Assessing the Problem-Solving Abilities and their Difficulties in Learning Mathematics as Basis for Instructional Strategies Framework

Baby-Lyn D. Mangilala[1], Allan Jay S. Cajandig[2]

[1]Teacher I, San Miguel National High School

[2]Sultan Kudarat State University Graduate School

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ABSTRACT

Problem-solving abilities in mathematics are essential for developing critical thinking and analytical skills, enabling students to apply logical reasoning to real-world situations. Understanding the strategies and challenges students face in mathematical problem-solving can help educators design more effective instructional approaches to enhance learning outcomes. This study focused on assessing the problem – solving abilities and difficulties in learning mathematics as basis for instructional strategies of Grade 9 students of San Miguel National High School. A total of 110 students were respondents including 30 experts for acceptability of instructional strategies framework. Respondents were selected through total enumeration. This study employed Research and Development (R&D) research design. The main research instrument employed in this study was the researchers' made questionnaire covering some topics of third quarter in the most essential learning competency of grade 9. Mean and standard deviation determined the student's problem-solving abilities and difficulties as classified in Level of SOLO Taxonomy. For the acceptability of students and experts, mean and standard deviation was also employed. One-Way Analysis of Variance (ANOVA) was used to determine the significant difference on the problem – solving abilities of students when classified in Level of SOLO Taxonomy.

The study revealed that findings highlight the need for targeted interventions to enhance students' problem-solving skills, particularly in re-examining solutions. Moreover, for experts, instructional strategies framework is generally well-received and considered suitable for implementation in educational settings. Hence, the data indicate that the instructional strategies framework is well-accepted by students, demonstrating effectiveness in various aspects of learning. Lastly, the ANOVA results revealed that there is no sufficient evidence to conclude that the problem-solving abilities of students significantly differ across the classifications of the SOLO Taxonomy.

Keywords: Problem-Solving Abilities, Instructional Strategies Framework, SOLO Taxonomy

THE PROBLEM AND ITS BACKGROUND

INTRODUCTION

Mathematics has long been recognized as a fundamental and applied science essential in everyday life, making it crucial for students to develop proficiency in this subject. Among the many aspects of learning mathematics, problem-solving stands out as a vital skill that fosters critical thinking, logical reasoning, and analytical abilities. Beyond being a key objective in mathematics education, problem-solving serves as an effective instructional approach for deepening students' understanding of mathematical concepts. As student progress academically, the complexity and nature of problem-solving exercises must align with their developmental needs, ensuring a continuous challenge that strengthens their competencies.

Globally, research underscores the significance of problem-solving skills in mathematics education, as students' abilities in this domain vary widely across different educational systems. Studies have shown that disparities in problem-solving proficiency often reflect broader curricular approaches and pedagogical strategies employed in various countries (Son et al., 2020). Effective teaching methodologies, such as structured problem-solving tasks and cooperative learning environments, have been linked to improved comprehension and application of mathematical concepts (Hasibuan et al., 2020; Klang et al., 2021). However, gaps in instructional methodologies, including insufficient emphasis on the problem-solving cycle, pose barriers to students' confidence and competence in tackling mathematical challenges (Sari, 2021).

In the Philippines, several studies have highlighted the urgent need for targeted interventions to strengthen students' problem-solving skills. Research indicates that Filipino students often struggle with complex mathematical tasks due to weak foundational knowledge and inadequate instructional support (Candari et al., 2022). Moreover, there is a noticeable gap between students' perceived self-efficacy and their actual problem-solving abilities, suggesting that factors beyond motivation influence their mathematical performance (Velez, 2024). Additionally, concerns have been raised regarding teacher preparation programs, as pre-service mathematics teachers often possess a strong theoretical grasp of problem-solving but lack the practical experience necessary to implement effective strategies in the classroom (Alonzo, 2024).

Locally, in South Cotabato, mathematics educators face similar challenges that impact students' problem-solving capabilities. Studies in the region have revealed that students experience difficulties in applying mathematical principles to real-world problems due to a lack of exposure to higher-order thinking tasks (Dela Cruz et al., 2023). Furthermore, traditional teaching methods, which emphasize rote memorization rather than critical thinking, have been cited as a contributing factor to students' struggles in problem-solving (Reyes et al., 2023). Teachers in South Cotabato have also expressed concerns about the limited availability of instructional resources tailored to enhancing problem-solving skills, which affects their ability to provide engaging and effective lessons (Santos et al., 2023).

Despite these findings, research gaps remain in understanding how instructional strategies can be optimized to develop problem-solving skills among students. While numerous studies have explored students' mathematical competencies, there is limited research on the effectiveness of localized instructional models specifically designed to enhance problem-solving proficiency (Garcia et al., 2024). Additionally, studies have yet to comprehensively examine how students' cognitive and metacognitive skills interact with instructional strategies to improve problem-solving outcomes (Lopez & Ramos, 2024). There is also a need for empirical investigations on how digital learning tools can be integrated into mathematics education to facilitate problem-solving skill development (Bautista, 2024).

This study addresses the urgent need to enhance students' problem-solving skills in mathematics, recognizing their importance for academic and real-world success. It aims to develop an effective instructional framework tailored to learners in South Cotabato, bridging learning gaps and supporting teachers in adopting strategies that promote deeper mathematical understanding and proficiency.

Conceptual Framework

The conceptual framework for this study was designed to systematically assess students' problem-solving abilities and the challenges they encountered in learning mathematics. This assessment aimed to inform the development of an instructional strategy framework that would enhance mathematical learning and teaching practices.

The input component encompassed the various factors that influenced students' problem-solving abilities in mathematics, such as cognitive skills, prior knowledge, instructional methods, and learning environments. The process component outlined the steps involved in assessing problem-solving abilities and identifying the specific difficulties students faced. This phase included diagnostic assessments, data collection, and analysis of students' problem-solving strategies. Finally, the output component represented the anticipated outcomes of the study, which included a well-structured instructional strategy framework designed to address students' difficulties and improve their mathematical problem-solving skills.

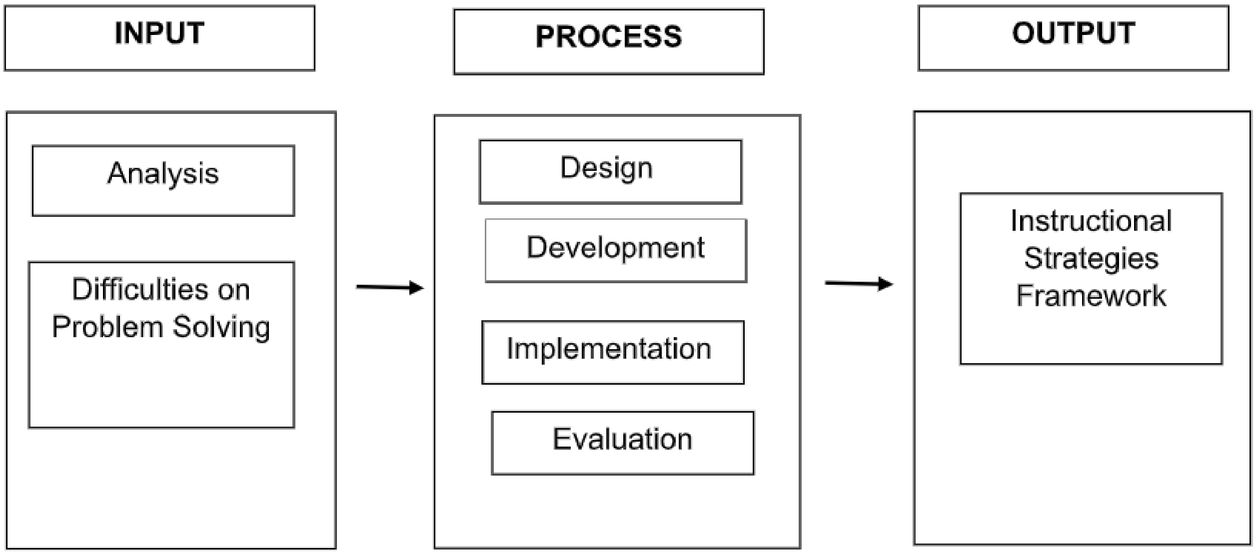


Figure 1. Conceptual Paradigm of the Study

Statement of the Problem

This study assessed students' problem-solving abilities and the difficulties they encountered in learning mathematics, serving as the basis for developing an instructional strategies framework.

Specifically, this study aimed to answer the following research questions:

1. What is the problem - solving abilities of students in terms of:

1.1 Understanding the Problem;

1.2 Designing Problem-Solving Strategies;

1.3 Performing Calculations; and

1.4 Re-Examining the Results of Problem-Solving?

2. Is there a significant difference on the problem-solving abilities of students when classified into SOLO Taxonomy?

3. What is the proposed instructional strategies framework to address the difficulty in problem - solving among students?

4. What is the acceptability of the proposed instructional strategies framework among experts? in terms of:

4.1 Relevance to Curriculum Standards;

4.2 Effectiveness in Addressing Student Difficulties;

4.3 Engagement and Motivation;

4.4 Feasibility of Implementation; and

4.5 Professional Development Support?

5. What is the acceptability of the proposed instructional strategies among students? in terms of:

5.1 Perceived Relevance;

5.2 Engagement Level;

5.3 Ease of Understanding;

5.4 Impact on Problem-Solving Skills; and

5.5 Feedback Mechanism?

Scope and Delimitation of the Study

This study was conducted to assess the problem-solving abilities and difficulties in learning mathematics among Grade 9 students at San Miguel National High School, Purok Rizal, Brgy. San Miguel, Norala, South Cotabato, for the school year 2024-2025. The participants consisted of three (3) heterogeneous sections of Grade 9, with the study employing total enumeration as the sampling technique.

A research and development (R&D) research design was utilized to generate essential investigative data. To ensure the validity of the assessment tools, the study adopted the Content Validity Ratio (CVR) using Lawshe's Method (Aithal et al., 2020) as a critical measure for evaluating the constructs related to problem-solving abilities in mathematics. Additionally, the study employed Yosuff's validation tool (2019), which demonstrated an acceptable Content Validity Index (CVI) of 0.83, ensuring the reliability and effectiveness of the assessment instruments.

METHODS

Research Design

The study employed Research and Development (R&D) research design modified by Sukmadinata (2005) to assess student's problem – solving abilities and their difficulties in learning mathematics. The goal of this design is to create new products or services, or improve existing ones. R&D is a series of activities that involves generating ideas, gathering knowledge, and testing and refining products.

This research demonstrates a strong association between research and design by integrating systematic inquiry with the development of practical, evidence-based instructional strategies. This association is reflected in the study's focus on understanding students' problem-solving abilities, identifying learning difficulties, and designing interventions to improve mathematics education outcomes.

Respondents of the Study

The respondents in this study were primarily Grade 9 students officially enrolled at San Miguel National High School for the school year 2024-2025. These students played a crucial role in understanding the current state of problem-solving abilities among early high school learners. Additionally, the study involved selected experts, including master teachers, master's graduates, and instructional material (IM) writers. These experts provided valuable insights into effective instructional strategies and the development of educational materials essential for enhancing students' problem-solving skills.

The inclusion of Grade 9 students allowed the researchers to assess the foundational problem-solving skills developed during early high school years. This age group was particularly significant as it marked a transition from basic arithmetic to more complex mathematical concepts, where problem-solving skills became increasingly critical (Codina et al., 2015).

The participation of master teachers and instructional material developers provided a comprehensive perspective on strategies to improve problem-solving skills. These experts offered insights into effective instructional techniques, such as structured problem-solving tasks and cooperative learning, both of which have been shown to enhance students' understanding and application of mathematical concepts (Hasibuan et al., 2020; Klang et al., 2021). Their input was crucial in developing a framework that addressed the specific needs of students in the region, aligning with broader educational goals to enhance problem-solving abilities in mathematics education (Sari, 2021).

The study included a total of 110 student respondents. Additionally, there were 30 expert respondents, comprising master teachers, master's graduates, and instructional material writers.

Sampling Technique

The researcher employed complete enumeration, as described by Aubry (2023), which involves a feasible univariate optimal partitioning. This sampling technique was purposefully chosen to ensure that the study encompassed the entire population of Grade 9 students at San Miguel National High School. By including all eligible participants, the researcher aimed to gather comprehensive data that accurately represented the students' mathematical problem-solving skills and challenges. This method also eliminated potential sampling bias, ensuring that findings were reflective of the entire group rather than a selected subset.

Data Gathering Instrument

The assessment tool used to evaluate the problem-solving abilities and difficulties of Grade 9 students, as well as the instrument for assessing the acceptability of the instructional strategies framework among experts and students, underwent a thorough validation process to ensure its validity and reliability.

The initial step involved a review by advisory committee members, who assessed the instrument's structure and grammar. After this review, the tool was further refined based on feedback from critical readers. Once enhancements were made, the content was evaluated by five experts—all of whom were passionate researchers from prestigious state universities and private higher education institutions with expertise in test structure assessment.

To ensure the content validity of the instrument, content validation was conducted to evaluate the relevance of each item to the problem-solving concepts being measured. The decision to retain an item was based on the Content Validity Index (CVI), which depended on the number of panelists involved. The research employed Yosuff's validation tool (2019), demonstrating an acceptable CVI of 1, indicating strong content validity.

Following the validation process, the researcher, with the assistance of subject-matter experts, conducted pilot testing of the instrument. The results from the pilot test were then submitted to a statistician for further assessment and refinement.

To measure the internal consistency and reliability of the questionnaire, Cronbach's Alpha reliability testing was conducted. Cronbach's Alpha is a widely used measure for assessing the reliability of scales and their items. In this study, an 8-item questionnaire with four indicators each was developed based on the Structure of the Observed Learning Outcomes (SOLO) Model (Biggs & Collis, 1989). The questionnaire comprised three questions under the unistructural level, three under the Mult structural level, and two under the relational level.

The reliability testing yielded a Cronbach's Alpha value of 0.72, which is approximately equal to 0.7, indicating acceptable internal consistency. According to Kline (1999), the generally accepted threshold for Cronbach's Alpha is above 0.7, while values greater than 0.6 are still considered acceptable for research purposes.

Data Gathering Procedures

This study employed the ADDIE Model, which was developed by the U.S. Army in the 1970s as part of a broader initiative to improve the educational training process. The ADDIE Model consists of five phases:

1. Analysis Phase – The researcher conducted interviews and focus group discussions with educators and students to identify specific challenges in mathematics learning. This phase aimed to establish a clear understanding of students' difficulties and instructional gaps.

2. Design Phase – The researcher tested the research instruments with a small group from the target population to ensure clarity and relevance. Feedback gathered from this pilot testing was used to refine the instruments for better accuracy and effectiveness.

3. Development Phase – The researcher outlined the procedures for administering tests and surveys, including detailed instructions for participants and structured data collection timelines to ensure a systematic approach.

4. Implementation Phase – The finalized research instruments were administered to the selected participants in a controlled environment to minimize external influences and ensure the reliability of responses.

5. Evaluation Phase – The researcher summarized the findings in relation to the study's objectives, emphasizing their implications for instructional strategies in mathematics education. This phase provided insights into how the results could inform and enhance teaching methodologies.

Finally, the researcher collected, verified, and tabulated the responses using Excel and consulted the Graduate School statistician for further statistical analysis. To arrive at meaningful conclusions, the researcher interpreted the data and conducted discussions based on the study's findings.

Statistical Treatment

To assess the acceptability of the instructional strategy framework, the researcher utilized mean and standard deviation as statistical measures. The mean was used to determine the overall level of acceptability based on respondents' ratings, while the standard deviation measured the variability or consistency of their responses. A four-point rating scale, adopted from Vagias (2006), was employed to interpret the weighted mean along with its corresponding verbal descriptions.

Scale	Interval	Verbal Description
4	3.26 – 4.00	Totally Acceptable
3	2.51 – 3.25	Acceptable
2	1.76 – 2.50	Unacceptable
1	1.00 – 1.75	Totally Unacceptable

To determine the problem-solving abilities and difficulties in learning mathematics, an 8-item researcher-developed test instrument was utilized. This test was validated by reputable mathematics experts to ensure its reliability and effectiveness in assessing students' mathematical skills. The instrument was a rubric-based test, with a five-point scoring system, where 5 (highest) represented "Excellent", and 1 (lowest) represented "Beginning."

Additionally, to analyze students' problem-solving abilities and difficulties, the researcher employed mean and standard deviation as statistical tools. The mean scores were then transmuted using the DepEd Transmutation Table, ensuring consistency with the Department of Education's grading system. The descriptors and grading scale were aligned with DepEd's official grading system, providing a standardized interpretation of students' performance levels in mathematics problem-solving.

Grading Scale	Descriptors
90 – 100	Outstanding
85 – 100	Very Satisfactory
80 – 84	Satisfactory
75 – 79	Fairly Satisfactory
Below 75	Did Not Meet Expectations

Hence, to examine the significant difference in problem-solving abilities among students when classified in SOLO Level of Taxonomy, the researcher employed one-way analysis of variance (ANOVA). The analysis was tested at a significance level of 0.05.

RESULTS AND DISCUSSION

Problem-Solving Abilities of Students as Classified to Level of SOLO Taxonomy

Table 2. Problem-Solving Abilities of Grade 9 Students According to Unistructural Level of SOLO

Indicator	Mean	SD	Descriptors
A. Understanding the Problem	78.16	0.79	Fairly Satisfactory
B. Designing Problem-Solving Strategies	74.1	1.16	Did Not Meet Expectations
C. Performing Calculation	71.38	1.28	Did Not Meet Expectations
D. Re-examining the Result of Problem Solving	67.95	0.82	Did Not Meet Expectations
Section Mean	**72.37**	**1.03**	**Did Not Meet Expectations**

The overall section mean of 72.37, with an SD of 1.03, also falls within the "Did Not Meet Expectations" category. This finding highlights the students' general struggle with problem-solving tasks at the Unistructural level, where they tend to focus on single aspects rather than integrating multiple elements of the problem.

Table 3. Problem-Solving Abilities of Grade 9 Students According to Mult structural Level of SOLO

Indicator	Mean	SD	Descriptors
A. Understanding the Problem	76.97	1.03	Fairly Satisfactory
B. Designing Problem-Solving Strategies	72.26	1.22	Did Not Meet Expectations
C. Performing Calculation	75.35	1.64	Did Not Meet Expectations
D. Re-examining the Result of Problem Solving	68.49	0.92	Did Not Meet Expectations
Section Mean	**73.27**	**1.23**	**Did Not Meet Expectations**

Overall, the section means of 73.27 with an SD of 1.23 falls under the Did Not Meet Expectations category. This collective result reveals that Grade 9 students demonstrate a generally insufficient level of problem-solving abilities within the multistructural level of the SOLO taxonomy.

Table 4. Problem-Solving Abilities of Grade 9 Students According to Relational Level of SOLO

Indicator	Mean	SD	Descriptors
A. Understanding the Problem	76.14	0.84	Fairly Satisfactory
B. Designing Problem-Solving Strategies	74.85	0.92	Did Not Meet Expectations
C. Performing Calculation	69.54	0.88	Did Not Meet Expectations
D. Re-examining the Result of Problem Solving	67.78	0.65	Did Not Meet Expectations
Section Mean	**72.08**	**0.83**	**Did Not Meet Expectations**

The data reveals that the highest mean score among the indicators is observed in "Understanding the Problem" (Mean = 76.14, SD = 0.84), which is descriptively interpreted as "Fairly Satisfactory". This suggests that the students exhibit a moderate level of comprehension when analyzing mathematical problems.

On the other hand, the remaining three indicators reflect a relatively lower performance. "Designing Problem-Solving Strategies" recorded a mean score of 74.85 (SD = 0.92), while "Performing Calculation" and "Re-examining the Result of Problem Solving" yielded mean scores of 69.54 (SD = 0.88) and 67.78 (SD = 0.65), respectively. These three indicators are categorized as "Did Not Meet Expectations", indicating a deficiency in students’ ability to effectively devise strategies, accurately perform mathematical operations, and critically evaluate their solutions.

Table 5. Analysis of Variance (ANOVA) on Problem-Solving Abilities of 110 Students when Classified in SOLO Taxonomy

	Sum of Squares	df	Mean Square	F	Sig
Between Groups	81.717	2	40.859	2.655	.072
Within Groups	5032.094	327	15.389		
Total	5113.811	329			

Significant at the 0.05 level.

The data reveals that the computed F-value is 2.655, with a corresponding p-value (Sig) of 0.072. Since the p-value exceeds the threshold of 0.05, the result is not statistically significant. This indicates that there is no sufficient evidence to conclude that the problem-solving abilities of students significantly differ across the classifications of the SOLO Taxonomy.

The between-groups sum of squares is 81.717, with 2 degrees of freedom, resulting in a mean square value of 40.859. On the other hand, the within-groups sum of squares is 5032.094 with 327 degrees of freedom, yielding a mean square value of 15.389. These values indicate that the variation within groups is considerably larger compared to the variation between groups, suggesting that the differences in problem-solving abilities are more likely attributable to individual variability rather than the classification according to the SOLO Taxonomy.

Instructional Strategy Framework for Enhancing Problem-Solving Ability in Mathematics

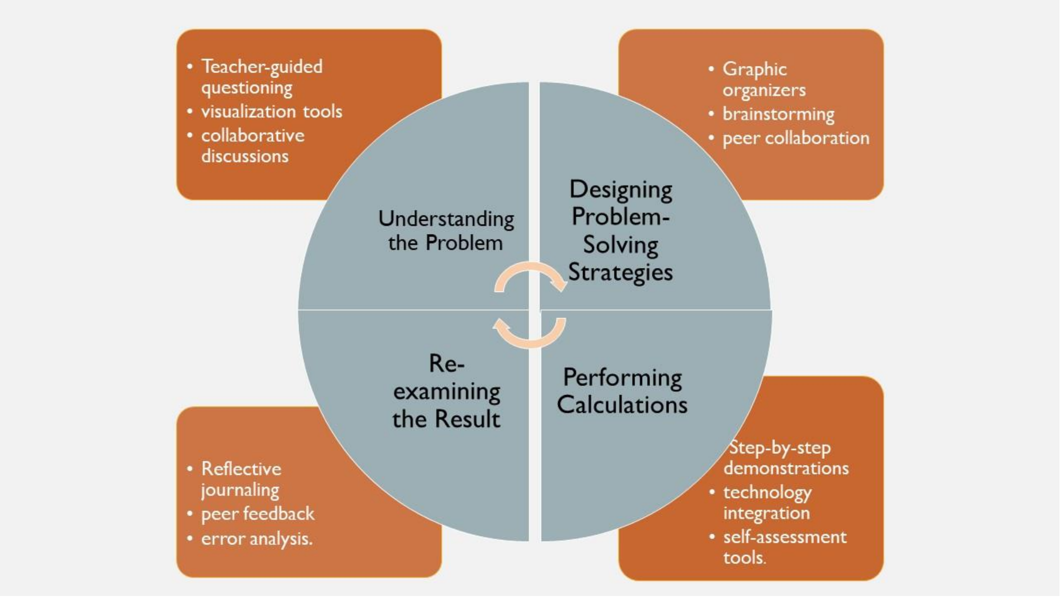
I. Introduction

This framework aims to enhance students' mathematical problem-solving abilities by focusing on key processes: understanding the problem, strategizing solutions, performing calculations, and re-examining results. It integrates pedagogical strategies that foster critical thinking, collaboration, and self-regulation.

II. Objectives

- Strengthen students' comprehension of mathematical problems.
- Equip learners with diverse problem-solving strategies.
- Enhance computational accuracy through guided practice.
- Develop reflective thinking and self-assessment skills.

III. Framework Components



A. Understanding the Problem

Description: Identifying given information and clarifying what is being asked.

Strategies: Teacher-guided questioning, visualization tools, collaborative discussions.

Outcome: Clear comprehension of problem context and requirements.

B. Designing Problem-Solving Strategies

Description: Formulating a structured approach to solving the problem.

Strategies: Graphic organizers, brainstorming, peer collaboration.

Outcome: Selection of effective and logical solution strategies.

C. Performing Calculations

Description: Executing computations based on the chosen strategy.

Strategies: Step-by-step demonstrations, technology integration, self-assessment tools.

Outcome: Accurate, systematic, and well-structured solutions.

D. Re-examining the Result (Core Focus)

Description: Evaluating the solution for accuracy and reasonableness.

Strategies: Reflective journaling, peer feedback, error analysis.

Outcome: Improved critical thinking, error identification, and solution refinement.

IV. Implementation Process

1. Introduce the framework and its components.
2. Model each stage using sample problems.
3. Facilitate guided practice sessions.
4. Provide feedback and encourage reflection.
5. Assess progress through formative assessments and journals.

V. Assessment and Evaluation

- Rubric-based evaluation of problem-solving tasks.
- Reflective journal submissions and peer feedback reports.
- Teacher observations and formative quizzes.

CONCLUSION

This framework provided a structured approach to mathematical problem-solving, fostering critical thinking, strategic application, and self-regulation. It encouraged students to analyze problems methodically, apply appropriate strategies, and regulate their learning processes effectively.

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Table 6. Level of Acceptability of Instructional Strategies Framework among Experts

Indicator	Mean	SD	Interpretation
Relevance to Curriculum Standards.	3.47	0.50	Totally Acceptable
Effectiveness in Addressing Student Difficulties	3.00	0.00	Acceptable
Engagement and Motivation	3.49	0.50	Totally Acceptable
Feasibility of Implementation	3.30	0.50	Totally Acceptable
Professional Development Support	3.41	0.49	Totally Acceptable
Grand Mean	**3.33**	**0.02**	**Totally Acceptable**

The findings reveal an overall mean score of 3.33 (SD = 0.02), interpreted as "Totally Acceptable." This suggests that the framework is generally well-received and considered suitable for implementation in educational settings.

Table 7. Level of Acceptability of Instructional Strategies Framework among Students

Indicator	Mean	SD	Interpretation
Perceived Relevance	3.29	0.45	Totally Acceptable
Engagement Level	3.28	0.45	Totally Acceptable
Ease of Understanding	3.34	0.48	Totally Acceptable
Impact on Problem-Solving Skills	3.32	0.47	Totally Acceptable
Feedback Mechanism	3.45	0.50	Totally Acceptable
Grand Mean	**3.34**	**0.48**	**Totally Acceptable**

The findings reveal that the framework is generally well-received, with an overall mean score of 3.34 (SD = 0.48), which falls within the "Totally Acceptable" category.

CONCLUSIONS

The study concludes that Grade 9 students possess a moderate level of understanding in problem comprehension based on the SOLO taxonomy levels—Unistructural, Multistructural, and Relational. However, they demonstrate consistent difficulties in designing strategies, executing accurate computations, and evaluating their results, indicating a critical gap in applying higher-order thinking skills. These findings emphasize the need for targeted instructional interventions to enhance students' comprehensive mathematical problem-solving capabilities. Interestingly, while student performance varied, statistical analysis showed no significant differences in problem-solving skills across SOLO taxonomy classifications, suggesting that individual learner differences may play a more significant role than cognitive categorization in shaping problem-solving performance.

Moreover, the study found the developed instructional strategies framework to be effective in addressing the students' problem-solving challenges. Expert validations confirmed that the framework aligns well with curriculum standards and is both feasible and relevant for classroom use. Additionally, students reported that the framework was engaging, clearly presented, and positively influenced their learning experiences. Despite its promise, the study recommends further refinement of the framework by enhancing its real-world application and incorporating more student-centered feedback to ensure greater long-term effectiveness and adaptability in improving mathematical problem-solving skills.

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