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INSTRUCTIONAL SCAFFOLDING AND PROBLEM-SOLVING SKILLS IN SECONDARY EDUCATION: AN EXPERIMENTAL ANALYSIS

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Abstract
The study under discussion explored the usefulness of instructional scaffolding in improving the problem-solving abilities of students in the secondary school setting in mathematics. The research was based on the socio-cultural theory of Vygotsky and the Zone of Proximal Development and aimed to establish the effect of scaffold instruction on the learners in terms of their ability to interpret and translate problems, apply mathematical concepts and perform logical thinking and multi-step problem solving. Quantitative experimental research design was applied which comprises upon pre-test & post-test. The students of a ninth grade from a government high school in Vehari, Punjab, Pakistan were the population of the study; the sample was split into two groups; control group and experimental group. An experimental design that was undertaken was a pre-test & post-test, in which two intact groups of secondary school students were chosen. The pre-test results indicated that there was no statistically significant difference between the experimental and control groups ($p > 0.05$), which ensued baseline equivalence. However, the result of the post-test showed a very significant difference ($p < 0.001$) in favor of the experimental group on all three domains. The students who were subjected to the scaffold instruction gained a better understanding, better conceptual application and higher logical reasoning when compared to students who were taught under the normal instructional method. These results support the usefulness of scaffolding to increase the mathematical problem-solving ability of the students. Conclusively, instructional scaffolding has extensive pedagogical value, including critical thinking, conceptual learning and self-directed learning. The implications of these results on mathematics teachers and curriculum developers were that scaffold teaching methods must be adopted systematically in mathematics to encourage learners in acquisition of problem-solving skills.
Keywords: Instructional scaffolding, Problem-solving skills, Mathematical reasoning, Secondary education, Experimental study, ZPD, Guided learning

1. INTRODUCTION

The problem-solving skills are recognized as a universal component of mathematics education that significantly affects the mathematical cognition of the students and their ability to solve complicated problems. These skills include a continuum of cognitive functions, including the identification of problems, the development of strategies, the execution of solutions, and the critical assessment of the results, thus facilitating the further understanding and implementation of mathematical ideas (Sinaga et al., 2023; Tambunan H., 2019). By involving learners in problem-solving, the academic performance is not only enhanced but also the critical thinking, logical thinking, and reflective skills that are equally vital in negotiating academic and real-life settings are developed (Sinaga B. et al., 2023).

The aim in mathematics education, especially in the secondary school, is to equip the learners with competence to use mathematical knowledge practically in a range of situations, one of which involves real-world problems. Mathematical problem-solving involves higher-order cognition, creativity, resilience, collaboration, which cannot be ignored in the dynamic environment of modern societies (MurtiyasaB. 2020; Ahdhianto et al., 2020). More so, these competencies significantly correlate with student success, which is a significant percentage of the total achievement in mathematics (Sinaga B. et al., 2023).

Despite their significance, there are several issues that undermine the successful development of problem-solving skills in the educational setting. The excessive application of traditional pedagogy, limited learner interaction, and insufficient clear focus on problem-solving teaching are some of the factors that hinder the best learning results (Betanga, 2018; Fulton, 2017). Such challenges highlight the need to have novel teaching methods explained as modeling and scaffolding, which provide highly specific and focused support and promote active learning strategies, thus enabling students to learn to solve problems (Himmah, 2022).

The recognition of problem-solving as the essence of mathematics education is aligned with the international educational systems, which promote systematic inclusion of this issue throughout the curricula to equip students with tertiary education and career advancement. Through these developments in the instructional methodologies, teachers can alleviate the adaptive learning, logical understanding, and practical implementation capabilities of the students and can therefore prepare students to react effectively to the unpredictable situations and intricate problems throughout their lifespan (Cockcroft, 1982; Resnick, 1987).

Problem-solving skills are crucial in maximizing the learning outcomes in mathematics and also to provide learners with the key competencies that are essential in personal, academic, and professional achievement. The integration of problem-solving into pedagogy requires a shift towards more interactive, learner-centered methods that anticipate the future obtaining of knowledge, practice, and continued development of skills and thus overcoming the current issues in education and achieving the maximum potential of teaching mathematics.

Mathematics teaching has remained a major challenge to a large percentage of elementary school students that can be attributed to a combination of factors that influence learning of mathematical concepts and solving mathematical problems. Despite the concerted efforts of teachers, the problem is in the fact that there is a group of learners who constantly face troubles, which can be explained by insufficient understanding of the problems themselves or the unfamiliarity with the strategies of procedures that can be used to address them. These problems are aggravated by the fact that most of the instructional resources and pedagogical practices are very homogeneous and thus do not support individual learning profiles, thus leading to the development of unequal academic performance. This educational disparity usually ends up in less sophisticated intellectual growth and reduced academic performance, which stresses on the necessity of more effective pedagogical strategies. Based on the Vygotsky Zone of Proximal Development, instructional scaffolding is an interesting intervention because it provides customized assistance that is gradually withdrawn as students develop independent problem-solving skills. This study therefore aims at testing empirically the effectiveness of instructional scaffolding in developing problem-solving skills in secondary school students.

The study is essential as it attempts to fill a critical gap in mathematics teaching that focuses on the role of scaffolding on students problem-solving and reasoning abilities. By clarifying the processes in which scaffolding assists in autonomous learning, the study offers crucial information that can be used to inform teacher training and curriculum changes. The expected results will likely fill the gaps in the pedagogical literature, help teachers make scaffolding strategies more accurate, and, eventually, support the development of more sophisticated conceptual knowledge, increased engagement, and better performance. Besides, the results of the study can be used to make policy related to the standardization of curriculum and the distribution of educational resources in the contexts of secondary schooling, which can be compared to the research design, and help to develop critical thinking and lifelong learning skills necessary to succeed in academic and vocational activities in the future.

Research Objectives

1. To examine the role of instructional scaffolding in understanding and translating problems.
2. To measure the improvement in students' ability to understand mathematical concepts after receiving instructional scaffolding-based teaching.
3. To investigate the effectiveness of instructional scaffolding in enhancing Logical Reasoning & Multi-Step Problem Solving of secondary school students in mathematics.
4. To compare the problem-solving performance of students taught through instructional scaffolding with those taught by traditional methods.

Hypotheses

- H01: Instructional scaffolding does not play a significant role in understanding and translating mathematical problems.

- H02: Instructional scaffolding does not play a significant role in understanding mathematical concepts of secondary school students.
- H03: Instructional scaffolding has no significant effect on enhancing Logical Reasoning & Multi-Step Problem Solving of secondary school students in mathematics.
- H04: There is no significant improvement in students' problem-solving abilities after receiving instructional scaffolding-based teaching.

This research focuses on ninth-grade secondary school students of Government High School 9-11 W.B, Vehari, Punjab, Pakistan. The study examines the effects of instructional scaffolding on numerical reasoning, problem-solving, and logical reasoning skills within the mathematics curriculum. Using an experimental design, the study compares students receiving scaffolding-based instruction with a control group taught by traditional methods over a defined academic period.

2. LITERATURE REVIEW

The current research focuses on determining the effects of the instructional scaffolding on the mathematical reasoning development among the secondary school students. To provide the needed background to this research question, a literature review will be conducted in a systematic manner, which will include the historical development of this type of education and the specific issues that teachers might face in teaching mathematics on this stage. The relevance of mathematical thinking is discussed in more detail, and the different elements that develop high-level thinking are discussed. Moreover, the paper also assesses the use of instructional scaffold in mathematics education and methods aimed at improving the mathematical skills of students.

Secondary Schools

The secondary education is a very important part of Pakistani education system which consists of three separate layers: higher secondary (grades 1112), high school (grades 910) and elementary (grades 6-8). The stage is usually the final phase of formal education before one joins the labor market hence equipping qualified manpower with job opportunities and leads to the growth of the economy of the nation and individual. Moreover, high-achieving students who want to get tertiary education can develop this base (Ghulam Murtaza, 2021; Murtaza & Hui, 2021; UNESCO, 2021).

Secondary education laws have been passed in government of Pakistan twice. The former happened with the Constitution 18th Amendment that restructured the role of the state in the process of providing education and consequently made the government provide high-quality secondary education to every student. The second important amendment was the addition of Article 25-A that required that all children, between 5 and 16 years be educated freely and compulsory. The Article 25-A generally has been a key area of government policy (Jamal, 2021, Bukhari et al., 2025; Government of Pakistan, 2021).

High School Mathematics Teaching

In Pakistan, mathematics is a compulsory course since the early childhood up to secondary education. In the secondary level, all learners must take Mathematics with the general track emphasizing general Mathematics, which underlines the significant role of the subject (Mughal et al., 2020). The reasoning skills have recently been included in the mathematics standards of the curriculum (Government of Pakistan, 2021). The mathematics curriculum is designed to have three main areas, namely arithmetic, algebra and geometry. The arithmetic section includes sets, number systems, and matrices; the algebraic one deals with polynomials and equations; the geometric section includes the measurements of shapes and trigonometry (Government of Pakistan, 2006; Khan et al., 2025; Makramalla et al., 2025). One of the key competencies that allow students to think critically and solve problems is mathematical thinking (Kotsis, 2025; Williams et al., 2022). It is considered a high-order thinking ability that is required in many situations, as provided by the National Curriculum (2021). Herbert and Williams (2023) and Boaler (2019) argue that such students are in a better position to understand mathematical concepts, solve problems, and come up with hypotheses, analogies, and generalizations. Mathematical reasoning has connections between various branches of mathematics based on their structure. According to Barbieri et al. (2015) and Gulzar et al. (2014), it facilitates the application of mathematical concepts by students in different fields. The overall performance in math is improved with the help of the reasoning exercises that require students to support their own beliefs and explain their comprehension (Ferguson, 2014; Kigamba, 2019).

Mathematical reasoning is the logical speculation concerning mathematics. It involves mathematical theories, finding relations between them, and using logical rules to deal with issues and make conclusions. This argument goes beyond the act of calculating and it captures knowledge of the internal principles and relations that make mathematical systems work. It requires careful consideration, accuracy, and the ability to develop logical arguments and support conclusions by the evidence (Urhan et al., 2023). And in mathematics, logic replaces memory (Das & Mondal, 2025). The lack of mathematical thinking skills is one of the main factors that contribute to a low level of arithmetic performance (Tum 3., 2024). Besides, mathematical reasoning and mathematical success are strongly correlated (Er Z, 2024; Daniar et al., 2023). Symbolic exercises are commonly used in the reasoning process and solving mathematical puzzles

(Kavanagh et al., 2025). Being considered the backbone of various mathematical formulas and processes, reasoning is the nature of mathematics (Torkildsen et al., 2025; Demirel et al., 2015). Along with helping individuals to develop an understanding of mathematical ideas, mathematical reasoning improves problem-solving skills and the capability to make hypotheses and generalizations (Vale et al., 2017). Engaging in logical tasks will help students establish links between mathematical concepts and use them in various situations (Boaler, J 2015; Krasa et al., 2022).

Problem-Solving

Problem identification, coming up with multiple plausible solutions, and executing the most optimal one are all part of the cognitive process called problem-solving. This ability is applied in daily life, both in making a simple choice and complicated organization issues. A number of problem-solving methodologies such as working backward, means-end analysis, difference reduction and trial and error have proved to be effective (Mathaha, 2024). A methodological process of resolving a problem usually includes creating an explanation of the problem, suggesting possible solutions, and assessing the solutions, and implementing the selected response (LOUCIF, 2024). In the case of secondary-school students, the ability to solve problems is invaluable as it is the foundation of academic success, as well as professional competence in the future. Skilled learners in problem solving are able to cope with complex situations, think critically and make effective decisions. Strong problem-solving skills allow the student to face real-life problems in the modern complex environment (Ariyani et al., 2019).

Formulating the problem, generating potential solutions, evaluating the ideas, and choosing the most appropriate one are common core steps of solving the problem (Asrawati et al., 2023). This is a way of enabling students to break down the big problems into smaller and manageable pieces. The ability is especially useful in the fields, which require logical thinking and analytical skills, including science and mathematics (Alexander et al., 2019). In addition, problem-solving promotes interaction and teamwork. When students have to solve a problem together they learn to pay attention to the other sides and to express their vision in a manner that can be easily understood by others. Teamwork does not only improve the knowledge of the content, but also equips the students with skills on how to work in a team (Cao, 2024). Group discussions and brainstorming sessions allow students to explore different solutions and realize that there are a number of possible ways of solving one problem.

Moreover, emotional intelligence of the pupils is also strengthened in cases where they are taught how to resolve problems. They get strong and capable of flexing with the challenges or drawbacks that they meet in the process of solving problems, which are critical in the professional and personal overall development (Asrawati et al., 2019). Such studies emphasize problem-solving as an essential feature of Mathematical Reasoning. In this regard, the tool used in the present research contained a detailed segment on the word problems, algebraic word problems, geometric problems, rate problems, ratio application and distance problems.

Sociocultural Theory of Lev Vygotsky

According to the sociocultural theory by Vygotsky, sociocultural context assumes that learning is a social process and intelligence is culturally based. The main principle of his theory is that discourse and interaction are significant to learning. Vygotsky (1978) explained that there are two processes that occur in two stages: first, knowledge is acquired by means of mutual cooperation with the other people, and then it is internalized to personal thinking. According to him, all functions of the cultural development of the child, he said, occur twice, once in the socially and the other in the individually level; once in the interpsychologically level between the people, and the other in the intrapsychologically level within the child (Vygotsky, 1978). Wood, Bruner and Ross (1976) confirmed this perspective by citing the advantages of tutoring and cooperative learning to solving problems. Wertsch (1985) also expounded the role of interaction in assisting cognitive development, and thus supports the statement made by Vygotsky that the learning process is inseparably associated with social experience.

Comparison of the Classical Teaching and Scaffolded Teaching

The traditional and scaffold is instructional methods that have specific benefits to the learning process, but both methods have striking differences in their goals, techniques, and results. The traditional practices are commonly defined by the use of lectures as the main forms of learning where the learner is viewed as a passive recipient and the teacher is the main source of knowledge and authority. The classical methods have been found to be the best in the representation of facts and the established realities (Good and Brophy, 2008). This approach is especially suitable to the fields where there is a need to perform some repetitions or rote memorization. However, the scaffolded one, which is based on the theory of the Zone of Proximal Development developed by Vygotsky (1978), changes the role of the instructor into a facilitator whose lessons should be modified to the immediate needs of the students. Scaffolding creates a responsive and supportive climate through which learners build their own meaning (Van de Pol et al., 2010).
Comparative research on traditional and scaffolding suggests that there are differences between the levels of student engagement and motivation. According to a report by Darling-,Hammond et al. (2020), the conventional teaching methods make individuals less engaged due to lack of active participation of students in the learning process. On the other hand, strategies of scaffolding, as guided questioning or problem-solving activities arouse greater involvement and active participation (Belland, 2013). The same point of view is supported by Chi et al. (2014) who show that students in scaffolded environments are more engaged since they actively participate in the process of knowledge

building that foster motivation and ownership of learning. This participatory learning has been demonstrated to foster active learning as opposed to the passive, teacher-centered methods (Collins and Kapur, 2006).

Solving problems and reasoning mathematically are very important in the achievements of students in mathematics. The authors like Schoenfeld (2016) accentuate the role of problem-solving strategies, metacognitive reflection, and application of various methods to solve the mathematical tasks. As a result of good reasoning skills, students are able to learn and apply math concepts, extrapolate results and be effective problem solvers. These skills are not only beneficial in improving academics in the field of mathematics but are also useful in solving real-life problems that are not only in the classroom.

In this research, the pre-test/ posttest control-group design was used to investigate the effect of instructional scaffolding on mathematical reasoning. The design was such that the researchers could see cause-and-effect relationships in a controlled environment. The students of the 9 th -grade students formed the population, and the sample size was 60 students equally split into the experimental and control groups. The grouping of these students in a similar manner the groups were to have similar abilities as dictated by pre-test scores.

3. RESEARCH METHODOLOGY

The study was quantitative and experimental in nature. It was designed to empirically investigate the effect of instructional scaffolding on the problem-solving skills of secondary school students in mathematics. It focused on measuring changes in students' problem-solving abilities following targeted instructional interventions, aiming to establish cause-and-effect relationships through controlled experimental procedures.

The research employed a pre-test, post-test, control group experimental design. The population consisted upon secondary school students enrolled in Grade ninth at Government High School 9-11 W.B Vehari, Punjab, Pakistan. The sample for this study was selected through a pre-test administered to all sixty, 9^{th}-grade students at Government High School (GHS) 9-11 W.B in Vehari, Punjab, Pakistan. Based on the students' pre-test scores, an equal distribution of marks was ensured while assigning students to two groups: thirty students were allocated to the experimental group, and thirty to the control group. This resulted in a total study sample consisting of sixty 9^{th}-grade students from GHS 9-11 W.B Vehari, providing a balanced basis for comparing the impact of instructional scaffolding versus traditional teaching methods on problem-solving skills.

The experimental group received mathematics instruction incorporating instructional scaffolding techniques, while the control group was taught through traditional methods. Data collection tools included pre- and post-tests developed to assess students' problem-solving skills validated through pilot testing. The intervention spans a set period, during which scaffolding strategies such as modeling, guided practice, I do, we do, you do model, and feedback were systematically applied in the experimental group sessions.

4. RESULTS AND DISCUSSIONS

The test was divided in three categorize, i.e. Understanding & Translating Problems, Applying Mathematical Concepts and Logical Reasoning & Multi-Step Problem Solving. Pre-test were taken and then analyzed through SPSS to check the baseline of both groups.

Table 1: Understanding & Translating Problems; Pre-Test Results of Control and Experimental Groups

	Group	**Mean**	**Std. Error**	**Sig.**
Understanding & Translating Problems	Control	2.87	0.133	0.880
	Experimental	2.93	0.135	

Table 1 presents the pre-test results of both the control and experimental groups in the domain of Understanding and Translating Problems. The control group obtained a mean score of 2.87 with a standard error of 0.133, while the experimental group recorded a slightly higher mean score of 2.93 with a standard error of 0.135. The significance value (Sig. = 0.880) indicates that there is no statistically significant difference between the two groups before the intervention.

This result suggests that both the control and experimental groups had comparable levels of ability in understanding and translating mathematical problems prior to the application of instructional scaffolding. Therefore, the groups can be considered equivalent at the baseline, which is essential for ensuring the validity of the experimental design. Any differences observed in the post-test phase can thus be attributed to the instructional treatment rather than pre-existing differences in students' abilities.

Table 2: Applying Mathematical Concepts: Pre-Test Results of Control and Experimental Groups

	Group	Mean	Std. Error	Sig.
Applying Mathematical Concepts	Control	5.47	0.093	0.629
	Experimental	5.57	0.092	

Table 2 shows the pre-test mean scores of the control and experimental groups in the area of Applying Mathematical Concepts. The control group achieved a mean score of 5.47 with a standard error of 0.093, while the experimental group obtained a slightly higher mean score of 5.57 with a standard error of 0.092. The significance value (Sig. = 0.629) reveals that the difference between the two groups is not statistically significant at the pre-test stage.
This finding indicates that before the implementation of instructional scaffolding, both groups demonstrated a similar level of proficiency in applying mathematical concepts. The absence of a significant difference confirms that the groups were homogeneous and equivalent at the outset of the experiment. Consequently, any improvement observed in the post-test phase can be more reliably attributed to the instructional scaffolding intervention rather than initial disparities in mathematical understanding.

Table 3: Logical Reasoning & Multi-Step Problem Solving; Pre-Test Results

	Group	Mean	Std. Error	Sig.
Logical Reasoning & Multi-Step Problem Solving	Control	6.70	0.109	0.696
	Experimental	7.20	0.111	

Table 3 presents the pre-test scores of both the control and experimental groups in the area of Logical Reasoning and Multi-Step Problem Solving. The control group obtained a mean score of 6.70 with a standard error of 0.109, while the experimental group recorded a slightly higher mean score of 7.20 with a standard error of 0.111. The significance value (Sig. = 0.696) indicates that there is no statistically significant difference between the two groups prior to the treatment.
This outcome suggests that both groups possessed comparable levels of logical reasoning and multi-step problem-solving skills before the introduction of instructional scaffolding. The similarity in pre-test performance ensures that the experimental and control groups were equivalent at the baseline, thereby validating the fairness of subsequent comparisons. Hence, any improvement observed in the post-test phase can be confidently attributed to the instructional scaffolding intervention rather than pre-existing differences in students' reasoning abilities.
The pre-test results across all three areas, Understanding & Translating Problems, Applying Mathematical Concepts, and Logical Reasoning & Multi-Step Problem Solving show that there were no statistically significant differences between the control and experimental groups before the intervention (Sig. values = 0.880, 0.629, and 0.696 respectively). This indicates that both groups were academically equivalent at the baseline, confirming that any subsequent differences in post-test results can be attributed to the instructional scaffolding intervention rather than pre-existing disparities in students' abilities.
Table 4: Understanding & Translating Problems; Post-test Results

	Group	Mean	Std. Error	Sig.
Understanding & Translating Problems	Control	3.53	0.093	0.001
	Experimental	4.00	0.083	

Table 4 displays the post-test mean scores of the control and experimental groups in Understanding and Translating Problems. The control group achieved a mean score of 3.53 with a standard error of 0.093, while the experimental group recorded a higher mean score of 4.00 with a standard error of 0.083. The significance value (Sig. = 0.001) indicates a highly significant difference between the two groups after the intervention.
This finding suggests that the instructional scaffolding approach implemented in the experimental group had a substantial positive impact on students' ability to understand and translate mathematical problems. The improvement demonstrates that scaffolding strategies, such as guided questioning, modeling of problem-solving steps, and gradual withdrawal of teacher support, enhanced learners' comprehension and interpretation of mathematical situations.

These results are consistent with the findings of Sinaga et al. (2023), who reported that scaffolded instruction significantly improved students' mathematical problem understanding by encouraging them to break down complex tasks into manageable steps. Similarly, Van de Pol, Volman, and Beishuizen (2019) found that well-structured scaffolding enabled students to internalize cognitive strategies for interpreting mathematical problems more effectively. Azevedo and Hadwin (2020) also highlighted that scaffolded learning environments promote metacognitive awareness, allowing students to better translate problems into solvable representations.

Table 5: Applying Mathematical Concepts; Post-test Results

	Group	Mean	Std. Error	Sig.
Applying Mathematical Concepts	Control	6.50	0.093	0.001
	Experimental	7.47	0.093	

Table 5 presents the post-test results of both the control and experimental groups in the area of Applying Mathematical Concepts. The control group obtained a mean score of 6.50 with a standard error of 0.093, while the experimental group achieved a higher mean score of 7.47 with a standard error of 0.093. The significance value (Sig. = 0.001) shows that the difference between the two groups is highly significant following the intervention.

This finding indicates that instructional scaffolding had a strong positive impact on students' ability to apply mathematical concepts effectively. Students in the experimental group demonstrated greater conceptual understanding and application skills compared to those taught through traditional methods. The results therefore, lead to the rejection of the null hypothesis (H_{02}) and confirm that instructional scaffolding significantly enhances students' understanding and application of mathematical concepts in problem-solving contexts.

These findings are consistent with those of Hammond and Gibbons (2020), who emphasized that scaffolding bridges the gap between conceptual knowledge and procedural application by providing temporary support until learners gain independence. Similarly, Pol, Volman, and Beishuizen (2019) found that scaffolding helps learners transfer theoretical understanding into applied reasoning, particularly in mathematics education. Sinaga et al. (2023) also observed that students exposed to scaffolded problem-solving showed greater improvement in applying learned mathematical concepts than those taught through conventional instruction. Moreover, Belland, et al. (2017) argued that scaffolded environments promote higher-order thinking by engaging learners in guided exploration, discussion, and justification, processes that strengthen conceptual application. The current findings align with this perspective, as the experimental group's superior performance reflects the impact of active guidance and gradual release of responsibility during learning.

Table 6: Logical Reasoning & Multi-Step Problem Solving; Post-test Results

	Group	Mean	Std. Error	Sig.
Logical Reasoning & Multi-Step Problem Solving	Control	8.57	0.092	0.001
	Experimental	9.47	0.093	

Table 6 presents the post-test results of both groups in Logical Reasoning and Multi-Step Problem Solving. The control group achieved a mean score of 8.57 with a standard error of 0.092, while the experimental group recorded a notably higher mean score of 9.47 with a standard error of 0.093. The significance value (Sig. = 0.001) indicates a highly significant difference between the two groups after the instructional intervention.

These results reveal that instructional scaffolding substantially enhanced students' logical reasoning and multi-step problem-solving skills compared to traditional teaching methods. Students who received scaffolded instruction performed better in organizing their reasoning, applying systematic strategies, and handling complex mathematical problems. Consequently, the null hypothesis (H_{03}) is rejected, confirming that instructional scaffolding has a significant positive effect on the development of students' reasoning and multi-step problem-solving abilities.

The result aligns with Wood, Bruner, and Ross (1976), who originally conceptualized scaffolding as a process that supports learners in mastering complex cognitive tasks by gradually transferring responsibility to them. Similarly, Lajoie (2005) and Holton and Clarke (2018) found that scaffolding enhances students' reasoning by providing structured prompts, feedback, and opportunities for reflective thinking. Van de Pol et al. (2019) also observed that scaffolded learners demonstrate improved problem-solving accuracy and logical consistency when handling multi-step mathematical challenges. Furthermore, Sinaga et al. (2023) reported that instructional scaffolding fosters deep reasoning by enabling students to articulate their thought processes, test alternative solutions, and justify their conclusions. Azevedo and Hadwin (2020) also highlighted that scaffolding strengthens self-regulated reasoning, allowing students to independently manage the cognitive demands of multi-step problem-solving tasks.

The post-test results across all three domains, Understanding and Translating Problems, Applying Mathematical Concepts, and Logical Reasoning and Multi-Step Problem Solving demonstrate a highly significant improvement in the performance of the experimental group compared to the control group ($p = 0.001$ in all cases). Students taught through instructional scaffolding consistently obtained higher mean scores, indicating notable gains in comprehension, conceptual application, and reasoning skills. These outcomes provide compelling evidence that scaffolded instruction effectively enhances students' mathematical learning and problem-solving proficiency by offering structured guidance, promoting cognitive engagement, and gradually fostering independence.

The observed improvement is consistent with a growing body of research emphasizing the value of scaffolding as an instructional strategy in mathematics education. Wood, Bruner, and Ross (1976) first conceptualized scaffolding as a process through which teachers provide temporary support to help learners achieve tasks beyond their independent capability. Building upon this foundation, Van de Pol, Volman, and Beishuizen (2019) demonstrated that adaptive scaffolding enhances students' conceptual understanding and metacognitive awareness, enabling them to analyze problems systematically. Similarly, Sinaga et al. (2023) found that scaffolded learning significantly improved students' problem-solving performance by fostering logical reasoning and reflective thinking.

Furthermore, Azevedo and Hadwin (2020) asserted that scaffolding strengthens self-regulation by helping students plan, monitor, and evaluate their learning processes—skills essential for multi-step problem solving. In the same vein, Belland, Walker, and Kim (2017) showed that scaffolded environments promote the development of higher-order thinking by guiding students through cycles of explanation, justification, and reflection. The present study's results parallel these findings, indicating that structured teacher support and guided questioning helped students to internalize strategies for understanding and applying mathematical concepts.

Additionally, Hammond and Gibbons (2020) emphasized that scaffolding bridges the gap between students' current competence and their potential understanding, especially in mathematics, where learners often struggle to connect abstract ideas with real-world applications. Holton and Clarke (2018) also reported that scaffolded instruction supports mathematical reasoning by enabling learners to move from concrete representations to abstract generalizations through dialogue and feedback. Similarly, Rahman, Abdullah, and Ghazali (2021) found that scaffolding interventions led to significant improvements in students' mathematical reasoning, particularly in tasks requiring logical sequencing and justification.

The findings of this study were also supported by Lajoie (2005), who stated that scaffolded learning promotes the development of cognitive flexibility and strategic reasoning, allowing students to transfer learned problem-solving skills to novel contexts. Chiu and Chung (2022) confirmed that scaffolded teaching strategies improved students' ability to interpret complex problem statements, plan solutions, and apply relevant mathematical principles more accurately. In a related study, Kim, Belland, and Walker (2018) concluded that scaffolding contributes to sustained engagement and deeper conceptual understanding in STEM learning environments.

Taken together, these studies reinforce the conclusion that instructional scaffolding has a significant positive effect on students' mathematical comprehension, conceptual application, and reasoning. The findings of the present study thus validate scaffolding as a highly effective pedagogical approach that enhances both the cognitive and metacognitive dimensions of problem-solving. By helping students gradually assume greater responsibility for their learning, scaffolding cultivates independent and reflective thinkers capable of tackling complex mathematical challenges.

Consequently, the post-test results lead to the rejection of all null hypotheses (H_{01}–H_{04}), confirming that the experimental intervention based on instructional scaffolding produced significant and meaningful improvements in students' mathematical performance. These results contribute to the growing empirical evidence supporting the integration of scaffolded learning strategies in secondary mathematics classrooms, providing a robust foundation for future curriculum design and teacher training initiatives.

5. CONCLUSION

This study was meant to measure the effect of instructional scaffolding on problem-solving skills of learners at secondary school level in mathematics. The findings provide strong empirical evidence to the claim that scaffold instruction provides students with statistically significant improvement in their performance in three key areas of problem-solving, including the understanding and translation of problems, the use of mathematical knowledge, and logical thinking in multi-step problems.

Pre-test scores in the baseline showed no significant difference between the control and experimental cohorts and, thus, determined their academic equivalence before the intervention. Conversely, the post-intervention results brought about very significant benefit ($p < 0.001$) in all the investigated areas in the experimental group. Students who received instruction by use of scaffold showed significantly better understanding, application of concepts, and reasoning as compared to their peers who were taught using traditional methods thus establishing the vital role of instructional scaffolding in enhancing mathematical thinking abilities and development of higher-order thinking capabilities.

The current results are consistent with a solid amount of literature stating the efficacy of scaffolding as a teaching modality. The conceptualized scaffolding was initially planned by Wood, Bruner and Ross (1976) as a supportive tool to encourage the independence of the learners, which is one of the tenets that are observed in the present results. Van de Pol, Volman and Beishuizen (2019) also asserted that adaptive scaffolding facilitates conceptual mastery as well as metacognitive monitoring. Regularly, the improvement in learning and analytical ability identified here supports Sinaga et al. (2023), who found the scaffolding instruction to be providing meaningful gains in mathematical reasoning and problem-solving abilities of the students.

Moreover, Azevedo and Hadwin (2020) developed that scaffolding enhances self-controlled learning through allowing students to observe, assess, and modify their problem-solving approaches - a skill that emerged in the study participants of the experimental group. Belland, Walker and Kim (2017) and Hammond and Gibbons (2020) also added that systematic guidance and feedback through scaffol instructions bring deeper conceptual understanding and higher-order thinking. Similarly, Holton and Clarke (2018) and Lajoie (2005) showed that scaffolding strengthens logical thinking and enables the learner to stop relying on the teacher and enter the reliant self-sufficiency in problem-solving.

These conclusions were supported by recent empirical studies. According to Rahman, Abdullah, and Ghazali (2021), scaffolded mathematics teaching increases the level of analytical reasoning and skills of students to solve multi-step mathematical problems. Similar results were also noted by Chiu and Chung (2022), which suggests that scaffolding helps students to break down intricate issues, construct a systematic solution, and use mathematical concepts as a learning tool. Moreover, Kim, Belland, and Walkers (2018) determined that scaffolding increases student engagement and conceptual knowledge retention in STEM learning situations.

This study, therefore, holds that, instructional scaffolding is a very effective pedagogical tool that helps in developing understanding of concepts, application of concepts, logical reasoning and independent thinking in learners in secondary schools. Through providing scaffolded instructions gradually to be gotten rid of as the students gain confidence, scaffolding enables students to actively build knowledge and engage in substantive problem-solving.

In general, the current research contributes to the increasingly accumulating body of literature on the confirmatory constructivist strengths of scaffolded learning in mathematics education. It highlights the need to introduce scaffolding techniques such as guided questioning, instructional modelling, collaborative discourse and formative feedback to the normal classroom activity of educators. This kind of integration can produce reflective, independent and competent problem solvers who are in a position to tackle the cognitive demands of the modern-day mathematics teaching.

Recommendations

- Teachers should integrate scaffolding techniques such as guided questioning, modeling, and gradual release of responsibility to strengthen students' problem-solving skills.
- Organize professional development programs to train teachers in the effective use of instructional scaffolding in mathematics classrooms.
- Incorporate scaffold learning activities into the mathematics curriculum to promote reasoning, conceptual understanding, and critical thinking.
- Employ regular formative assessments to identify learning gaps and adjust the level of scaffolding based on students' needs.
- Encourage group and peer-assisted learning tasks to allow students to support one another through collaborative scaffolding.
- Conduct additional studies on the long-term effects of scaffolding and its application across different subjects and educational levels.
- Educational policymakers should include scaffolding-based pedagogies in teacher training and instructional standards to enhance learning outcomes.

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