, stimulate creative thinking and reasoning, encouraging students to justify their strategies and compare different methods [24]. Collaborative problem-solving, in which students work in groups, fosters communication, argumentation, and the sharing of diverse strategies—elements that deepen understanding and promote mathematical discourse [27].

Technology also plays a vital role in supporting problem-solving instruction. Digital tools, manipulatives, and visual representations facilitate exploration and visualization, making abstract concepts more concrete and accessible [28]. For example, dynamic geometry software enables students to experiment with and discover properties interactively, fostering a deeper engagement.

Designing practical mathematical problems is crucial for successful instruction in problem-solving. A practical problem should challenge students without causing frustration, promote conceptual understanding rather than rote memorization, and be relevant to real-world contexts. Polya [11] emphasized that problems should be cognitively demanding but accessible, encouraging students to think critically and strategize. Lesh and Doerr [24] further advocate for problems that have multiple entry points and solutions, supporting diverse learners and fostering discussion and reflection. Clarity and structure are also important; well-structured problems with clear instructions and sufficient information help students focus on reasoning and strategy rather than deciphering the task. Finally, problems should prompt students to analyse their solutions, justify reasoning, and explore alternative approaches—elements that deepen understanding and promote metacognitive reflection.

While the body of evidence supporting problem-solving instructions is compelling, several challenges and gaps persist in the current literature. One significant challenge is ensuring implementation fidelity, as teachers' understanding and consistent application of problem-solving strategies vary widely, often due to limited professional development or resources [24]. This variability influences the effectiveness of problem-solving instruction and highlights the need for comprehensive teacher training and ongoing support. Additionally, assessments tend to emphasize procedural fluency, often neglecting reasoning, strategy use, and reflection. Developing assessments aligned with problem-solving skills remains an ongoing challenge, limiting the ability to measure the full impact of these instructional approaches.

Furthermore, cultural, socioeconomic, and curricular contexts influence the effectiveness of problem-solving instruction, and more research is needed to explore these variables across diverse settings. While many studies focus on short-term gains, fewer longitudinal investigations examine the long-term impact of problem-solving instruction on achievement, attitude, and mathematical identity. Moreover, designing high-quality, open-ended problems that are both accessible and challenging for all learners remains a complex task. Researchers also call for a more nuanced understanding of how to tailor problems and strategies for different age groups and learning needs.

Despite these challenges, the existing body of research underscores the importance of problem-solving instructions as a pedagogical approach that can significantly enhance students' mathematical achievement. Grounded in constructivist and cognitive theories, effective problem-solving instruction involves the use of explicit strategies, scaffolding, collaborative learning, and meaningful problems designed to promote reasoning and conceptual understanding. As educational institutions and teachers seek to improve mathematics outcomes, integrating structured problem-solving instructions remains a promising avenue for fostering mathematical literacy, reasoning, and perseverance among learners.

In summary, the literature consistently demonstrates that problem-solving instructions have a profound impact on students' mathematics achievement. The theoretical foundations rooted in constructivist learning, cognitive apprenticeship, and heuristic strategies support their adoption. Empirical evidence suggests that well-implemented problem-solving approaches lead to enhanced conceptual understanding, procedural fluency, motivation, and skill transfer. While challenges related to implementation and assessment remain, ongoing research and professional development can address these gaps. Overall, problem-solving instructions are integral to effective mathematics instruction and hold great promise for fostering deeper learning and achievement in mathematics classrooms.

8. Methodology

This section describes the research design and other aspects of the methodology that is used in this study. It outlines the target population, sampling technique, sample size, data collection approach, data analysis plan, and ethical considerations.

8.1 Research Design

The study utilized a quasi-experiment research design. The Quasi-Experiment design is deemed the most suitable in this context as it allows for the examination of cause-and-effect relationships without the need for random assignment of participants to groups. The quasi-experiment also facilitated a full investigation into how problem-solving instruction may impact the algebraic performance and overall achievement of Grade 10 students in mathematics.

Two groups of students were involved:
1) The control group was taught algebra using traditional instructional methods.
2) The treatment group utilized a problem-solving approach.

Before the intervention, all participating students completed a pre-test. This was to establish their baseline algebraic abilities. The intervention lasted for three weeks, during which:
1) The Control Group received instruction on algebraic topics via traditional methods, that is, teacher-centred approaches.
2) The Treatment Group was engaged with problem-solving strategies, that is, student-centred methods,

These methods were used to determine which of the two methods was more effective in improving students' understanding and performance in mathematics.

The instructional content to be covered will include:
- Week One: Solving linear equations
- Week Two: Solving simultaneous equations
- Week Three: Factorizing quadratic expressions

At the end of the intervention, both groups completed a post-test designed to measure their learning gains. This facilitated a comparison of achievement between the two instructional approaches and their effectiveness.

To ensure consistency, the same teacher instructed both groups throughout the study. Additionally, students' attendance was monitored and recorded regularly to determine its influence (if any) on students' learning outcomes.

This study exclusively collected and analyzed quantitative data, focusing on students' test scores and attendance records to objectively assess the effectiveness of the instructional methods.

8.2 The Participants

The target population for this study consisted of approximately 280 Grade 10 students at a low-performing, non-traditional high school in rural Jamaica, with each class comprising approximately 35 students. The school's total enrolment is approximately 1,700 students in grades 7-13. A convenience sampling method was used to select the participants, comprising 70 students drawn from two of the eight Grade 10 classes. At this stage, the students were performing below the expected grade 10 ability level. Consequently, this study is aimed at addressing student academic challenges by employing different teaching strategies to improve students' performance. Since the researcher taught the two classes and had established rapport with their parents, it was easier to facilitate participant recruitment and parental consent, thereby enhancing the feasibility of the study [29]. In accordance with established guidelines for quasi-experimental research, as stated by Gay & Airasian [30], a group size of 30 or more was considered adequate for quasi-experimental designs to detect moderate effect sizes. With approximately 35 participants per group, this study exceeded the standard. Due to students' absence from classes, only 64 of the 70 completed the pre-test and the post-test; indicating 6 were excluded.

8.3 Data Collection and Data Analysis

The researcher utilized a comprehensive data collection method to accurately assess students' algebraic ability and the intervention's effectiveness. Selecting an appropriate data collection instrument was a critical component of the research process, as the chosen instruments must demonstrate validity, reliability, and suitability in addressing the research questions [31]. Specifically, the study utilized pre-test and post-test assessment instruments to measure students' algebraic baseline abilities, students' achievement, and gathered relevant data. The selected students were divided into two groups: a control group and a treatment group. The group assignment was based on the existing class division to ensure comparability. The control group was taught algebra using the traditional instructional method, while the treatment group received instruction through a problem-solving instruction approach. The test instrument was administered separately to the control group and treatment group to ensure precise measurement of the intervention's impact. At the beginning of this phase, students completed a pre-test to establish their baseline algebra abilities. At the end of this phase, both groups took a post-test similar in content to the pre-test. The instructional sessions were scheduled as three one-hour classes per week, each dedicated to one specific topic. Each topic was covered in three one-hour sessions per week, totaling nine sessions per group, over three weeks. Each instrument comprised 15 items focusing on different types of algebra questions with emphasis on solving linear and simultaneous equations, as well as factorization of quadratic equations. The tests were structured into three distinct sections: (1) solving linear equations, (2) solving simultaneous equations, and (3) factoring quadratic expressions. Each section included sub-items comprising both mathematical expressions and word problems used to comprehensively evaluate procedural skills and problem-solving abilities. The instruments consisted of questions selected from Caribbean Secondary Examination Certificate (CSEC) past paper questions that have been used over several years, there was no need for pilot testing, as validity and reliability had already been established. The aim was to assess students' procedural skills and problem-solving abilities. The expected outcome of the tests is that students in the treatment group, who were exposed to the problem-solving instructions, would demonstrate statistically significant improvements in their ability to solve linear and simultaneous equations and factorise quadratic expressions, when compared to the control group. It was also expected that students would show greater accuracy and clarity in their solution steps, reflecting a deeper understanding of the problem-solving processes. Also, a standardized mark scheme was employed to evaluate the students' responses. This rubric provided clear criteria for assessing the correctness of solutions, the clarity of solution steps, and the application of appropriate mathematical procedures. For instance, students were expected to show detailed solution steps for each expression or equation, including the identification of relevant concepts and the logical progression of their solutions. This approach ensured consistency and objectivity in scoring and facilitated reliable comparison of student performance across the two groups.

Firstly, an assessment instrument comprising 15 structured items on linear, simultaneous, and quadratic equations was developed for the students. Each aspect of the assessment instrument had at least two worded questions (See Appendix D). This assessment will be administered at two points: a pre-test administered before instruction and a post-test administered after the intervention. Its purpose is to evaluate students' performance after engaging with traditional teaching methods and subsequently after implementing problem-solving instructional strategies. The assessment focused on the Algebra strand of the mathematics syllabus.

Secondly, instructional sessions were conducted using two pedagogical approaches: traditional instruction and problem-solving instruction, over three weeks. The students' attendance log was also critical to the process of data collection. This meant that the attendance data was taken daily, with a view to assessing the impact that problem-solving may have on student attendance.

Data analysis was integral to converting raw data into meaningful insights that can inform teaching practices and improve student learning outcomes. In this study, following the collection of assessment scores from both pre- and post-test administrations, the data were systematically organized to facilitate comparison. The primary objective was to determine whether the problem-solving instructional approach had any significant effect on students' understanding of algebra. The data was input into Excel for analysis. Descriptive statistics, such as mean scores, standard deviations, and score distributions, were computed for both the traditional teaching phase and the problem-solving instructional phase. These statistics gave a clear summary of student performance and progress.

Paired sample t-tests were used to determine if there was any statistically significant difference between pre-test and post-test scores. This method was suitable because it compared the scores of the same students before and after the intervention. Attendance was recorded daily, and the percentage of students present was calculated. The average attendance rates of the students in the treatment group before and during the intervention were compared. A paired t-test was utilized to determine whether there was a significant difference in attendance rates before and during the intervention. Additionally, descriptive statistics were also used to show attendance trends.

These analyses assisted in drawing meaningful conclusions about the practicality of the problem-solving instructional approach in improving algebra skills among Grade 10 students.

8.4 Ethical Consideration

The researcher sought and obtained ethical approval for the research from the university's ethics committee. The researcher also received permission to conduct the study at the research site with Grade 10 students. Before participation, written informed consent was obtained from all students and parents/guardians, explaining the purpose of the study, the procedures involved, confidentiality, and their right to withdraw at any time without penalty. The participants were informed that confidentiality and anonymity would be ensured so they would not be identified and the data would be aggregated for analysis and discussion of findings. The researcher also stored all collected data securely in password-protected files accessible only to the researcher.

9. Results

These findings were presented according to each of the research questions.

9.1 Results Based on Research Question 1

Is there any difference in the performance of Grade 10 students taught using traditional teaching methods compared to those taught using the problem-solving instruction method?

This question compares the performance of students taught using traditional teaching instruction with that of students taught using the problem-solving instruction method. The findings only account for sixty-four (64) of the seventy (70) students initially selected for the study, where the remaining six (6) students were excluded due to absence from classes and did not complete the pre-test and post-test. For the reported analyses, the study comprised thirty-one (31) in the control group and thirty-three (33) in the experimental group who completed both the pre-test and post-test. A pre-test was administered to determine the baseline performance of the two student groups before the intervention. The mean and standard deviation of the pre-test scores of the students taught by the traditional teaching instruction, the control group, were five (5) and 7.78, respectively. The mean and standard deviation of the pre-test scores of the students taught by the problem-solving instruction, the experimental group, were 13.31 and 12.77, respectively. (Table 1). The pre-test scores indicated that the experimental group had a higher baseline average than the control group before the intervention.

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Table 1: Pre-test results for both the control and experimental groups

Group	N	Mean	Standard Deviation
Control Group	31	5	7.78
Experimental Group	33	13.31	12.77

Note: N represents the number of students in each group.

An independent -sample t-test was conducted to compare the pre-test scores of the control and experimental groups. The results showed a statistically significant difference between the Control Group (M = 5, SD = 7.78) and the Experimental Group (M = 13.3, SD = 12.77), t (53.861) = -3.174, p < 0.001(Table 2).

After the intervention, a post-test was administered to both the control and the experimental groups to determine if there was any improvement in their academic performance. The post-test scores showed an increase in both groups, with the experimental group showing a more substantial increase. To determine whether there is a statistically significant difference in students' performance based on the teaching method, an independent samples t-test was conducted on the post-test scores.

Table 2: Independent Sample T-test comparing pre-test and post-test scores between groups

Independent Sample Test					
t-test for Equality of Means					
					95% Confidence Interval of the Difference
	T	Df	p-value	Mean Difference	Upper
Pre-test A	-3.174	53.861	.001	-8.24242	-3.03628
Post-test B	-1.751	56.717	.043	-8.13196	1.17038

The results indicate that the Control Group (M = 15.323, SD = 14.887) and the Experimental Group (M = 23.455, SD = 21.819), t (56.717) = -1.751, p < 0.043. (Table 3).

Table 3: Post-test of both the control and experimental groups

Group	N	Mean	Standard Deviation
Control Group	31	15.323	14.887
Experimental Group	33	23.455	21.819

Since p = 0.043, which is less than 0.05, this indicates a statistically significant difference between the control and experimental groups on the post-test. Therefore, based on this result, we accept that there is a significant difference between the pre-test and post-test scores. This result suggests that the problem-solving instructional method may have had a positive effect on the students' academic achievement. However, the findings revealed that the two groups differed significantly at pre-test (p < 0.001, Table 2), indicating that this unadjusted post-test comparison blurs the distinction regarding the instructional method from the initial benchmark difference between groups. Consequently, the result above should be interpreted with this limitation in mind.

However, since the groups were not equal at the pre-test level, further analysis was required to control for initial differences. A paired-samples t-test was performed within each group to assess the improvement from pre-test to post-test. It should be noted that the current results are only suggestive because a paired t-test ignores baseline differences, and an analysis of covariance (ANCOVA) is required for a conclusive comparison.

Table 4: Paired Samples **Test** for the control group

t-Test: Paired Two-Sample for Means - Control Group		
	Pretest	Posttest
Mean	5	15.32258
Variance	60.53333	221.6258
Observations	31	31
Pearson Correlation	0.174111	
Hypothesized Mean Difference	0	
df	30	
t Stat	-3.69588	
P(T<=t) one-tail	0.000437	
t Critical one-tail	1.697261	
P(T<=t) two-tail	0.000874	
t Critical two-tail	2.042272	

The analysis of post-test scores in Table 4 shows that the control group's mean was 15.32 (SD = 14.89), whereas the experimental group's mean seen in Table 5 was significantly higher at 23.46 (SD = 21.82). Both groups demonstrated improvements from their respective pre-tests. These results provide evidence supporting the effectiveness of enhancing students' achievement in algebra. The students taught using problem-solving instruction performed better than their counterparts who received traditional instruction, with post-test achievement scores indicating a statistically significant difference in favour of the experimental group. Additionally, Pearson's correlation coefficients indicated a moderate relationship between pre- and post-test scores for the control group (r = 0.174) and a stronger relationship for the experimental group (r = 0.396). However, the large standard deviation in comparison to the mean, especially for the experimental group, suggests that while there is a significant difference overall, there is a wide variation in individual scores. Therefore, the results should be interpreted with caution.

Table 5: Paired Samples Test for the experimental group

t-Test: Paired Two-Sample for Means – Experimental Group		
	Pretest	Posttest
Mean	13.24242	23.45455
Variance	158.0644	476.0682
Observations	33	33
Pearson Correlation	0.395912	
Hypothesized Mean Difference	0	
df	32	
t Stat	-2.87306	
P(T<=t) one-tail	0.003581	
t Critical one-tail	1.693889	
P(T<=t) two-tail	0.007162	
t Critical two-tail	2.036933	

9.2 Results Based on Research Question 2

How does the Problem-Solving Instruction (PSI) method impact student attendance, as measured by changes in average attendance rates before and after implementation?

The analysis of the attendance data reveals a statistically significant increase in the average attendance rate following the implementation of the Problem-Solving Instruction (PSI) method. The mean attendance rate before problem-solving instruction was approximately 76.58% (SD =13.99), and the mean attendance after problem-solving instruction was approximately 84.24% (SD = 13.24) as shown in Table 6. The difference between these two periods was statistically significant, with a p-value of 0.013. The increase in attendance rates during the implementation of Problem-Solving Instruction is statistically significant, indicating that problem-solving instruction had a positive influence on student attendance.

Table 6: Average attendance before and during intervention for the experimental group

Group	N	Mean%	Standard Deviation
ADABI	31	76.576	13.991
ADADI	33	84.242	13.236

Note: ADABI & ADADI represent average attendance before and during the intervention

Although the data analysis suggests an increase in students' attendance during the intervention, it is essential to acknowledge that attendance is influenced by many factors beyond the instructional approach, such as motivation, illness, socioeconomic conditions, and school events, among others. Since we did not account for these factors that could have affected the results, we cannot be completely sure that the increase in scores is only because of the problem-solving instruction.

10. Further Discussions

Research Question 1 examines the impact of problem-solving instruction on students' academic achievement. The analysis of post-test scores shows the control group's mean was 15.32 (SD = 14.89), whereas the experimental group's mean was significantly higher at 23.46 (SD = 21.82). Both groups showed improvements from their respective pre-test. These results provide evidence to support the effectiveness of enhancing students' achievement in algebra. The results indicated that the students taught using the problem-solving instruction performed better than their counterparts who received traditional instruction, with post-test achievement scores demonstrating a statistically significant difference in favour of the experimental group (p = 0.043).

This aligns with previous research, suggesting that integrating problem-solving strategies into instructions can lead to meaningful improvement in students' understanding and application of mathematical concepts. This was corroborated by Boaler [21], who noted that problem-solving instruction fosters meaningful learning by encouraging students to understand the underlying principles rather than merely memorizing procedures. Schoenfeld [22] shares a similar perspective, contending that authentic problems that require reasoning and exploration motivate students to engage deeply with concepts, leading to durable understanding and better transfer of skills to new problems. This is consistent with constructivism, which stresses active engagement and understanding over rote learning. One such constructivist is Vygotsky [12], who introduced the concept of the Zone of Proximal Development (ZPD), emphasizing the importance of scaffolding, supporting learners just beyond their current level of competence, to facilitate learning.

Paired samples t-tests were conducted comparing pre-test and post-test scores for both groups of participants. The results showed significant improvements from pre-test to post-test scores for the control group (t = -3.696, p = 0.008) and the experimental group (t = -2.873, p = 0.007). Additionally, Pearson's correlation coefficients indicated a moderate relationship between pre- and post-test scores for the control group (r = 0.174) and a stronger relationship for the experimental group (r = 0.396), suggesting that students in the experimental group obtained relatively higher scores after the intervention. However, the baseline difference in pre-test scores complicates the interpretation. Since the experimental group started with higher pre-test scores, some of the post-test differences may reflect pre-existing differences rather than the effect of the instruction alone.

Regarding Research Question 2, data were collected from the students exposed to the problem-solving instruction. This study indicates an increase in the average attendance rates following the implementation of the Problem-Solving Instruction (PSI) method. The data showed that the mean attendance improved from before the implementation to after the implementation. The analysis of the attendance data shows a statistically significant increase in the average attendance of the experimental group during the implementation of the problem-solving instruction method compared to before. Specifically, the mean attendance rate before the intervention was approximately 76.58% (SD = 13.99), and during the problem-solving instruction, it increased to approximately 84.24% (SD = 13.24). The difference between the two periods was statistically significant, with a p-value of 0.013.

11. Conclusion

Both groups improved from pre-test to post-test, with the experimental group showing a larger mean increase. However, the significant baseline difference between the groups limits the extent to which the post-test difference can be attributed specifically to problem-solving instruction. The intervention therefore appears promising, but the findings should be interpreted cautiously because the study involved one school, a relatively small sample, and a quasi-experimental design. Attendance in the experimental group increased significantly during the intervention, but this finding does not establish that problem-solving instruction caused the increase because other influences on attendance were not controlled. Future research should use more comparable groups, larger samples, appropriate adjustment for baseline achievement, and stronger controls for factors affecting attendance.

12. Recommendations

The following recommendations are made based on the findings of the study:

- Implement Covariate Analysis in Future Studies:
- Ensure Group Equivalence at Baseline when designing future experiments

- Increase Sample Size and monitor score variability to enhance the reliability and generalizability of the results.
- Further studies should explore other factors that might influence attendance and better understand the relationship with problem-solving instruction.
- Future researchers should implement additional measures to monitor the impact of problem-solving instruction over time and gather more detailed data for more accurate results.

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