International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Stepwise Guide Questions in Improving Grade 12 Stem Students' Attitudes and Approaches to Problem-Solving in Physics

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ABSTRACT
Problem-solving is the process of using concepts and mathematical methods to solve problems involving physical phenomena. Scaffolding techniques have been proven to improve students' proficiency in this area. This study looks at how stepwise guide questions, used as a scaffolding tool in problem-solving instruction, affect students' attitudes and approaches to problem-solving. The study involved students enrolled in the General Physics 2 class. The AAPS survey was used to collect students' attitudes and approaches prior to the intervention. After using stepwise guide questions in instruction, the students' attitudes and approaches were investigated to track improvement from pre-intervention. The findings revealed that, overall, students' attitudes and approaches improved following intervention. Significant progress was made, particularly in the areas of metacognition in problem-solving, their perception of the importance of illustrations and diagrams in problem-solving, and their difficulty in solving problems symbolically. As a result, the researchers recommend adapting the use of stepwise guide questions in problem-solving classes. To support its effectiveness in instruction, future researchers may investigate the impact of this intervention on students' academic performance in problem-solving subjects.

Keywords: Scaffolding, Guide Questions, Attitudes and Approaches, Problem-Solving, Physics

1. Introduction

In physics, problem-solving is the systematic application of conceptual frameworks and mathematics to examine and resolve problems that involve physical processes. This involves understanding the problem's context, developing an organized plan to solve it, carrying out the plan using conceptual reasoning or mathematical calculations, and analyzing the outcomes considering the problem's circumstances.

Problem-solving is regarded in the context of physics education as a cognitive process requiring active engagement. This process is highlighted by Jonassen (2011), who defined it as the application of learned concepts along with the development of critical thinking skills, creativity, and adaptability. Similarly, Hmelo-Silver (2004) emphasizes the value of problem-solving as a way to master concepts and increase comprehension, stressing the significance of genuine, real-world challenges in fostering intellectual development.

Problem-Solving in NAT and NAT results

Students are assessed on a variety of 21st-century skills, such as information literacy, critical thinking, and problem-solving, on the National Achievement Test for Grade 12 (NAT G12) (BEA, 2023). The purpose of this assessment is to monitor and improve the quality of education in the Philippines.

The NAT G12 results for 2018–19 show poor problem-solving ability in all tracks, including Academic, Sports, Technical-Vocational Livelihood, and Arts and Design. The academic track's overall mean percentage score of 41.68% indicates that the majority of students have difficulty solving problems. This is reflected in the overall mean percentage scores (MPS).

One of the goals of the NAT G12 test design is to evaluate problem-solving abilities using a range of subskills and progression indicators.:

1. Analyzing Outcome
a. Identify association
b. Identify cause and effect
c. Predict outcomes
2. Executing Strategy/Methods
a. Identify a strategy or method
b. Select appropriate methods to solve the problem
c. Identify alternative methods to solve the problem

Problem-solving in physics requires students to analyze physical phenomena, recognize relevant principles, and apply appropriate strategies in order to comprehend and solve complex scientific problems. The NAT G12 includes multiple-choice questions designed to assess problem-solving skills in physics. Examples of such items might involve:

1. Analyzing functions and graphs to determine outcomes
2. Applying mathematical principles to solve physics problems
3. Understanding and interpreting experimental data to predict physical behaviors

The report on the result of the NAT G12 (SY 2022-2023) of the University of La Salette, Incorporated High School highlights an issue with students' problem-solving performance in both science and mathematics. The MPS for mathematics and science for problem-solving are low; at 34.26 and 38.52, respectively, they are classified as "Low Proficient." These results indicate a particular weakness in the fields of math and science, as they are significantly lower than those in other subjects like philosophy (67.45) and language and communication (57.09).

1.1 Students' Scores in Problem-Solving

Throughout their physics course, the researchers observed that students' performance on problem-solving tasks was generally low. Their results on summative assessments and their performance on quizzes both demonstrated this pattern.

Students' qualitative feedback exposes the difficulties they face when completing independent problem-solving tasks. A possible gap in transferability across contexts was highlighted by the majority of students who said that they understood the problem-solving process during teacher demonstration but found it difficult to apply when working on problems independently. Many students also expressed feeling overwhelmed by unfamiliar situations and having trouble knowing which concepts to apply to various problems. Although they were confident in their theoretical understanding, many acknowledged that they

had made calculation mistakes when working through problems on their own. These realizations highlight how difficult it is for students to connect theory to practice and navigate a variety of problem sets.
Supporting this qualitative data are the mean of the percentage and standard deviation of the scores of students' problem-solving performance, further validating the observed challenges. The data presents a mean percentage score of 52.67 with a standard deviation of 11.10.

Table 1. ***Summary of scores of students in problem-solving items***

Mean Percentage Score	Standard Deviation
52.67	11.10

This data shows a reasonably moderate mean score with a significant standard deviation, indicating performance variability amongst individuals. The wide range of scores highlights the variety of difficulties students face when solving problems, as some may perform exceptionally well while others struggle greatly. Combining these quantitative results with qualitative feedback offers a thorough grasp of the complex problems affecting students' ability to solve physics-related problems.

1.2 Novice vs. Expert Attitudes and Approaches in Problem-Solving

Negative attitudes and wrong methods used by students can hinder their ability to learn the subject matter and solve problems. In the study of Wakhata, et. al. (2022), the relationship between students' attitudes toward mathematics, and their performance in word problems involving linear programming, is investigated. The results demonstrate a strong positive correlation, mediated by active learning heuristic problem-solving techniques, between students' attitudes and performance. This implies that having a positive attitude toward problem-solving can improve performance, underscoring the significance of creating supportive learning environments in schools.
In order to differentiate expert vs. novice attitudes and approaches in problem-solving, Mason & Singh (2016) compared the perspectives, strategies, and levels of confidence of expert and novice learners in their study. Faculty, PhD students, and introductory physics students were involved in the study.
Their study found a number of significant differences between the approaches to problem-solving used by experts (faculty and PhD students) and novices (introductory students). Professors and PhD candidates typically find greater enjoyment in solving difficult physics problems than introductory physics students, who are more motivated and satisfied when they can solve simpler problems correctly right away.
A deeper level of engagement is suggested by the experts' enjoyment of the subject. Additionally, faculty members often do not need to explicitly think about the underlying concepts because they are automatic as a result of extensive experience. Conversely, novices need to take these concepts into explicit consideration, which shows that they lack productivity and experience when it comes to problem-solving (Mason & Singh, 2016).
Experts, such as PhD students and faculty, approach problems by delving deeper into conceptual analysis, while novices typically take a "plug and chug" approach, concentrating on formulas without adequate planning. Novices' direct approach lacks the strategic depth of experts, who, because of their advanced expertise, can recognize the relevant principles and equations right away. Additionally, after solving a problem, PhD students and faculty members are more likely to think back on and draw lessons from it—a habit that is less common among introductory students who don't anticipate seeing the same kind of problem on subsequent exams (Mason & Singh, 2016).

The way that symbolic and numerical problems are handled differs significantly as well. Symbolic manipulation can be difficult for beginners, who would rather start solving problems with numbers. Experts, on the other hand, have little trouble solving symbolic equations and usually save the numerical substitution for last. A gap in intuitive comprehension is evident in the fact that while novices find it difficult to understand and apply physics equations, PhD students find them more intuitive and are able to apply them to a variety of situations (Mason & Singh, 2016). These variations highlight the necessity of teaching methods that support beginners in acquiring more expert-like techniques and metacognitive abilities in order to enhance their problem-solving capabilities.

Experts and novices approach physics problems in very different ways. Experts start by analyzing the problem based on their strong understanding of the underlying concepts. Only then do they move on to applying the relevant mathematical equations. Finally, they reflect on the answer's validity. In contrast, novices jump straight into searching for a formula that might solve the problem, often disregarding the need for conceptual analysis. If their initial guess doesn't work, they try another formula, hoping to find one that delivers the desired answer. This trial-and-error approach is a stark contrast to the expert's thoughtful process, built on deep understanding and cognitive skills, which allows them to solve problems with greater confidence (Reddy, 2019).

Novices often struggle with physics problems because they lack a deep understanding of the concepts. They tend to categorize problems based on superficial similarities, leading them to jump back and forth between different approaches without a clear direction. In contrast, experts exhibit a more refined problem-solving process. They continuously assess their solution methods and justify their final answers. The appropriate level of mathematics is always a consideration in physics problem-solving, as integrating mathematical tools is essential. However, experts understand that mathematical fluency isn't enough – it must be coupled with a strong grasp of the underlying physics principles (Reddy, 2019).

A study by Balta and Asikainen (2019) identified four main student approaches to physics problem-solving: scientific approach, formula-focused ("plug-and-chug"), memorization, and lacking a clear strategy. The most common approach, "plug-and-chug," involves identifying variables and searching for a matching formula rather than analyzing the underlying physics. This often leads to difficulties because it bypasses a deeper understanding of the concepts at play.

Studies on how people solve physics problems reveal key differences between experts and novices. Experts have a well-organized knowledge base that allows them to employ effective and complex strategies when tackling problems. In contrast, novices often struggle to see beyond the equations themselves. They might rely on surface-level comparisons or analogies, which can limit their understanding and ability to solve problems effectively. The way information is presented (text, equations, graphs) can significantly impact how students approach physics problems. Studies show that students often adapt their problem-solving strategies based on the type of representation used. However, this isn't the only factor influencing student performance. Prior knowledge and experience solving problems play a big role, especially for students who struggle academically. Interestingly, research also suggests that even when asked to explain a science concept without calculations, students might still rely on equations or numbers. This suggests a tendency to translate qualitative problems into a quantitative framework, even when not explicitly required. Previous research focused on students using equations without truly understanding the underlying concepts. However, recent studies emphasize the crucial role of mathematical modeling in physics. Physics relies on connecting the physical world to its mathematical representation through equations. These equations aren't just calculation tools, but rather symbolic expressions of logical reasoning. In essence, they condense a wealth of conceptual knowledge within themselves (Park, 2021).

1.3 Scaffolding and Guided Practice in Problem-Solving

According to cognitive theories, mastering complex tasks requires scaffolding, in which students receive progressively more intense temporary support until they reach a higher level of understanding and proficiency. The Zone of Proximal Development (ZPD), as proposed by Vygotsky, highlights the significance of offering assistance to students just beyond their current level of competence. The difference between what students can accomplish on their own and what they can with assistance is known as the ZPD. In the ZPD, efficient scaffolding promotes confidence and motivation in addition to helping with skill acquisition (Vygotsky, 1978). This method works especially well in difficult subjects like physics, where critical thinking and problem-solving skills are crucial.

Problem-solving techniques in physics have already been taught using scaffolding and guided practice using prompts. It has been demonstrated that scaffolding aids students in developing their problem-solving abilities.

According to a research by Arifin et al. (2020), conceptual scaffolding greatly improves students' ability to solve problems. Their study involved giving students questions, both written and spoken, to guide them throughout the problem-solving process. In comparison to students who did not receive this kind of support, the study indicated that students who received conceptual scaffolding prior to problem-solving demonstrated a greater capacity for identifying underlying connections and applying concepts successfully. This improvement was seen in both large-scale written tests and small-scale interviews, indicating that scaffolding may help students grasp concepts more deeply and solve problems more effectively.

Similarly, procedural e-scaffolding was developed and evaluated by Saman et al. (2018) to improve students' physics problem-solving abilities. Borg & Gall's R&D design was used in the study, which included phases like expert validation, limited implementation, product design, and effectiveness testing. Students using blended learning environments with e-scaffolding performed significantly better in the effectiveness test than students using traditional learning methods. In the study, students are given prompts that guide them throughout the problem-solving process.

Using an embedded experimental model and a mixed-methods research design, Nikat et al. (2020) examined the effects of the Scaffolding computer packet instruction (SCPI) learning system on students' physics problem-solving abilities. The scaffolding that the SCPI system offers to students includes immediate feedback on conceptual questions, a section summarizing material that they may have misunderstood, and the option to retake assessments that require them to solve problems in order to reinforce what they have learned. Based on both quantitative and qualitative analyses, the study showed a significant improvement in students' problem-solving skills following the implementation of SCPI. Data from the pretest and posttest showed normalcy and homogeneity, and statistical analyses supported the usefulness of SCPI in improving students' problem-solving abilities. It has been demonstrated that integrating scaffolding techniques—conceptual or procedural—significantly improves students' ability to solve physics-related problems.

Effective interventions are necessary in light of the challenges in problem-solving proficiency within physics education, as demonstrated by assessments such as NAT results and quizzes. The use of targeted prompts as tools for scaffolding was proven effective in alleviating difficulties of students in problem-solving as evidenced by the studies mentioned above. When compared to experts, novice learners' less successful approaches to problem-solving point to a large gap that needs to be filled. Based on cognitive theories, scaffolding techniques show promise in improving students' problem-solving skills as well as their ability to comprehend concepts more deeply and critically.

Therefore, this study aims to assess the use of stepwise guide questions as a scaffolding approach in teaching problem-solving.

1.4 The Stepwise Guide Questions

Inspired by Replinger (2020), the stepwise guide questions are a scaffolding approach meant to help students develop their problem-solving skills. This approach uses guide questions embedded in word problems to take students step-by-step through the process of solving problems. First, the students are given targeted questions that focus their attention on finding given values, creating diagrams, creating equations, and performing calculations.

This method starts with specific prompts that walk students through every stage of the problem-solving process, drawing inspiration from Replinger's approach in his article "A Simple Way to Scaffold Physics" (Replinger, 2020). In order to formulate and apply equations, for example, students first identify given values and create diagrams. The objective of this methodical approach is to enhance students' self-assurance and proficiency in handling complex physics problems.

Table 2. ***Sample problem with detailed prompts***

Problem	Prompts
Calculate the electric force acting between the two balls 1 and 2 with charges 12 μC and 16 μC which are separated by a distance of 1 m. (Take the value of coulomb's constant, k = 8.98×10^9 N m^2/C^2)	**Prompt 1.** What are the given values in this problem, including the charges of Ball 1 and Ball 2, the distance between them, and the value of Coulomb's constant?
	Prompt 2. Draw a simple diagram representing the two charged balls, labeling their charges and the distance between them.
	Prompt 3. What equation will you use to calculate the electric force between the two charged balls? Write down the formula for electric force based on Coulomb's Law.
	Prompt 4. Substitute the given values into the formula for electric force. Be sure to convert the charges from microcoulombs to coulombs before plugging them into the equation.
	Prompt 5. Calculate the electric force acting between Ball 1 and Ball 2 using the substituted values and the formula for electric force.
	Prompt 6. Examine the units of your calculated electric force. Do they match the standard unit for force (N)? Is the magnitude of the force reasonable given the nature of electric forces?

	Prompt 7. Write a sentence expressing the calculated electric force between Ball 1 and Ball 2. Include the direction of the force if applicable.
	Prompt 8. Does your calculated electric force align with the expected behavior described by Coulomb's Law? Consider the relationship between charges and distance in the context of electric forces.

Through the use of a set of structured prompts, modeled after Replinger's methodology in "A Simple Way to Scaffold Physics" (2020), students are helped to first understand and apply basic concepts. The scaffolding gradually disappears as they go along, encouraging autonomous problem-solving abilities and critical thinking. This method gives students the tools to not only become experts in a particular problem category but also to approach and solve new problems on their own (Replinger, 2020).

1.5 Research Questions/Objectives

The purpose of this study is to determine how well stepwise guide questions work in physics classrooms as an intervention to enhance students' attitudes and approaches. Unlike simple prompts, stepwise guide questions are intended to gradually guide students through the problem-solving process by offering specific steps and prompts at each turn. This study aims to provide useful insights into physics education and possibly a useful tool to help students overcome their obstacles by investigating the effectiveness of this approach. Specifically, this research aims to answer the following questions:

1. What is the effect of stepwise guide questions to students' attitudes and approaches in problem-solving in terms of;

a. Metacognition and enjoyment
b. Utility of pictures, diagrams or scratchwork
c. Perception of problem-solving approach
d. General expert-novice differences in physics problem-solving
e. Difficulty in solving problems symbolically
f. Problem-solving confidence
g. Sense-making
h. Problem-solving sophistication

2. What is the relevance of Stepwise Guide Questions in enhancing Physics instructions?

1.6 Significance of the Study

The findings of this study offer an insight into possible ways of improving instruction and learning in the field of education, specifically in handling subjects that offers problem solving.

To Educators. The findings of this study may benefit educators by providing an insight on student attitudes and approaches regarding problem-solving. This overview may help educators device strategies to work on improving the attitudes and approaches of students on problem-solving. Other than that, the results of this study emphasize on the use of 'questioning' in the field of education. Therefore, the result of this study may serve as a rapport to improve classroom learning environment by highlighting the importance of questioning.

To Students. The findings of this study may benefit students by providing an avenue to improve their learning and address the perceived anxiety regarding problem-solving and the subject Physics. This study also provides a technique that may help students understand the lesson through active learning.

To Future Researchers. The findings of this study lay foundation for more studies on whether this approach help improve learning and help students improve in answering problem-solving questions.

2. Methods

2.1 Research Design

The study used a one-group pre-test post-test design with a non-randomized participant group to investigate how stepwise guide questions affected participants' attitudes, approaches and performance when solving physics problems.

An outcome variable is measured in a single group of participants using the one-group pretest-posttest design, both before and after they receive a particular intervention or treatment. It seeks to assess how the group has changed over time and assign these changes to the intervention (Marsden & Torgerson, 2012). It is frequently employed in pilot studies or preliminary assessments of interventions to determine their possible effectiveness prior to more extensive research (Marsden & Torgerson, 2012).

2.2 Research Locale and Participants

The study titled, "Stepwise Guide Questions in Improving Grade 12 STEM Students' Attitudes and Approaches to Problem-Solving in Physics" was conducted at a private catholic secondary high school in the City of Santiago. It involved 38 students from Grade 12 Science, Technology, Engineering and Mathematics students.

2.3 Research Instruments

2.3.1 The AAPS Survey

The results of Mason and Singh's (2016) analysis of the AAPS survey were used by the researchers to examine how students approached and felt about solving physics problems. Mason and Singh (2016) used principal component analysis (PCA) to analyze the survey and found nine important factors, each of which consisted of two or more survey questions. According to Mason and Singh (2016), these variables accounted for 53% of the variance in the total, indicating that the survey was successful in capturing various facets of students' problem-solving abilities.

This indicates that the nine factors that were determined to be responsible can account for 53% of the overall variability in the survey responses from the students. This indicates that these factors are responsible for more than half of the differences in the ways students answered the questions, providing us with a comprehensive understanding of their perspectives and approaches to problem-solving.

There was a significant contribution made by each survey question to the overall comprehension of students' attitudes and approaches, as each question was present in at least one of these nine factors. The elements included both more general problem-solving strategies and more specialized ones, like making diagrams and doing scratch work (Mason & Singh, 2016).

Table 3 presents the nine factors in the AAPS survey, as identified by Mason & Singh (2016), with their total number of items and corresponding item numbers.

Table 3. ***Descriptions and corresponding items of the nine factors of the AAPS survey according to Mason & Singh (2016)***

Factor	Description	Total Number of Items	Item Numbers in the AAPS
Factor 1	Metacognition and enjoyment in physics problem-solving	12	4, 6, 7, 10, 13, 14, 20, 21, 22, 25, 27, 29
Factor 2	Utility of pictures, diagrams or scratchwork in physics problem-solving	4	15, 17, 18, 19
Factor 3	Perception of problem-solving approach	6	5, 8, 9, 11, 12, 26
Factor 4	General expert-novice differences in physics problem-solving	5	8, 21, 24, 28, 29
Factor 5	Difficulty in solving problems symbolically	2	30, 31
Factor 6	Problem-solving confidence	4	1, 6, 23, 24
Factor 7	Solving different problems using the same principle	2	32, 33
Factor 8	Sense-making	3	2, 3, 5, 16
Factor 9	Problem-solving sophistication	4	3, 9, 20, 25

To obtain a thorough understanding of how stepwise guide questions affected students' attitudes and approaches in problem-solving, the researchers focused these different factors in the AAPS survey. A systematic framework for evaluating the impact of the on students' attitudes and approaches in problem-solving was made available by these factors.

2.4 Data Gathering and Analysis

Assigned as the data “Before,” pre-intervention phase includes the conduct of lectures and quizzes the traditional way. At the start of the second quarter of their General Physics 2 course, the students are given the Attitudes and Approaches in Problem Solving (AAPS) survey by Mason and Singh.

In the post-intervention phase, the students are given the stepwise guide questions as scaffolding tool in teaching problem-solving. At the end of the course, the students took the AAPS survey to determine their attitudes and approaches regarding problem-solving to measure changes in their attitudes and approaches to problem-solving.

The Wilcoxon signed-rank test was used to measure significant change in attitudes and approaches using the AAPS survey. This test is non-parametric, which makes it appropriate for paired data that might not meet the assumptions needed for parametric tests like the paired samples t-test (Conover, 1999). The Wilcoxon signed-rank test can compare the median differences of these paired scores effectively. This method provides an assessment of the impact of stepwise guide questions on performance and attitudes and approaches to problem-solving while being less sensitive to outliers and non-normal distributions.

Using a 5-point Likert scale, the researchers referenced expert responses found by Mason & Singh (2016). On this scale, a response with a score of 5 represents an expert response, and a score of 1 represents a novice response.

3. Results and Discussions

This study investigates the impact of stepwise guide questions on the attitudes and approaches of students in problem-solving. This section discusses the results obtained from the data in the study.

3.1 Metacognition and enjoyment in problem-solving

Using a 5-point Likert scale, where scores ranged from 1 (novice approach/attitude) to 5 (expert approach/attitude), with 3 denoting neutrality, the study evaluated students' perceptions of metacognition and enjoyment in physics problem-solving.

These indicators on metacognition and enjoyment in physics problem-solving suggest a strong positive connection between metacognition and enjoyment in physics problem-solving.

Several statements highlight a deep focus on understanding the underlying concepts (question 4, 10, 14). This reflects a student who is actively thinking about "thinking" - a core aspect of metacognition.

There's also a strong emphasis on self-monitoring and reflection (questions 7, 13, 22, 25, 27). The student is aware of when things don't seem right and takes the initiative to identify and learn from mistakes. This self-awareness and control over the problem-solving process are crucial aspects of metacognition.

Learning from mistakes (question 25) and reflecting on solutions after successful attempts (question 20) further demonstrate a growth mindset and a desire to improve strategies. This can lead to increased confidence and a sense of accomplishment, ultimately contributing to enjoyment of the problem-solving process (question 29).

Overall, these indicators suggest a student who is not just solving physics problems but actively thinking about how they solve them. This metacognitive awareness can lead to a deeper understanding, a greater ability to handle novel situations, and ultimately more enjoyment in the problem-solving journey.

Table 4. ***Summary of responses on metacognition and enjoyment in physics problem-solving***

	Mean	**Standard Deviation**
Before Intervention	3.64	0.44
After Intervention	3.87	0.49

Students' average perception score before the intervention was 3.64 (SD = 0.44), but after the intervention, it increased to 3.87 (SD = 0.49). After the intervention, there appears to have been a slight improvement in students' perceptions of their metacognitive strategies and their enjoyment of solving physics problems.

Table 5. ***Wilcoxon signed-rank test results on metacognition and enjoyment in physics problem-solving***

Negative Ranks	**Positive Ranks**	**Ties**	**Asymp. Sig (2-Tailed)**	**Z-score**
10	24	4	0.003	-2.987

Students' perceptions of metacognition and enjoyment in solving physics problems varied before and after the intervention, which was examined using the Wilcoxon signed rank test. Ten negative ranks, or a drop in scores, twenty-four positive ranks, or an increase in scores, and four ties, or no change in scores, are shown in the results. At a conventional significance level (usually $p < 0.05$), the observed change is statistically significant, according to the asymptotic significance (2-tailed) value of 0.003. The reliability of the results was validated by the Z-score of -2.987, which was linked to this significance level.

Metacognition refers to "thinking about thinking" - it's our awareness and control over our own learning processes. The passage suggests that simply having prior knowledge and motivation isn't enough. Students who struggle to apply their knowledge to new situations might benefit from stronger metacognitive skills.

The research of (Pozas, 2020) points out a gap in our understanding. While studies have explored how contextualized problems affect student performance and motivation, they haven't paid enough attention to the role of metacognition, specifically the student's experience of using these thinking strategies.

The prevailing idea is that positive metacognitive experiences, where students feel confident and in control of their learning strategies, can significantly impact how they use their knowledge. This suggests that fostering these experiences, such as teaching students how to reflect on their problem-solving process and choose appropriate strategies, could be crucial for success in applying physics knowledge in different contexts and ultimately increase their enjoyment of problem-solving.

3.2 Utility of pictures, diagrams or scratchwork in problem-solving

The study also investigated the change in the perception of students on how useful pictures, diagrams, or scratchwork were when solving physics problems.

These indicators suggest a strong positive attitude towards using visual aids like pictures, diagrams, and scratchwork in physics problem-solving.

All the indicators highlight a frequent use of these tools, regardless of the question format (multiple choice or open ended) or potential credit for them (question 18). This demonstrates a belief in the overall usefulness of these visuals for problem-solving, not just for points.

The student likely finds these visuals helpful in the initial stages of understanding the problem (question 15). Visualizing the situation can clarify relationships between objects and forces, which can be particularly helpful in physics.

Furthermore, using scratchwork (question 19) suggests a comfort level with actively working through the problem on paper. This can involve calculations, exploring different approaches, or simply jotting down ideas. Overall, these indicators suggest a student who leverages the power of visual aids and actively engages with the problem-solving process.

Table 6. ***Summary of responses on utility of pictures, diagrams or scratchwork in physics problem-solving***

	Mean	Standard Deviation
Before Intervention	3.55	0.77
After Intervention	3.99	0.71

Students' scores on the scale represent how useful they thought the materials were. Students' average perception score was 3.55 (SD = 0.77) prior to the intervention, and it increased to 3.99 (SD = 0.71) following the intervention. This shift implies that, after the intervention, students' perceptions of the value of visual aids in assisting with their understanding and problem-solving of physics have significantly improved. The standard deviation dropped from before to after the intervention, suggesting that students' opinions about the value of visual aids are becoming more uniform. These results suggest that the intervention most likely had a positive impact on improving students' understanding and use of visual aids when solving physics problems.

Table 7. ***Wilcoxon signed-rank test results on utility of pictures, diagrams or scratchwork in physics problem-solving***

Negative Ranks	Positive Ranks	Ties	Asymp. Sig (2-Tailed)	Z-score
7	25	6	0.001	-3.327

Further evidence for this assumption comes from the corresponding results of the Wilcoxon signed rank test, which show 7 negative ranks (a decrease in scores), 25 positive ranks (a rise in scores), and 6 ties (no change in scores). A statistically significant change is indicated by the reported Asymptotic Significance (2-Tailed) of 0.001. The statistical significance is further supported by the associated Z-score of -3.327, which indicates that it is unlikely that the observed increase in students' perceptions of the usefulness of visual aids following the intervention happened by accident.

Physics has a reputation for being the most challenging science subject, attracting fewer students compared to other branches. This difficulty stems partly from the way physics is taught. Students grapple with not only complex concepts but also various representations like formulas, equations, and diagrams. On top of that, problem-solving is a core aspect of learning physics, and it's often the area where students struggle the most. In essence, effectively teaching problem-solving skills is crucial for overcoming this hurdle and improving student engagement with physics (Mallari, 2020).

3.3 Perception of problem-solving approach

Table 8. ***Summary of responses on perception of problem-solving approach***

	Mean	Standard Deviation
Before Intervention	2.71	0.33
After Intervention	2.83	0.34

The mean score on their perception of problem-solving approach improved from 2.71 before the intervention to 2.83 after it, despite the fact that the scores were generally low. This suggests that students' perceptions of their approach to solving physics problems have slightly improved. In both cases, the standard deviations point to comparatively little variability around the means, suggesting consistency in the responses from the students.

Table 9. ***Wilcoxon signed-rank test results on perception of problem-solving approach***

Negative Ranks	Positive Ranks	Ties	Asymp. Sig (2-Tailed)	Z-score
12	22	4	0.094	-1.672

Twelve negative ranks (indicating a decline in scores), twenty-two positive ranks (indicating an increase in scores), and four ties (indicating no change in scores) are displayed in the Wilcoxon signed rank test. The observed change in perception of the problem-solving approach following the intervention is not statistically significant at the conventional threshold of $p < 0.05$, according to the asymptotic significance (2-tailed) of 0.094. According to the associated Z-score of -1.672, the observed difference could plausibly result from chance under the null hypothesis.

Individuals with high problem-solving perception tend to be more successful than others in coping with the problems they encounter. (Docktor et al. 2016) have developed the problem-solving steps into five steps, as follows: focusing on the problems, describing them as concepts, planning the solutions, implementing the plans, and evaluating the solutions. The process involves understanding the problem (Meyer et al., 2014), choosing the proper concept, and checking the problem's suitability with the proposed solution (Gunawan et al., 2020). It requires a good understanding of concepts and high-level thinking skills (Hermansyah et al., 2019). The problem-solving steps that the students should understand are as follows: visualizing the problem using the sketch; writing what is known and asked from the questions; simplifying the situation with the use of specific mathematical variables or a required concept; finding the relationship between the equations (formula) and available data and information; solving the questions by using the formula; and rechecking all steps of problem-solving to see the accuracy and suitability of the answers to the questions (Melawati et al., 2022).

3.4 General expert-novice differences in problem-solving

Table 10. *Summary of responses in general expert-novice differences in physics problem-solving*

	Mean	Standard Deviation
Before Intervention	3.63	0.45
After Intervention	3.72	0.47

After the intervention, the mean score for general expert-novice differences in physics problem-solving went up from 3.63 to 3.72. This suggests that students' ability to distinguish between expert and novice approaches to problem-solving has somewhat improved. There appears to be a moderate degree of agreement among students, as indicated by the standard deviations, which indicate relatively consistent responses around the mean in both conditions.

Table 11. *Wilcoxon signed-rank test results on general expert-novice differences in physics problem-solving*

Negative Ranks	Positive Ranks	Ties	Asymp. Sig (2-Tailed)	Z-score
12	21	5	0.174	-1.359

The Wilcoxon signed rank test results show 12 negative ranks, which correspond to lower scores, 21 positive ranks, which correspond to higher scores, and 5 ties, which correspond to scores that remain unchanged. The observed change is not statistically significant at the traditional threshold of $p < 0.05$, according to the asymptotic significance (2-tailed) of 0.174. This result is corroborated by the associated Z-score of -1.359, which indicates that the observed variation in expert-novice differences in problem-solving may have been accounted for by chance.

In the Randles and Overton's study (2015) experts evaluated their solution during and at the end of the process whereas undergraduate students engaged in an evaluation of the solution at the end. In addition, experts engaged in more evaluation than undergraduate students did. In other words, evaluating the process of solution and the end product are more likely to be related to being an expert.As Randle and Overton (2015) stated, expert problem solvers are able to develop a strategy and apply a logical approach when they face with a problem. Those types of strategies used by experts should be implemented by teachers in class while solving a problem. Studies that compare expert and novice problem solvers reveal that although there are major differences in the way they solve problems, these distinctions can be blurred as novice problem solvers can behave like experts in certain situations (Leak et al., 2017).

3.5 Difficulty in solving problems symbolically

The study assessed students' perceptions of difficulty in solving problems symbolically using descriptive statistics and the Wilcoxon signed rank test.

Table 12. ***Summary of responses on difficulty in solving problems symbolically***

	Mean	Standard Deviation
Before Intervention	2.53	0.70
After Intervention	2.80	0.74

Before the intervention, students reported an average difficulty score of 2.53 (SD = 0.70), which increased slightly to 2.80 (SD = 0.74) after the intervention. This indicates that, on average, students perceived symbolic problem-solving as somewhat more challenging prior to the intervention. The standard deviations suggest moderate variability in responses around these mean scores.

Table 13. ***Wilcoxon signed-rank test results on difficulty in solving problems symbolically***

Negative Ranks	Positive Ranks	Ties	Asymp. Sig (2-Tailed)	Z-score
9	16	13	0.045	-2.001

After additional data analysis using the Wilcoxon signed rank test, the results showed that there were nine negative ranks (which indicated lower scores), sixteen positive ranks (which indicated higher scores), and thirteen ties (which showed no change). Asymptotic Significance (2-Tailed) = 0.045 indicates statistical significance at the conventional significance level ($p < 0.05$) for the observed change in difficulty perception following the intervention. According to the associated Z-score of -2.001, which also supports this finding, the improvement in students' perceptions of the difficulty of solving problems symbolically was probably significantly impacted by the intervention.

However, according from the study of Umrotul,. et al 2022, the results revealed that students have difficulties addressing kinematics problems in both representations, however problem solving in symbolic representations is more challenging than in numeric representations. Furthermore, using a mix of symbolic representations, such as numbers, variables, and operations, can challenge students to think more abstractly and reinforce the conceptual understanding students gain from working with diverse problem-solving. (Chan., et al 2022). This approach can help students develop a deeper understanding of the underlying mathematical principles, rather than just memorizing procedures for solving specific problem types.

3.6 Problem-solving confidence

Table 14. ***Summary of responses on problem-solving confidence***

	Mean	Standard Deviation
Before Intervention	3.01	0.51
After Intervention	3.21	0.36

After the intervention, students' confidence in their ability to solve problems increased to a mean score of 3.21 from 3.01 prior to the intervention. This shows that after the intervention, students' confidence in their ability to solve problems increased on average. The standard deviation decreased from 0.51 before the intervention to 0.36 afterward, indicating a decrease in the variability of students' confidence levels and a more consistent increase in confidence following the intervention.

Table 15. ***Wilcoxon signed-rank test result on problem-solving confidence***

Negative Ranks	Positive Ranks	Ties	Asymp. Sig (2-Tailed)	Z-score
8	20	10	0.053	-1.935

The reported Asymptotic Significance (2-Tailed) value is 0.053, indicating that the observed change in confidence following the intervention is approaching statistical significance but falls short of the traditional threshold of $p < 0.05$. With an associated Z-score of -1.935, it can be inferred that the observed change in confidence is less than two standard deviations from the expected value.
The use of new intervention in improving mathematical problem-solving ability of students showed a significant impact towards their confidence. (Simamora., et al 2018) In addition, according from the study of Ningrum., et al 2023, the used a strategic approach in creating cooperative model improved students' self-confidence and mathematical problem-solving abilities. Self-confidence enables students to tackle challenges without hesitation, allowing them to find the best possible solution.

3.7 Sense-making

The indicators included in the AAPS indicate a limited approach to problem-solving in physics. The first statement (question 2) reflects an understanding that simplifying assumptions can be useful, but it doesn't show a strong emphasis on understanding the impact of those approximations.
The second statement (question 3) prioritizes mathematical manipulation over conceptual understanding. Physics isn't just about applying formulas; it's about using them to represent real-world phenomena.
The third statement (question 5) suggests a memorization-based approach, where the focus is on finding the right formula rather than understanding the underlying physics.
The last statement (question 16) highlights a disconnect between qualitative (conceptual) and quantitative (mathematical) aspects of physics. Trusting "gut feeling" for conceptual questions suggests a lack of confidence in applying physics principles to explain those concepts.
Overall, these indicators suggest a student who might be successful in plugging numbers into equations but struggles with the deeper understanding of why those equations work and how they connect to the real world.

Table 16. ***Summary of responses on sense-making***

	Mean	Standard Deviation
Before Intervention	2.42	0.47
After Intervention	2.47	0.54

The students' mean score in sense-making improved slightly from 2.42 to 2.47 following the intervention. This suggests that, generally speaking, students' sense-making skills have improved somewhat as a result of the intervention. The responses around these mean scores appear to be moderately variable, with a slightly greater variability seen following the intervention (SD=0.54) than before (SD=0.47).

Table 17. ***Wilcoxon signed-rank test result on sense-making***

Negative Ranks	Positive Ranks	Ties	Asymp. Sig (2-Tailed)	Z-score
13	14	11	0.951	-0.061

According to the reported Asymptotic Significance (2-Tailed) of 0.951, the observed alteration in sense-making subsequent to the intervention is not statistically significant at the standard significance level of $p < 0.05$. The corresponding Z-score, which is nearly zero, indicates that the observed shift in sense-making is within the range that would be predicted by chance.

With the shift of the values on Table 17 on the Wilcoxon signed-ranked test result on sense-making, it coincides with the study of (Schoenfeld, 2016) which states that the traditional view sees mathematics as a static body of knowledge with clear rules and procedures to memorize. Learning here is like building a wall, one brick (fact or procedure) at a time. This approach often leads students to focus on memorizing formulas and rote procedures for solving problems, without a deeper understanding of the underlying concepts.

The modern approach, however, views mathematics as a dynamic subject for making sense of the world. Here, the focus shifts to students actively exploring patterns, formulating conjectures, and seeking solutions, not just answers. This aligns with the idea that students should be empowered to "speak the language" of mathematics, not just follow pre-defined rules.

3.8 Problem-solving sophistication

On the other indicators found on this factor, question 9 suggests a somewhat limited approach. While it's valuable to have a foundational method for solving problems of a certain type, a sophisticated problem solver can adapt their approach to different situations. Recognizing the underlying principles and being flexible in applying them is a key aspect of sophistication.

However, the other statements indicate positive aspects. Prioritizing understanding the mathematics behind the problem solving (question 3) is a strength, as it allows for deeper analysis and application of concepts.

Reflecting on problem solutions (question 20) is another sign of sophistication. Analyzing not just the answer but also the process fosters a deeper understanding and identifies areas for improvement.

Finally, learning from mistakes (question 25) is crucial for any effective problem solver. Sophisticated problem solvers view mistakes as opportunities to learn and improve their approach.

Overall, while there's an indication of prioritizing formulas (statement two), the focus on understanding the math, reflecting on solutions, and learning from mistakes are positive signs of developing problem-solving sophistication.

Table 18. ***Summary of responses on problem-solving sophistication***

	Mean	Standard Deviation
Before Intervention	3.17	0.49
After Intervention	3.25	0.37

After the intervention, the mean problem-solving sophistication score went from 3.17 to 3.25, indicating a slight increase. This indicates that after the intervention, students' problem-solving sophistication improved somewhat on average. The standard deviation dropped from 0.49 before the intervention to 0.37 after it, indicating a decrease in response variability from the students and a more steady improvement in sophistication following it.

Table 19. ***Wilcoxon signed-rank test result on problem-solving sophistication***

Negative Ranks	Positive Ranks	Ties	Asymp. Sig (2-Tailed)	Z-score
12	17	9	0.346	-0.942

At the traditional significance level of $p < 0.05$, the observed change in problem-solving sophistication following the intervention is not statistically significant, according to the reported Asymptotic Significance (2-Tailed) of 0.346. The corresponding Z-score is -0.942, indicating that the observed shift in sophistication falls within the probability range.

The key idea is that by focusing on repetitive exercises with a single "correct" solution method, students get the impression that math is about memorizing and applying pre-defined formulas. This creates a passive learning style where students wait to be shown the answer rather than actively seeking their own solutions.

This approach hinders the development of problem sophistication. Sophisticated problem solvers are adept at not just finding answers, but also understanding the underlying concepts and exploring alternative approaches. They are comfortable with ambiguity and willing to experiment with different methods.

By contrast, the study encourages a "one-size-fits-all" mentality, where students are discouraged from independently exploring or questioning the presented method. This can lead to a lack of confidence and a limited understanding of the subject matter (Schoenfeld, 2016).

Generally, it cannot be said that one problem-solving strategy is better than the others (Naumann, 2019), however problem-solving patterns and strategies are closely related to problem-solving proficiency (Park, 2022). Therefore, providing a stepwise guide or a scaffold can greatly improve the students' ability to solve problems (Arifin et. al, 2020). Along with this, the use of guiding questions also helps students form structure, training them to delve into conceptual analysis: identifying underlying connections usually observed in experts (Wakhata, et. al, 2022) as compared to the "plug-and-chug" approach that often leads to difficulties because it bypasses a deeper understanding of the concepts at play (Balta, 2019).

A study found that students' perception of themselves (self-concept) strongly impacts their attitude towards solving algebraic problems (ATPS), but in a negative way. In other words, students with a lower self-concept tend to have a worse attitude towards tackling these problems. Interestingly, the study also showed that strong problem-solving skills have a positive influence on ATPS, but these skills aren't directly linked to self-concept. This suggests that a student's outlook and confidence, not just their ability, determine their approach to algebraic problems. Therefore, teachers and parents should focus on building a positive self-concept in students. This can boost their confidence and make them more interested in problem-solving. Additionally, schools and the Department of Education could work together to organize math competitions focused on algebraic problem-solving. These competitions, both within and between schools, can further build confidence and encourage students to tackle challenges independently (Julius, 2022).

The difference in the attitudes and approaches of students in solving physics problems before and after the intervention can be observed in Tables 4– 19. The results obtained from the AAPS survey through the analysis of the Wilcoxon signed-rank test results revealed that the intervention made a significant difference in terms of the attitude and approach on physics problem solving skills of the students. Nurturing a positive learning environment is crucial for students to excel in physics problem-solving. This environment fosters a growth mindset, where students see challenges as opportunities to learn and improve. By encouraging a positive approach to knowledge acquisition, students become more confident and effective problem-solvers (Reddy, 2019).

4. Conclusion and Recommendations

The results of this study indicate the positive effect of using stepwise guide questions in improving attitudes and approaches of students towards solving physics problems. The intervention resulted in the increase in the mean of all the summary of responses and the z-value of the different criteria. This implies the positive effect of the intervention on the attitudes students have regarding problem solving as referenced by the result of the conducted AAPS before and after the implementation of the intervention. The calculated result is but inconclusive, it could suggest a possible program to address the problem on problem-solving asimplied by the weakness identified using the NAT G12 for SY 2022-2023. On the other hand, using the AAPS survey the significant change in the attitudes and approaches of the participants, this indicates that students excelling better with the intervention the use of stepwise guide questions in solving physics problems, is effective and therefore, could be adopted in the classroom.
The positive results of this study on a sample indicates the possibility of a good result when adopted to the population. Therefore, the researchers suggest that the intervention analyzed in the study be applied on subjects with problem-solving aspects like Science, Math, English and Social Science. This could be a good way to train the students in adopting a systematic approach to address problem-solving.
For the students, the results of this study indicates that the scaffolding technique employed which is stepwise guided questioning is an effective strategy in improving problem solving skills and could be use in mastering subjects that involve problem solving.
For future researchers, further study on the effect of the intervention on academic performance should be studied to draw up quantitative conclusion on its possible impact on the students.

Acknowledgment

The researchers would like to extend their gratitude to the Grade 12 STEM students and the Faculty, Staff and Administrators of the University of La Salette, Incorporated, High School Department.

References

1. Arifin, Sujinal & Zulkardi, Zulkardi & Indra Putri, Ratu & Hartono, Yusuf & Susanti, Elly. (2020). *Scaffolding in mathematical problem-solving.* Journal of Physics: Conference Series. 1480. 012054. 10.1088/1742-6596/1480/1/012054.
2. Balta, N., & Asikainen, M. (2019). *Introductory students' attitudes and approaches to physics problem solving: Major, achievement level and gender differences.* Journal of Technology and Science Education, 9(3), 378. https://doi.org/10.3926/jotse.666

3. The Bureau of Education Assessment (BEA). (2023). *National Achievement Test for Grade 12 (NAT G12) Primer.* BEA-Education Assessment Division. Retrieved from: https://drive.google.com/file/d/1yN4IgmdGaIW3vgB9DIkuiec--qe9isXK/view
4. Chan, J. Y., Ottmar, E. R., Smith, H., & Closser, A. H. (2022). *Variables versus numbers: Effects of symbols and algebraic knowledge on students' problem-solving strategies.* Contemporary Educational Psychology, 71, 102114. https://doi.org/10.1016/j.cedpsych.2022.102114
5. Conover, W. J. (1999). *Practical Nonparametric Statistics.* John Wiley & Sons.
6. Gunawan, H. A., Nisyah, M., Kusdiastuti, M., and Herayanti, L. (2020). *Improving students' problem-solving skills using inquiry learning model combined with advance organizer.* Int. J. Instr. 13, 427–442. doi: 10.29333/iji.2020.13427a
7. Hermansyah, H., Gunawan, G., Harjono, A., and Adawiyah, A. (2019). *Guided inquiry model with virtual labs to improve students understanding on heat concept.* J. Phys. Conf. Ser. 1153:012116. doi: 10.1088/1742-6596/1153/1/012116
8. Hmelo-Silver, C. E. (2004). *Problem-Based learning: What and how do students learn?* Educational Psychology Review, 16(3), 235–266. https://doi.org/10.1023/b:edpr.0000034022.16470.f3
9. Ince, E. (2018, May 15). *An Overview of Problem Solving Studies in Physics Education.* Retrieved from https://files.eric.ed.gov/fulltext/EJ1179603.pdf
10. Jonassen, D. H. (2010). *Learning to solve problems.* In Routledge eBooks. https://doi.org/10.4324/9780203847527.
11. Julius, E. (2022). *The relationship between self-concept and problem-solving skills on students' attitude towards solving algebraic problems.* Contemporary Mathematics and Science Education, 3(2), ep22020. doi:10.30935/conmaths/12509
12. Kojo, A., Laine, A., & Näveri, L. (2018). *How did you solve it? – Teachers' approaches to guiding mathematics problem solving.* LUMAT: International Journal on Math, Science and Technology Education, 6(1), 22–40. https://doi.org/10.31129/LUMAT.6.1.294
13. Leak, A. E., Rothwell, S. L., Olivera, J., Zwickl, B., Vosburg, J., & Martin, K. (2016, November 30). *Examining Problem Solving in Physics-Intensive Ph.D. Research.* Retrieved from https://eric.ed.gov/?id=EJ1150440
14. Mason, Andrew & Singh, Chandralekha. (2016). *Surveying college introductory physics students' attitudes and approaches to problem solving.* European Journal of Physics. 37. 055704. 10.1088/0143-0807/37/5/055704.
15. Marsden, Emma & Torgerson, Carole. (2012). *Single group, pre-post test research designs: Some methodological concerns..* Oxford Review of Education. 38. 583-616. 10.2307/41702779.
16. Meyer, E. F., Falkner, N., Sooriamurthi, R., and Michalewicz, Z. (2014). *"Understanding the problem" in Guide to Teaching Puzzle-based Learning.* ed. W. Wheeler (Springer).
17. Naumann J. (2019). *The Skilled, the Knowledgeable, and the Motivated: Investigating the Strategic Allocation of Time on Task in a Computer-Based Assessment.* Front Psychol. 2019 Jun 27;10:1429. doi: 10.3389/fpsyg.2019.01429. PMID: 31379637; PMCID: PMC6660318.
18. Nikat, Rikardus Feribertus & Henukh, Anderias & Simbolon, Meiana & Reski, Andi & Sari, Dela. (2020). *Scaffolding computer packet instruction (SCPI) to analyze student's problem solving performance on physics.* Journal of Physics: Conference Series. 1569. 042084. 10.1088/1742-6596/1569/4/042084.

19. Ningrum, S. A., & Rejeki, S. (2023). *Improving students' self-confidence and problem-solving ability through RME approach with TTW type cooperative learning model setting.* Numerical: Jurnal Matematika dan Pendidikan Matematika, 7(1), 145-156. https://doi.org/10.25217/numerical.v7i1.3093
20. Park, M. (2021). *How do students use equations when solving conceptual physics questions?* Proceedings of the 2021 AERA Annual Meeting. https://doi.org/10.3102/1680179
21. Pozas, M., Löffler, P., Schnotz, W. & Kauertz, A. (2020). *The Effects of Context-based Problem-solving Tasks on Students' Interest and Metacognitive Experiences.* Open Education Studies, 2(1), 112-125. https://doi.org/10.1515/edu-2020-0118
22. Reddy, L. (2019). *Student's attitude and approaches to problem solving in physics at a South African university.* INTED2019 Proceedings. doi:10.21125/inted.2019.0259
23. Replinger, J. (2020, June 12). *A simple way to scaffold physics.* Edutopia. https://www.edutopia.org/article/simple-way-scaffold-physics?fbclid=IwZXh0bgNhZW0CMTAAAR3c0ntL4o7oMseoTktqGanD99kEGhNMX7d3Ft9BeUpDD5pCmz_WZ0CaDpg_aem_SyqCnLS6Fxa9CxWRcFA6fA
24. Saman, Muhammad, Koes-Handayanto, Supriyono & Sunaryono, Sunaryono. (2018). *Procedural E-scaffolding in improving students' physics problem-solving skills.* Unnes Science Education Journal. 7. 10.15294/usej.v7i2.23290.
25. Simamora, R. E., Saragih, S., & Hasratuddin, H. (2018). *Improving students' mathematical problem solving ability and self-efficacy through guided discovery learning in local culture context.* International Electronic Journal of Mathematics Education, 14(1). https://doi.org/10.12973/iejme/3966
26. Schoenfeld, A. H. (2016, April). *Learning to Think Mathematically: Problem Solving, Metacognition, and Sense Making in Mathematics.* Journal of Education, 196(2), 1-38
27. Umrotul, U., Jewaru, A. A., Kusairi, S., & Pramono, N. A. (2022). *The ability to solve physics problems in symbolic and numeric representations.* Revista Mexicana de Física E, 19(1 Jan-Jun). https://doi.org/10.31349/revmexfise.19.010209
28. Vygotsky, L. S. (1978). *Mind in Society: the Development of Higher Psychological Processes.* Cambridge, MA: Harvard University Press.
29. Wakhata, R., Balimuttajjo, S., & Mutarutinya, V. (2022). *Relationship between Students' Attitude towards, and Performance in Mathematics Word Problems.* bioRxiv. https://doi.org/10.1101/2022.11.21.517411