The Contextual Turn in Mathematics Education: A New Paradigm for Enhancing Problem-Solving Competence

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ABSTRACT

The current study was conducted to determine the effect of contextualized mathematics education on the ability of secondary school learners to solve problems. This research was based on the realization that there is the need to adopt an approach to mathematics education that goes beyond mere procedural approach into an approach that applies the mathematical knowledge to life situations. For this study, a quasi-experimental research method was used where two groups were created: one experimental and one control group. It has been found that the problem-solving ability of the experimental group students improved significantly compared to the control group students. In general, there was an improvement in the scores of the experimental group from 45.20 marks in the pre-test to 68.75 marks in the post-test. Meanwhile, there was a slight improvement in the scores of the control group from 44.80 marks in the pre-test to 55.30 marks in the post-test. There is a considerable difference in the score improvement of both groups; the experimental group had a bigger increase than the control group by 23.55 compared to the latter's 10.50 marks. In addition, the qualitative data indicated that the contextual learners were highly involved in the learning process, confident with their performance, and able to use different strategies to solve problems. In conclusion, the research has shown that contextual learning of mathematics has proven to be quite effective.

Keywords: *Contextual Mathematics Instruction; Problem-Solving Competence; Mathematics Education; Contextual Learning; Secondary School Students; Quasi-Experimental Design; Mathematical Literacy; Real-Life Problem Solving.*

1. Introduction

The approach to studying mathematics in educational institutions has shifted from procedural learning to problem-solving skills acquisition(Basid et al., 2024). Nevertheless, in most educational institutions, mathematics lessons involve rote techniques, and it becomes impossible to apply the acquired knowledge in practice(Liljedahl & Vail, 2024). It means that although the students perform well in traditional assessments, their problem-solving skills leave much to be desired(Makonye & Moodley, 2023). Thus, there is a need for strategies aimed at helping them to combine the theoretical knowledge with practical skills.

Contextual learning appears to be one of the most effective techniques for teaching mathematics(Kohen & Nitzan-Tamar, 2022). In essence, it involves embedding math-related problems within some context that requires analysis and interpretation of the problem to find the best solution(Chavarría-Arroyo & Albanese, 2023). The interactive nature of contextual learning helps students understand that math can be applied practically(Ogunsola et al., 2021). There are studies that have demonstrated that such a technique is beneficial for mastering mathematical concepts and developing problem-solving skills(Szabo et al., 2020).

However, despite all the advantages offered by contextual learning, its incorporation in everyday classroom practice is still underutilized. There exist numerous pieces of research that focused on one aspect or another: some of them considered problem-solving competence separately from contextual teaching while others did vice versa, and very few studies concentrated on examining the influence of the combination of both(Leinonen et al., 2021). Moreover, no research has offered a conceptualization or framework for designing and implementing contextual problems so that different aspects of problem-solving competence could improve(Kusumadewi & Retnawati, 2020).

The purpose of the present study is to fill this gap through the investigation of the effects of contextual mathematics teaching on secondary school students' problem-solving ability. In particular, the following objectives will be pursued: (i) creation and implementation of contextual mathematical problems that arise from real-world experiences, (ii) evaluation of the success of such problems on the development of students' problem-solving skills, and (iii) testing the practicability of the proposed approach for actual implementation. A quasi-experimental study design including an experimental group, a control group, pretest, and posttest was used to fulfil these objectives.

What makes this research novel is its multidimensional perspective that incorporates contextual learning, problem-solving skills, and feasibility evaluation into one model. This is quite different from other researches, which mainly emphasize on one single area, whereas this research offers an all-round view of the impact of contextual learning on teaching and learning. In terms of its scientific contribution, the study contributes in developing problem types that can be used for contextual purposes and proves its efficacy through experiments conducted during the research process.

2. Literature Review

2.1 Reframing Problem-Solving in Mathematics Education

Problem solving has always played a vital role in the teaching of mathematics, but its definition and instructional approach have undergone significant changes throughout history(Amalia et al., 2024). There was an important shift away from the focus on skill development to a more comprehensive view of the subject matter that encompasses strategies, metacognition, and contextualizing the given problems(Manfreda Kolar & Hodnik, 2021).

Although theoretical advances in problem solving have been made, the actual teaching methods for many decades have continued to rely on conventional algorithms and drill-and-practice tasks(Boaler, 2022). Although such an approach was very successful at building procedural proficiency, it did not provide enough practice to develop the necessary skills to solve problems in novel situations. The contemporary research on problem solving aims to address this issue by redefining the concept in terms of situated learning(Kohen & Orenstein, 2021).

Such a move reflects a realization that mathematics is not only about solving problems but is rather a combination of many different skills like reasoning, representing and making decisions(Kaiser, 2020). Contemporary research of problem-solving skills tends to give more attention to context-based learning experiences.

2.2 Contextual Learning: Theoretical and Pedagogical Foundations

Growing interest in context-based teaching of mathematics has many commonalities with the concept of constructivism as the process of acquiring knowledge through interactions and interpretations(De Bortoli et al., 2023). Indeed, it has been recognized as an effective approach to education, and CTL has gained much recognition due to its ability to establish relations between theoretical aspects of math and practical applications.

The key component of contextual learning is not the selection of realistic examples but rather the way in which the situation is organized to include learners' modeling and interpretation. Studies show that learning mathematics within the framework of practical tasks results in more stable concept acquisition because it is not dependent on memorization alone(Santos-Trigo, 2020).

Contextualization not only makes learners more engaged but also makes them more motivated and stimulated due to its relevance(Zehetmeier et al., 2020). This can be seen from the fact that learners who are working on context-related tasks usually show better retention as well as the ability to explain what they have done or why they have performed certain tasks in certain ways(Herianto et al., 2024). Moreover, incorporating digital technology into context-based learning also adds to its opportunities.

2.3 Linking Contextualization to Problem-Solving Competence

Numerous studies conducted using quasi-experimental designs have shown that contextualized learning positively affects students' problem-solving skills(Hwang & Tu, 2021). Quasi-experimental researches show that when it comes to measures of understanding, reasoning, and interpretation, the students who participated in contextualized tasks performed better than other students did.

It should be noted that one common feature of many such studies was the enhanced translation skills of students from contextual examples into mathematical models – an integral part of mathematical literacy. In addition to enhanced performance on mathematical problems, students also showed better reasoning in the process of problem solving(Dockendorff & Zaccarelli, 2025).

This is further supported by the meta-analysis conducted by some researchers that show the application of teaching methods through realistic scenarios can result in large effect sizes. This clearly shows that aside from the motivational factor associated with contextualization, there is also a possibility of increasing cognition.

2.4 Contemporary Directions: Context, Technology, and 21st-Century Competencies

Within the last few years, the emergence of a contextual paradigm in math education has found itself intersecting with new technological trends and approaches that stress the development of skills over pure cognitive processes(Ilyas & Liu, 2020). As a result, the advent of computer-mediated environments allowed creating sophisticated data-based problem scenarios similar to those found in real-life situations.

The following major directions are now identified within existing studies. First, the increasing importance of problem-solving and inquiry-based learning approaches, where students construct knowledge themselves while performing various tasks. Second, the concept of mathematical literacy has been updated by adding skills related to the critical evaluation and use of quantitative information in different contexts(Skinner & Cuevas, 2023). Finally, new technological advancements can make it possible to personalize contextual learning.

These changes fit well with the requirements of modern education in the 21st century, where it has become equally important to be able to creatively use one's knowledge as to have it. Therefore, contextual problem solving becomes less of a supplementary method and more of a fundamental element of modern mathematics education.

2.5 Persistent Challenges and Pedagogical Constraints

Despite the proven advantages of using contextual approaches, there are some obstacles when implementing them in the classroom setting(Sury & Pilchin, 2025). The most common problem mentioned in numerous studies is the students' inability to switch from describing a real-life situation to creating a math model. This process not only involves a deep understanding of the subject matter but also calls for skills in recognizing related variables and connections between them, which cannot be acquired through conventional teaching practices(Niss & Blum, 2020).

Another issue to consider is cognitive load. While some students can benefit from the increased cognitive load due to context, others with a lower level of prior knowledge may experience difficulties when trying to solve problems(Mullis et al., 2020).

In terms of the teacher, developing contextual problems that are efficient requires not only creativity but also teaching knowledge. It is noted by many teachers that there is a problem of connecting contextual activities to the requirements of the curricula and assessment criteria. Moreover, current evaluation methods value the correctness of procedures rather than interpretation and analysis.

3. Materials and Methods

3.1. The Context of the Study

This present study has been conducted in the setting of mathematics classes in secondary schools where the mode of teaching is highly dependent on textbooks and process-oriented learning, but not practical application in real-world settings. Recognizing the weaknesses in the current approach to teaching mathematics, this study has included the use of a contextual teaching technique, which aimed at developing relationships between mathematics and its real-world application via problem-solving tasks such as finance, measurements, and interpreting basic statistics. This was done to find out whether a contextual approach to teaching mathematics would improve problem-solving abilities among students.

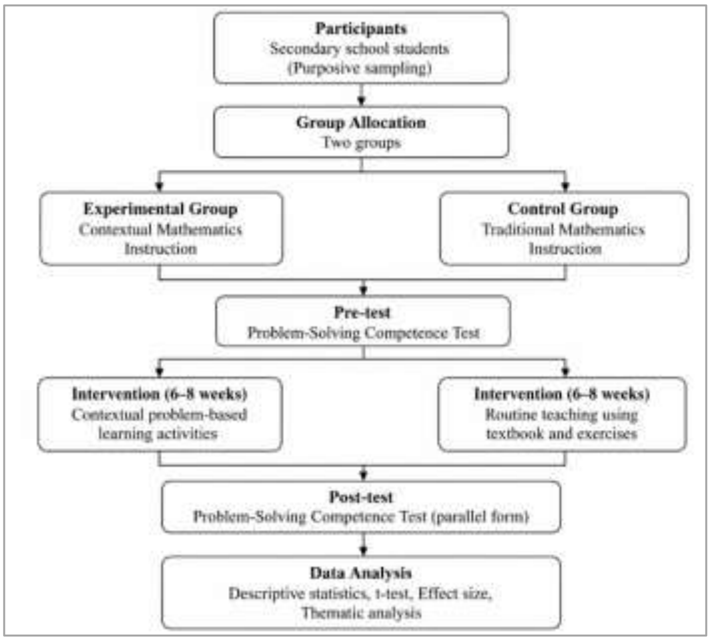

Figure 1. Quasi-Experimental Research Design for Contextual Mathematics Instruction

This figure 1 provides an overview of the research design employed in this investigation, indicating the flow process from selection of participants to the process of data analysis. This is further emphasized by how students were categorized into the experimental and control group, before undergoing the pre-test, intervention, and post-test phases.

3.2. Participants and Procedures

As for the participants of the experiment, they were secondary school students selected purposely for purposes of meeting the objectives of the study. Two groups of students were selected from the pool of participants. One group of students, called experimental group, was subjected to the teaching of mathematics through contextualization, whereas another group of students, called control group, was subjected to teaching of mathematics using traditional methods. The experimental design used for carrying out the experiment involved three stages of conducting activities. In the first stage, termed as pre-test, both groups of students were subjected to problem-solving test for measuring their proficiency levels. In the second stage, called intervention stage, experimental group was trained in solving problems within rich context environment, while control group was taught using conventional method for about six to eight weeks.

Table 1. Descriptive Statistics of Participants' Problem-Solving Competence in Contextual and Traditional Mathematics Groups

Group	N	Pre-test Mean	Pre-test SD	Post-test Mean	Post-test SD	Mean Gain
Experimental Group	40	45.20	6.15	68.75	7.10	23.55
Control Group	40	44.80	5.90	55.30	6.45	10.50

The following table 1 shows the results of descriptive statistics regarding the problem solving scores of the experimental and control groups both before and after the treatment. In this regard, although the groups had almost equal means in pre-test, but post-test mean score in the experimental group was much better. This difference suggests the effectiveness of contextual approach to math teaching for problem solving ability improvement.

3.3. Research Tools

Collection of data related to the study involved the use of both structured and unstructured measurement instruments designed to obtain cognitive and behavioral information relating to learning. Some of these measures involved conducting a problem-solving competency test designed to measure the ability of students to understand the problem, utilize strategies, and evaluate solution strategies. Contextual and non-contextual problem sets were also taken into account. Contextual learning activity sheets for the experiment group were also used. The activity sheet comprised of mathematics problems in real-life situations intended to foster reasoning skills among the students. Students' feedback questionnaire was used and based on the Likert scale in an effort to establish interest and confidence of students regarding contextual learning.

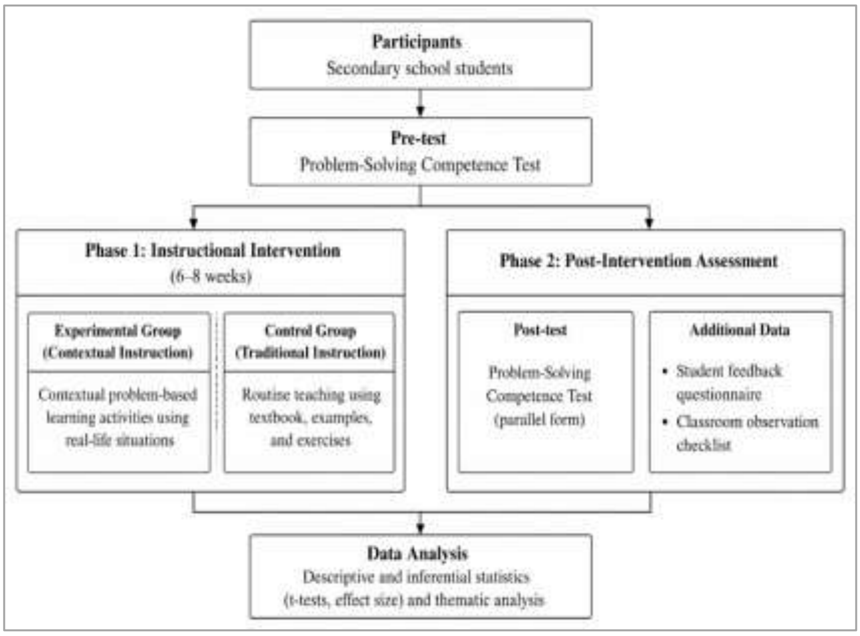

Figure 2. Two-Phase Instructional Procedure for Contextual Mathematics Problem-Solving Study

Figure 2 illustrates the process used in this research, which begins with recruiting participants and ends with testing their problem-solving skills before the experiment. The figure clearly demonstrates the two stages that were utilized in this research, that is, the training stage, where the experimental group was trained, while the control group was not, and the second stage of testing their problem-solving skills.

3.4. Data Analysis

A range of descriptive and inferential statistical methods were employed to analyze the data collected and make sense of findings gained from the research. Descriptive statistics such as means and standard deviations helped in identifying trends in the test scores of the two tests conducted both pre- and post-intervention. The inferential statistics that were employed included paired t-tests to help determine improvement in scores for the individuals involved. This is together with the use of independent t-tests to see if there was any significant difference between the scores obtained by the experimental and control groups with p-values of less than 0.05 indicating significance. Furthermore, calculation of effect sizes was done in an attempt to establish the importance of the context-based approach.

4. Results

4.1. Characteristics of Contextual Mathematics Problems Used in the Study

In order to measure the effects of contextual mathematics on students' problem-solving skills, the researcher developed realistic life-context mathematics problems for the purposes of the current experiment. These problems were based on practical situations that would allow the subjects to feel related and comfortable when solving them, and to be able to use their knowledge of budgeting, measuring and analyzing basic statistics. Contrary to conventional math questions found in textbooks, the problems developed in this case called for students to use their mathematical formulas and solve a problem by analyzing context and making reasonable decisions.

These tasks were set up according to increasing difficulty levels from practical life applications to a more complex integration and combination of several steps and processes. In addition, solving problems would require translating practical situations into mathematical expressions and formulas, which is an integral part of problem-solving skills.

The students appeared more lively in the sessions dealing with the contextual problems than in any other sessions. This was because the discussions were very lively as the students tried different ways to solve the problem. The use of contextual problems helped the students understand and analyse the concepts better.

Table 2. Characterization of Contextual Mathematics Problems Based on Problem-Solving Competence Dimensions

Problem Type	Real-Life Context Used	Mathematical Concept	Competence Dimension Assessed	Cognitive Level	Example Task Description
Financial Literacy	Budget planning	Arithmetic operations	Understanding & Application	Moderate	Calculate monthly expenses within a fixed budget
Measurement-Based	Length and area estimation	Geometry	Representation & Interpretation	Moderate	Find area required for flooring a room
Data Interpretation	Survey results	Statistics	Analysis & Reasoning	High	Analyze data and draw conclusions
Time Management	Daily schedule planning	Ratio & Proportion	Strategy Selection	Moderate	Allocate time efficiently for tasks
Multi-Step Problem	Shopping and discounts	Percentages	Integrated Problem-Solving	High	Calculate final price after multiple discounts

This table 2 shows the classification of the contextual mathematical problems adopted for the study with respect to context, mathematics content, and dimensions of problem-solving competence. This demonstrates how various mathematical problems were generated from the same context to evaluate the cognitive and analytical abilities of students.

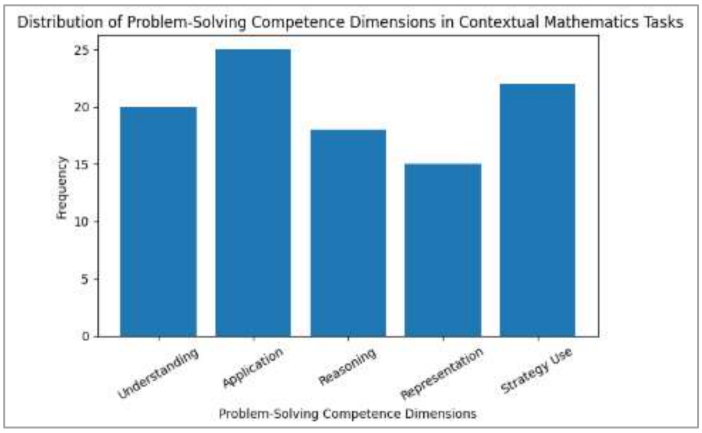

Figure 3. Distribution of Problem-Solving Competence Dimensions in Contextual Mathematics Tasks

In this case, figure 3 depicts the distribution of various competences in solving problems in relation to context-oriented mathematics problems applied in the research process. From the graph presented below, it is evident that there is an even distribution of competencies such as understanding, applying, reasoning, representing, and strategy usage.

4.2. Effectiveness of Contextual Mathematics Instruction on Problem-Solving Competence

The findings from this study clearly show an enhanced capability in solving problems in the experimental group as opposed to the control group. Although both groups had almost equal pre-test performance, post-test analysis revealed improved performance for the students receiving contextual mathematical teaching than the control group. The difference in mean gain score provides additional proof to the effectiveness of the intervention.

The experimental group performed significantly better than the control group in terms of understanding problem situations and selecting relevant strategies to solve the problems. Additionally, students who participated in contextual learning were able to give accurate interpretations of their solutions. On the other hand, the control group was not as competent as they could not make any sense out of problems posed to them.

Analysis with the help of t-tests showed that there was a statistically significant difference between both groups. Furthermore, the effect size was also calculated to measure the effect of context-based learning on students' performance. The results showed that there was a very strong practical effect of context-based learning on students' performance.

Table 3. Feasibility of Integrating Contextual Mathematics Instruction in Secondary Classrooms Based on SWOT Analysis

SWOT Component	Description	Implications for Classroom Practice
Strengths	Enhances real-life understanding and improves problem-solving competence	Encourages active learning and deeper conceptual clarity
Weaknesses	Requires more time for planning and implementation	May increase teacher workload and classroom management effort
Opportunities	Supports development of 21st-century skills and critical thinking	Can be integrated with digital tools and innovative pedagogy
Threats	Limited teacher training and rigid curriculum structure	May hinder effective adoption in traditional school settings

This table 3 contains SWOT analysis for contextual mathematics teaching in secondary education settings. This analysis includes the strengths and opportunities available, which could lead to effective teaching and learning processes. It also shows some limitations and challenges involved in the process of contextual teaching.

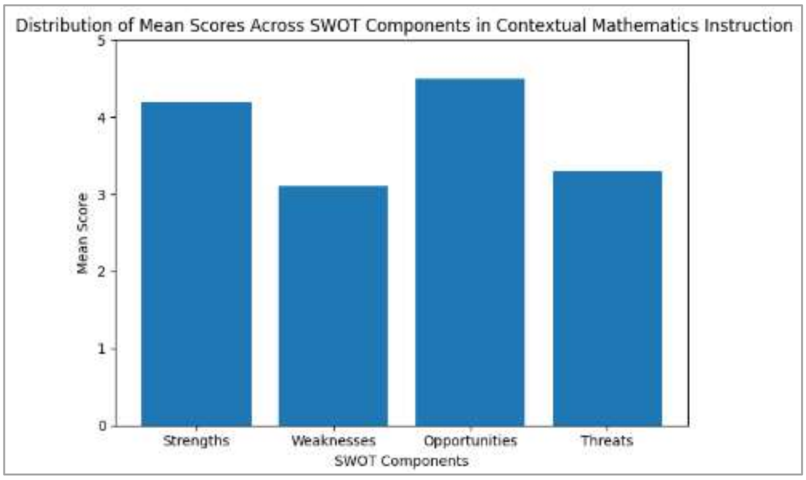

Figure 4. Distribution of Mean Scores Across Strengths, Weaknesses, Opportunities, and Threats in Contextual Mathematics Instruction

The following is Figure 4 depicting the mean ratings generated from each of the components in conducting a SWOT analysis for the implementation of contextual mathematics teaching. This depicts that the mean ratings generated from the strength and opportunity components were much higher than those generated from the weakness and threat components.

5. Discussion

It has been found that contextual approach in mathematics education greatly enhances problem-solving skills among students when contrasted to conventional approaches. The use of contextual approach enabled the students to develop a better grasp of knowledge about mathematical concepts as well as how to implement them in varied circumstances.

Through the use of contextual approach, it was possible for the students to link the mathematical concepts with their daily lives. This made them learn through meaning rather than through rote memory alone.

Indeed, the results obtained are in agreement with the findings in previous researches about the role of contextual learning in fostering math literacy and critical thinking. Nonetheless, there are some challenges such as a higher workload for teachers and difficulties faced by learners during the beginning stage. However, the aforementioned challenges can be overcome by conducting adequate training.

This means that despite its many advantages, the use of contextual learning requires adequate support from the teachers as well as a flexible curriculum design.

6. Conclusion

From this study, it becomes clear that contextual mathematics education is superior to conventional methods of teaching in improving students' problem-solving skills in mathematics. It will be relatively easy for the students to understand the problems presented, recognize appropriate problem-solving strategies, and interpret their solutions.

Additionally, contextual education is very important in promoting the development of essential skills such as logic, analysis, and decision-making. Though there are some challenges such as the need for adequate time and preparation by the teacher, contextual education offers many benefits.

Therefore, it is advisable that teachers in mathematics incorporate contextual education practices in a gradual process. In proper circumstances, contextual education can help bring about a positive effect on education.

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