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Problem-Based Learning Approach in Developing Mathematical Skills

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Abstract

Many students perceive mathematics as an abstract because it involves development of problem-solving skills. This study employed problem-based learning (PBL) approach to make simple strategies in the teaching and learning process. This study used descriptive-correlational research method. For the school year 2020-2021, 40 Grade 9 students from Calamba City Science High School took the validated adapted-modified three-item examination and answered a researcher-made survey questionnaire. The results showed no significant relationship between respondents' perceptions of problem-based learning in terms of authentic problem, collaboration, developing expertise, and authentic assessment, and their problem-solving performance in terms of conceptualizing the problem, devising a strategy, implementing the strategy, and reflecting on the solution. The study affirms that the teacher's expertise in implementing the PBL approach is critical. Further results imply that the learning abilities and techniques of the students have significant impact to the teaching-learning process.

Keywords: *students' perception, authentic problems, collaboration, developing expertise, authenthic assessment, problem-solving skills*

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1. Introduction

Mathematics is widely seen as an abstract idea to be studied (Fritz, 2019). Most of the times, many people believe that "it is okay" not to be like math because "not everyone can be a math genius" (Rattan, 2012). These concepts of the subject lead to the bad interest and fear of the students in learning mathematics. With the preconceived notion, students emerge disengaged, uninterested and demotivated to face and study numerical subjects.

Studies show that the students' perception of mathematics as a difficult subject posed extreme consequences resulting to failure and dropping out from school (Fhloinn et al., 2014). Many students develop a mental anguish on mathematics which hamper their performance. The extreme consequences of the wrong perception seriously challenge the students in most of the subjects with numerical contents. While most of the students associate mathematics as irrelevant to their personal and professional life, many scientific and technological sectors rely heavily on mathematics. According to Li and Scoenfeld (2019), learning mathematics opens more opportunities for students when finding jobs and chasing after their careers. Without math, the world would misplace the key component to its composition (Schuster, 2016).

Mathematicians have always considered problem solving as the center of the discipline because without problem solving there is no mathematics (Klerlein & Hervey, 2017). Problem-solving has been at the center of educational theory (Pólya, 1945) which illustrates mathematics as not similar to sports. For the students to understand mathematics, they must try to do it. It means to be able to solve mathematical problems, they must try to solve it (O'Brien et al., 2011).

In learning mathematics, the use of real-world problem solving can assist people to be familiar with managing and handling daily occurrences. In the same way, the use of authentic problems in the teaching and learning can build students' real world problems solving skills. This is the exact concept of the problem-based learning (PBL). The PBL is an instructional style that provides students with the tools to solve problems using real-world scenarios. It begins with an unstructured challenge for students to solve. Afterwards, students identify information they already know from the data they need to learn in order to find a solution after investigating the situation. Students as learners, educators as guides, and the problem as the setting are the three main components of this method (Carrió et al., 2011).

The importance of problem solving in mathematics education was induced this study, which sought to investigate the correlation between students' problem-solving skills and their use

of the PBL approach. The four principles of problem solving by Polya (1945), which includes understand and explore the problem, find a strategy, use the strategy to solve the problem and look back and reflect on the solution as well as the four elements of PBL Approach in classroom including authentic problems, collaboration, developing expertise, and authentic assessment were considered. The study specifically looked into the relationship between the four elements of PBL and the learners' problem-solving skills.

2. Literature Review

2.1 Problem-Based Learning Approach

PBL is an effective heuristic teaching method that enlightens the development of student autonomy through collaboration between students and lecturers, as well as among students. It is a student-centered instructional model that places learning in a real-world problem-solving environment, and it has been used as an experimental teaching tool in medical schools and some technology courses for decades (Yin et al., 2021). The four elements of PBL include authentic problems, collaboration, developing expertise and authentic assessment (Mills & Tuesday, 2017).

Authentic Problems. According to Mills and Tuesday (2017), within the real world, students experience problems that are complex, not well characterized, and need a clear solution and approach. They ought to be able to identify and apply distinctive methodologies to solve these problems. Be that as it may, problem solving abilities do not essentially create actually; they have to be an unequivocally instructed in a way that can be exchanged across multiple settings and contexts.

Collaboration. The autonomous evolution of students can only be accomplished by heuristic instruction. Heuristic teaching entails active intellectual interaction with the aim of improving students' fundamental skills. PBL is an effective heuristic teaching method that enlightens the development of student autonomy through collaboration between students and lecturers, as well as among students. With a focus on cooperation, PBL provides a period of identifying the problem statement, independent analysis, group discussion, and presentation of a problem-solving plan, as well as reflection (Yin et al., 2021).

Developing Expertise. Expertise is a process of continuous reinvestment of relevant discipline-based expertise and skills, according to Sammamish Collaboration (2015), to build increasingly higher levels of knowledge and problem solving skills. Learning expertise includes

awareness and skills in content, practice in education and learning, and access to the social and cultural capital that exists within a culture.

Authentic assessment. Authentic assessment seeks to emulate the tasks and performance expectations usually found in the world of work and has been found to have a positive effect on student learning, autonomy, motivation, self-regulation and metacognition; highly employability-related skills. The lack of conceptualization of the term authentic evaluation that is sufficient to inform evaluation design at the individual course level may be one challenge (Koçyiğit, 2011).

2.2 Problem- Solving Skills

As stated by Vettleson (2010), "i*n the discipline of mathematics, the use of problem solving skills has been extremely important and highly influential. Problem solving is the foundation of all mathematical and scientific discoveries.*" There is a very large impact in the fields of mathematics utilizing problem solving skills. According to Dahar (2011), "*the ability to solve a problem is basically the main purpose of the educational process*." It is really important to solve math problems so that the general objective of teaching mathematics, even as the center of mathematics, is more important than the method and, as a result, the emphasis of school mathematics and aims to help improve mathematical thought. The four principles of problem solving includes understand and explore the problem, find a strategy, use the strategy to solve the problem and look back and reflect on the solution.

Understanding the Problem. According to Vula and Kurshunmlia (2015), the problem-solving difficulties of students can be solved by different methods and practices. The comprehension of the problem, particularly the terms that are used in some problems, is a particular part of solving word problems. Not knowing such words poses the difficulties of solving word problems, allowing sufficient mathematical operations to be misapplied. In addition, if learners understand the definition of vocabulary, they can easily learn mathematical concepts and improve the requisite math skills.

Find a Strategy. According to Polya (1945), one of the most important factors in solving a problem is determining the right strategy. Estimation, systematic list, finding similarities, drawing diagrams, writing equations or inequalities are among the most problematic problem-solving methods, allowing easy use of solutions to similar problems with retrospection and judging by tables (Ersoy & Güner, 2014). In this regard, the focus is placed on coping with

cognitive, emotional and behavioral problem-solving skills in order to assess the most suitable approach and collect knowledge about the problems (Tüysüz, 2013).

Applying the Strategy. At this level, teachers help learners acquire 4C skills through networking and design thinking (critical thinking, innovation, communication, and collaboration). This, at the same time, helps learners to collaboratively accomplish goals (Zsuzsanna et al., 2020). According to Lein et al. (2020), intervention results for schema-based transfer instruction were greater than those for schema-based instruction. The use of schema wherever possible, demonstrating that mathematical word-problem-solving approaches are often appropriate for students with learning disabilities and/or mathematical difficulties.

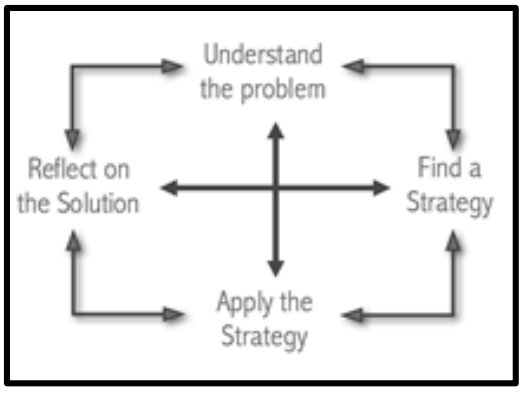
Reflecting on the Solution. Hung and Seokhee (2018) assert that any idea or solution gained by students through independent internalization will remain in the long term as an active part of their knowledge and mathematical arguing. Evaluation, consideration, and feedback help all problem solving methods. The solution does not work for everyone, may cause new issues, or may be so efficient. None of that is possible without taking the time to analyze and, if necessary, change the success of the solution generated in the problem solving model (Smart, 2020).

2.3 Theoretical Framework

According to Klerlein and Hervey (2017), a successful instructor models positive problem-solving behaviors for their students. Their questions are intended to assist children in solving problems using a range of techniques and resources. Without a strategy in mind, students sometimes want to begin. The instructor gives students some structure to start the problem without telling them exactly what to do, through necessary questions. The following four problem-solving principles by Pólya (1945) help teachers help their students.

Figure 1

Pólya's principles of problem-solving



In accordance with this model, there are considerations for using PBL. Rather than teaching relevant material and subsequently having students apply the knowledge to solve problems, the problem is presented first. PBL assignments can be short, or they can take a whole semester and be more active. Students generally must: examine and define the problem; explore what they already know about underlying issues related to it; determine what they need to learn and where they can acquire the information and tools necessary to solve the problem; evaluate possible ways to solve the problem; solve the problem and report on their findings (Nilson, 2010).

PBL is fundamentally based on constructivist assumptions about learning. Constructivism is defined by five tenets concerning knowledge, meaning making, and learning (Jonassen, 1991). Constructivism in education has its roots in epistemology, which is a theory of knowledge in philosophy that is concerned with the logical categories of knowledge and their justification (Steffe & Gale, 2012). According to Zhang (2012), two major types of constructivism have been valued in educational fields over the years of evolution of constructivism. They are cognitive constructivism, which is based on Jean Piaget's learning theory (1972), and social constructivism, which is based on Vygotsky's theory that is part of scaffolding learning theory (1978).

3. Methodology

This study utilized descriptive-correlational research design. This study adapted a descriptive and correlational research design to examined the relationship of the implementation of a problem-based learning approach and the students' performance towards their problem solving skills. Descriptive research design is a scientific method that entails examining and describing a subject's behavior without affecting it in any manner. The major purpose of a descriptive correlational study is to characterize links between variables rather than attempting to establish a causal link (Katzukov, 2020).

The respondents were composed of 40 Grade 9 students from Calamba City Science High School in the Philippines. The random sampling was used to give each student an equal probability of being chosen. According to Thomas (2020), each member of the population has an exact equal chance of being chosen using this sampling method.

The research instruments involved the researcher-created exam that assessed the pupils' problem-solving skills as well as a series of survey questionnaire checklists designed to evaluate

the pupils' perceptions of the problem-based learning strategy. The examination, a three-item test utilized the principle of *problem solving* and that was guided with designated Most Essential Learning Competency (MELC). This tool examined the impact of the implementation of the problem-based learning approach as well as the application of the different steps while answering an authentic problem. On the other hand, the survey questionnaire contained the 4 key elements of problem-based learning approach. It is a 5-point Likert scale developed to measure and to explore the problem solving skills of the students through the implementation of the teaching approach.

The instruments passed the metric for determining internal consistency before it was actually used. The Cronbach's alpha is a metric for determining the internal consistency or dependability of a set of scale or test items. The reliability refers to how constant it is in measuring a notion measured through Cronbach's alpha (Goforth, 2015). It accepts numbers from 0 to 1, with 1 denoting total inner precision. In addition, Cronbach alpha levels of less than 0.7 indicate adequate inner accuracy (Taber, 2017). The instrument's test of internal consistency is presented in Table 1.

Table 1

Cronbach's alpha

Subscale	No. of Items	Cronbach's Alpha
Problem-based Learning Approach		
Authentic Problem	5	.953
Collaboration	9	.792
Developing Expertise	5	.838
Authentic Assessment	5	.910

The table reveals that the Cronbach's Alpha result for all sub-variables is greater than .70, indicating that the given items in each of the independent variable's components are all internally consistent from acceptable to very good level with .80 or greater.

Descriptive statistics was used to describe the problem-based learning of Grade 9 students with authentic problems, collaborate, developing expertise, academic discourse and authentic assessment on the variables and descriptors set in the study. Frequency and percentages were used in response to the presentation of descriptive data on the examination on problem-solving skills assessment. Spearman's Rho correlation was used to test the significant

relationship between the problem-based learning approach and the students' problem-solving skills.

4. Findings and Discussion

Table 2

Students' Perception towards Authentic Problems Element of PBL

Indicators	Mean	SD	Interpretation
Being exposed to Problem Based Approach…			
1. helps me be familiarized on provided word problems.	4.55	0.55	Strongly Agree
2. makes me competent to solve the word problems given.	4.40	0.67	Agree
3. aids me to relate condition in the problem to real life contexts.	4.33	0.73	Agree
4. provides me detailed evidences of authentic situations from the problems.	4.38	0.70	Agree
5. helps me associate learnt concept to real practice.	4.40	0.59	Agree
OVERALL	**4.41**	**0.65**	**Agree**

Legend: *4.50-5.00 Strongly Agree/Highly Evident, 3.50-4.49 Agree/Evident, 2.50-3.49 Moderately Agree/Moderately Evident, 1.50-2.49 Disagree/Less Evident, 1.00-1.49 Strongly Disagree/Not Evident*

Table 2 shows the students' perception towards the authentic problems element of the PBL. It has an overall mean of 4.41 with an SD of 0.65 and an interpretation of 'Agree.' This indicates an evident majority of students were exposed to problems that led into more than one viable solution or strategy for a solution that enhanced the students' ability to learn. Results also show that the highest mean of 4.55 among the indicators (*helps me be familiarized on provided word problems*), equates to an assumption that exposure to authentic problems in PBL helps the student be more familiarized with provided problems and they are more likely to answer word problems if they already encountered the given topic. On the other hand, the lowest mean of 4.33 (*aids me to relate condition in the problem to real life contexts*) means an evident indication that if the students are aware of the given problem they become more engage in answering and finding the solution.

The results are parallel to the exact explanation of Gurat (2018) that problems situated in real-life context become more authentic, which students tend to be more appreciative to understand the lesson. Similarly, the results affirm the findings of Lehtinen et al. (2017) on the importance of repeated practice leading to the mastery of the skills.

Table 3

Students' Perception towards Collaboration Element of PBL

Indicators	Mean	SD	Interpretation
Being exposed to Problem Based Approach…			
1. makes me be aware of adapting ideas and strategies in solving problems from my instructor.	4.55	0.64	Strongly Agree
2. I am now able to solve word problems through the interaction with my teacher.	4.38	0.59	Agree
3. I am able to get the idea I want to know through discussing it with my teacher.	4.50	0.60	Strongly Agree
4. My learning ability is developed through work collaboration with my teacher.	4.40	0.71	Agree
5. I can present information, findings and arguments clearly, concisely and logically in the class.	4.13	0.72	Agree
6. I am more confident in engaging in the course discussion.	4.18	0.71	Agree
7. I can develop ideas and uses style appropriate to the purpose and learning tasks.	4.45	0.68	Agree
8. I can clearly address alternatives, opinions and perspectives with confidence and logic.	4.25	0.59	Agree
9. I can speak clearly and participates actively in class discussion.	4.18	0.71	Agree
OVERALL	**4.33**	**0.66**	**Agree**

Legend: *4.50-5.00 Strongly Agree/Highly Evident, 3.50-4.49 Agree/Evident, 2.50-3.49 Moderately Agree/Moderately Evident, 1.50-2.49 Disagree/Less Evident, 1.00-1.49 Strongly Disagree/Not Evident*

Table 3 shows the students' perception towards the collaboration element of the PBL. The overall mean of 4.33 implies that when students are exposed to PBL, teachers can help the students improve their communication and relationship-building abilities. In this case, the constant collaboration with the teacher produces effective results in solving a problem. The results further show that when the students are exposed to PBL, it makes them aware of adapting ideas and strategies in solving problems (4.55) and they are able to get the idea they want to know (4.50).

Through the PBL approach, teacher provides guidance to the students on the necessary steps students need to consider in accomplishing the solutions. This result coincides with the findings of Kojo et al. (2018) and Hähkiöniemi and Francisco (2019). Similarly, the collaboration between the teacher and the students in answering Mathematical problems create positive working connections as explained by Ching (2020) and Arthur et al. (2017).

Table 4

Students' Perception towards Developing Expertise Element of PBL

Indicators	Mean	SD	Interpretation
Being exposed to Problem Based Approach…			
1. helps me enhance my ability to learn.	4.73	0.45	Strongly Agree
2. enhances my critical thinking skills.	4.68	0.53	Strongly Agree
3. improves my strategy in learning.	4.58	0.55	Strongly Agree
4. helps me to enhance my computational skills.	4.48	0.55	Agree
5. ensures mastery of the most essential learning competency.	4.38	0.70	Agree
OVERALL	**4.57**	**0.56**	**Strongly Agree**

Legend: *4.50-5.00 Strongly Agree/Highly Evident, 3.50-4.49 Agree/Evident, 2.50-3.49 Moderately Agree/Moderately Evident, 1.50-2.49 Disagree/Less Evident, 1.00-1.49 Strongly Disagree/Not Evident*

Table 4 shows the students' perception towards the developing expertise element of the PBL. The overall mean of 4.57 (SD=0.56) with an interpretation of 'Strongly Agree' means that exposure to PBL helps students develop their expertise in solving problems through the development of the necessary skills. Among the indicators, the PBL helps students enhance their ability to learn has the highest mean of 4.73 (SD=0.45) while the PBL ensures mastery of the most essential learning competency got the lowest mean of 4.38 (SD=0.70). The results are congruent to the explanation of Hendriana et al. (2018) that problem-based or scenario-based approaches help students develop the skills to become experts in Mathematics.

Table 5

Students' Perception towards Authentic Assessment Element of PBL

Indicators	Mean	SD	Interpretation
Being exposed to Problem Based Approach…			
1. provides learning assessments that establishes my creativity, conciseness and logical ability.	4.45	0.71	Agree
2. allows me to experience answering assessment with high-quality of questions that engage us to solve correctly.	4.40	0.84	Agree
3. helps me think and use different strategies in solving math problems.	4.50	0.60	Strongly Agree
4. provides assessment that are linked to reference for future endeavors.	4.53	0.60	Strongly Agree
5. provides a variety of assessments for me to enhance my problem solving skills.	4.50	0.64	Strongly Agree
OVERALL	**4.48**	**0.68**	**Agree**

Legend: *4.50-5.00 Strongly Agree/Highly Evident, 3.50-4.49 Agree/Evident, 2.50-3.49 Moderately Agree/Moderately Evident, 1.50-2.49 Disagree/Less Evident, 1.00-1.49 Strongly Disagree/Not Evident*

Table 5 shows the students' perception towards the authentic assessment element of the PBL. The overall mean of 4.48 (SD=0.68) explains the ability of the students to complete tasks

in addition to the quality of their work. This is the exact assertion of Koh (2017) that authentic assessment in Mathematics problem solving encourages students to demonstrate their deep comprehension, higher-order thinking, and sophisticated problem solving which would enable learners to understand fully the lessons. The results further show that authentic assessments are linked to reference for future endeavors (M=4.53; SD=0.60). As the PBL requires that the problems in the assessment given to the students are always expressed in real-life applications, the results suggest that students are highly appreciative of the worded problems given to them.

Table 6
Students' Performance under "Understanding the Problem" Principle

Scores	Frequency	Percent	Interpretation
17-21	27	67.5	Advanced
12-16	10	25.0	Proficient
6-11	2	5.0	Developing
0-5	1	2.5	Beginning

Mean= 17.65, SD= 4.16, VI= Advanced
Legend: *17-21 Advanced, 12-16 Proficient, 6-11 Developing, 0-5 Beginning*

Table 6 shows the students' performance in the researcher-made tests reflecting their understanding of the problem. The majority of the students at 67.5% performed in the advanced level while the 25% are in the proficient level. However, there are still three students in the lower levels; 5% under developing and 2.5% under the beginning level.

Since most of the students performed at an advanced level wherein the steps in problem-solving were followed, this implies that students read the problem carefully, analyzed what is the given and what is needed in the given problem. By reading the problem efficiently, it is evident among students who reached the advanced level that they were able to identify effectively what is being asked which guides them to think of potential ways how to solve the problem. This coincides with the explanation of Gurat (2018) that students were able to identify the details needed in the solution as a process of understanding the problem.

Under the advanced level of skill in the principle of understanding the problem, the example in figure 2 clearly demonstrates that the MELC was met. The student clearly enumerates the given in the problem and stated what was being questioned.

Figure 2

Sample Student Response with Highest Score in Understanding the Problem

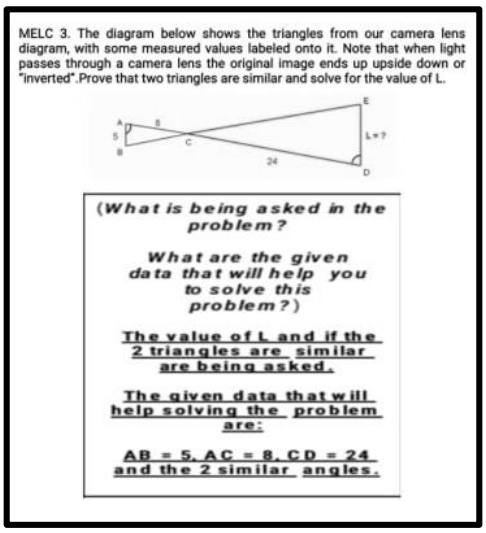


Figure 3 illustrates that student's response demonstrates a poor understanding of the topic and its broader context. This indicates a lack of capacity to demonstrate the key ideas required for a smooth and comprehensive flow of answers and strategies into the following stages of problem-solving.

Figure 3

Sample Student Response with Lowest Score in Understanding the Problem

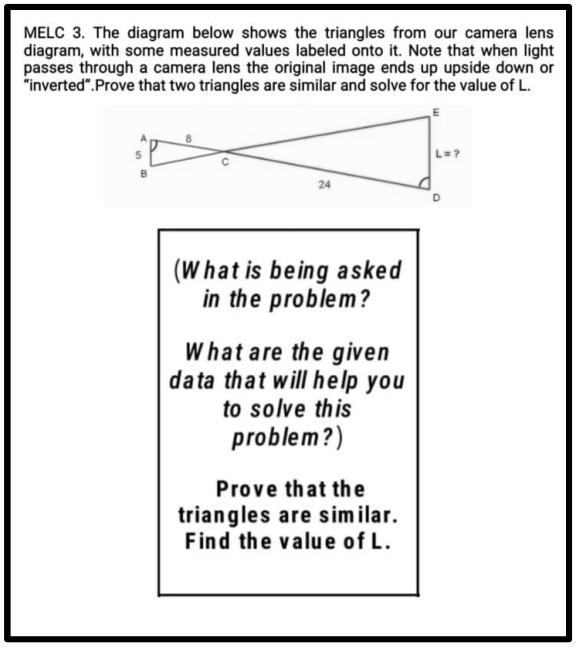


Table 7

Students' Performance under "Finding a Strategy" Principle

Scores	Frequency	Percent	Interpretation
17-21	10	25.0	Advanced
12-16	9	22.5	Proficient
6-11	20	50.0	Developing
0-5	1	2.5	Beginning

Mean= 13.08, SD= 4.70, VI= Proficient
Legend: *17-21 Advanced, 12-16 Proficient, 6-11 Developing, 0-5 Beginning*

As observed in table 7, most of the students are in the developing level (50%) when it comes to finding a strategy to be employed in answering a problem in Mathematics. It means that the students are on progress to device an appropriate plan as to operation to be used and the appropriate way in order to solve the problem. Even though they were able to identify what is being asked and the details needed in the solution for the understanding stage, students find it difficult to plan effectively the necessary steps in solving the problem. However, there are 25% in the advanced level and 22.5% in the proficient level. There is still one student (2.5%) in the beginning level. The results are similar to the findings of Utomo and Syarifah (2021) that students in Mathematics find it difficult to strategize in answering worded problems.

Figure 4

Sample response in Finding Strategy with the highest score

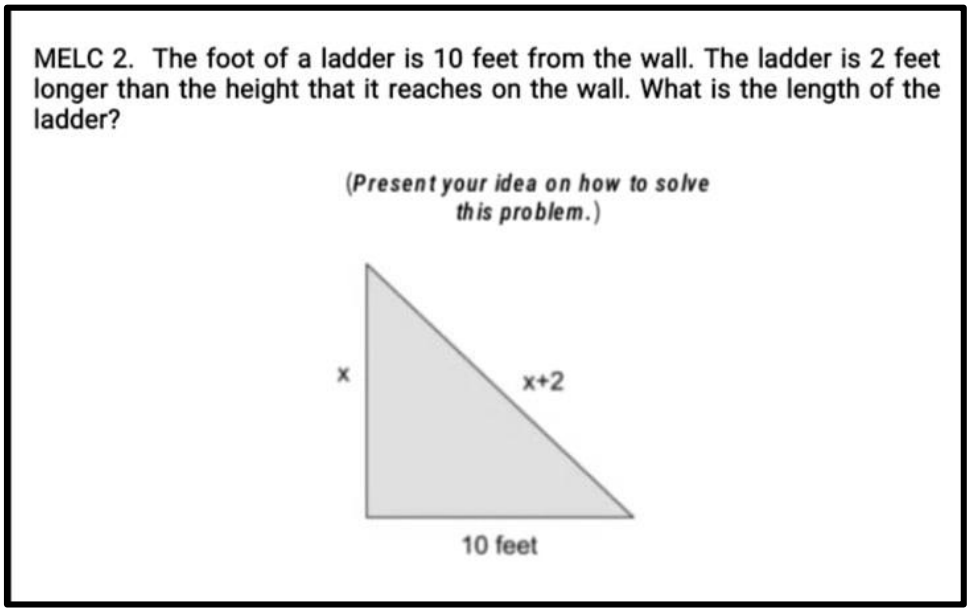
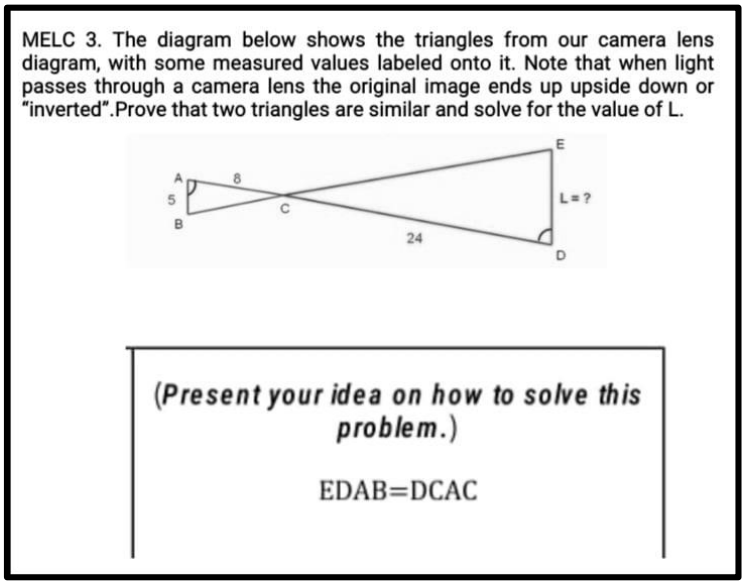


Figure 4 shows an example showing student's strategy with the highest score. Based on student's solution, there is an insufficient description of what should be done after seeing a visual representation of the method. In addition, this implies the need of a broaden and exact explanation of how and what strategy should be utilized for the given problem. This implies that the student can identify a viable strategy especially when keywords are provided and plan is straight forward.

Figure 5

Sample response in Finding Strategy with lowest score



As shown in figure 5, the answer of student is in the beginning level that the student chooses a method without respect to the circumstances in the problem and instead rely on basic phrases or keywords in the problem. It shows a small amount of representation that the two triangles are similar, but it is still insufficient.

Table 8

Students' Performance under "Application of the Strategy" Principle

Scores	Frequency	Percent	Interpretation
17-21	28	70.0	Advanced
12-16	9	22.5	Proficient
6-11	3	7.5	Developing
0-5	-	-	Beginning

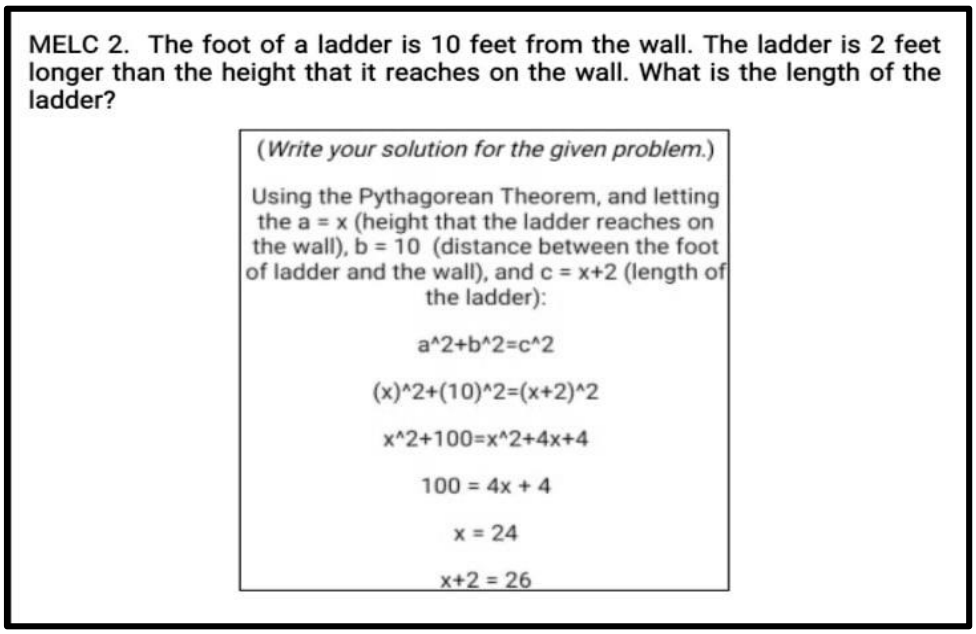
Mean= 17.55, SD= 3.62, VI= Advanced

Legend: *17-21 Advanced, 12-16 Proficient, 6-11 Developing, 0-5 Beginning*

It is depicted in table 8 that most of the students (70%) are in the advanced level in applying the strategy. This shows the students ability for proper execution with complete and clearer flow of the solution. Students were able to apply what they have learned with their teacher in executing an appropriate solution. In this case, students followed the demonstrated solution of the teacher and applied those in the problems that they encountered. This is similar to the explanation of Ng and Dindyal (2016) that students in the advanced level create a pattern to execute the same flow with the same problem-set to be given by the teacher.

Figure 6

Sample response in Applying the Strategy with the highest score



For the highest score shown in figure 6, the result indicates that the learner understands the need for multiple paths to complete the strategy. The ability to reason or think is completely developed. The student was able to carry out plans including multiple processes or steps (including inverse processes) and reliably identify at least one correct or feasible (often creative) solution (s).

Figure 7

Sample response in Applying the Strategy with the lowest score

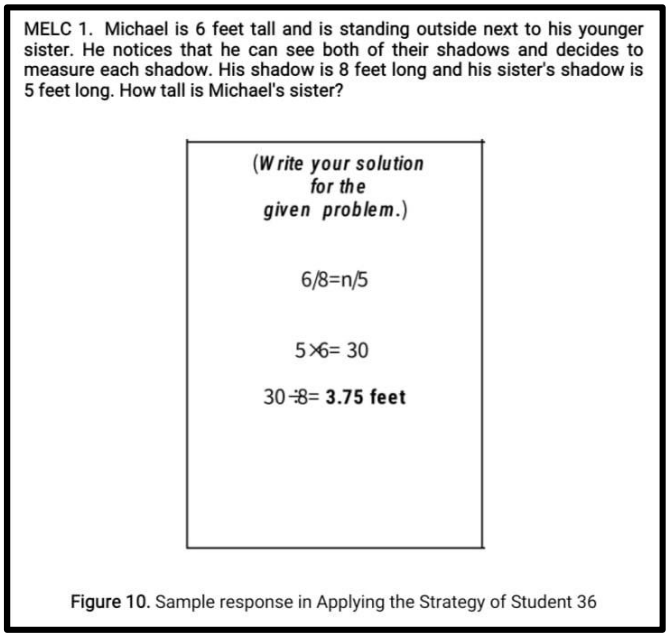


Figure 7 shows a sample with lowest score where the offered solution is incomplete. The learner does not display well-developed thought or reasoning in carrying out the plan at this level of presenting ideas. The learning competency that must be demonstrated by the student is partially met.

Table 9

Students' Performance under "Reflect on the Solution" Principle

Scores	Frequency	Percent	Interpretation
17-21	12	30.0	Advanced
12-16	5	12.5	Proficient
6-11	20	50.0	Developing
0-5	3	7.5	Beginning

Mean= 12.35, SD= 5.48, VI= Proficient
Legend: *17-21 Advanced, 12-16 Proficient, 6-11 Developing, 0-5 Beginning*

Table 9 shows that most of the respondents are in the developing level (50%) when it comes to the principle of reflecting on the solution while there are only 30% of the students in the advanced and 12.5% in the proficient levels. The results proved that students can solve problems and have a right answer but failed to show and reflect on their solutions. In this scenario, students lack the ability to analyze and reflect on whether they arrived at the correct

answer or not. As suggested by Nurkaeti (2018), there is a need to check or verify whether the process is correct by means of substituting the derived answer to the Mathematical equation if it will equate to the process.

Figure 8

Sample response in Reflection on the Solution with the highest score

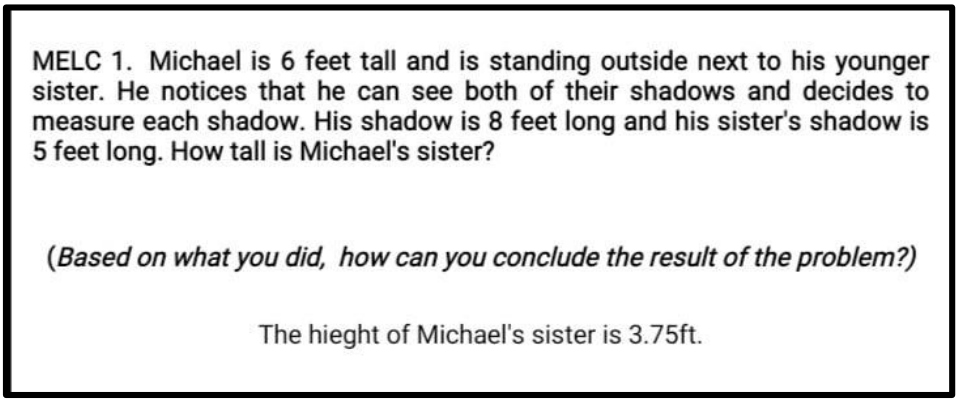


Figure 8 shows an example on reflection. It is noted that the student's response is in the developing stage. This level of skill indicates that the student identified partially correct solutions with some reasoning and a limited ability to check their answer and, if so, is unable to make adjustments in their planning or execution stages.

Figure 9

Sample response in Reflection on the Solution with the lowest score

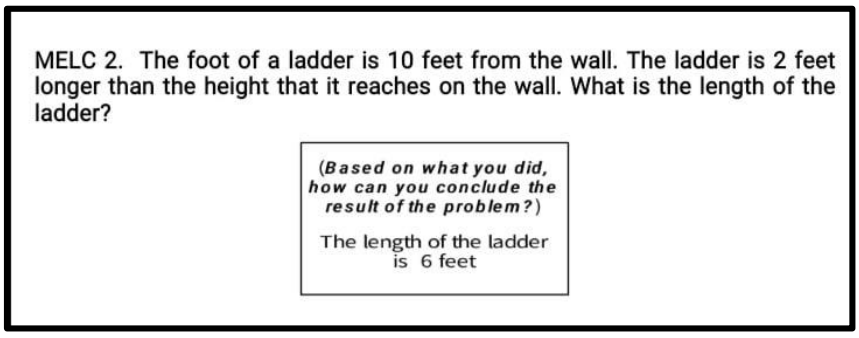


Figure 9 shows a wrong response with respect to reflection. The fact that the student gave a wrong response is the first factor that contributes to the low score. This means that, despite the fact that there are four stages, the student does not examine or synthesize the

outcomes, implying that solutions are rarely checked. With little reasoning, the student also recognizes unworkable solutions.

Table 10
Relationship between PBL Approach and Problem Solving Skills

Problem-Based Learning	Problem Solving Skills			
	Understanding the Problem	Find a Strategy	Applying the Strategy	Reflecting on the Solution
Authentic problems	0.091	0.158	-0.003	0.135
Collaboration	0.113	0.277	0.050	0.211
Developing Expertise	0.092	0.234	0.064	0.237
Authentic Assessment	-0.020	0.066	-0.102	-0.026

Table 10 shows the test of relationship between the PBL approach and problem solving skills of the students. Overall, the result shows no significant relationship between the use of the PBL approach and the students' performance in problem solving. This is the exact opposite of Kadir et al. (2016) that PBL approach has been widely used in various disciplines which improved students' soft skills.

In addition, there is a weak positive correlation for some sub-variable of the PBL and problem-solving principles. There is limited evidence that when students are exposed to authentic problems, it will help students to process well the problem in order to find meaning from it. This is also in contrast to the discussion given by Bevan and Capraro (2021), that when the problems in Mathematics are expressed with real-life implications, the more that they can understand the context and importance of the concepts.

There is also a weak positive relationship between the collaboration of the teacher and students to ensure success in solving Mathematical problems. It only means that there is no enough evidence to tell that the efforts of the teacher in assisting the students in explaining the solutions help them understand the process of solving it. There might be other factors that help students to successfully arrive at the correct answer considering that they are at home during modular learning modality. This explains the findings of Kalogeropoulos et al. (2021) that students also collaborate with parents, classmates, and others whom they seek help while learning at home.

Similarly, there is a weak positive relationship between the mechanism of developing expertise in PBL and the skills in problem solving. There is no enough evidence that when the students become experts in mathematics through PBL it indicates that they can successfully understand the problem, device and apply a plan and reflect on the final answers. As Mazana et al. (2019) explained that other factors help them develop their ability to execute solving the problems such as positive attitude and eagerness to learn.

Finally, being exposed to authentic assessments in PBL has a weak relationship in developing the skills in problem-solving. The connections of the assessment contents to real-life contexts may not only be the indication to help students understand the problems given by the teachers. Since students were oriented already by the examples provided by the teacher, students treat it as a solution pattern to directly solve the problem while ignoring its connection to a real-life situation (Ulu, 2017).

5. Conclusion

This study sought to determine the relationship between PBL approach and the problem-solving skills of Grade 9 students. The findings showed no correlation between respondents' perceptions of PBL and their problem-solving performance. Although the majority of the results in terms of learners' perceptions of the implementation of the PBL approach are agreed upon, it was depicted that there is no enough evidence to tell that PBL helps in developing the Mathematical skills of the students in solving problems. This indicates that being exposed to a PBL strategy has minimal influence on the problem-solving skills developed by learners. Furthermore, there is limited evidence that when students are exposed to authentic challenges, they interact, build knowledge, and authentically evaluate themselves, all of which would aid them in problem-solving when it comes to the four principles given.

This study hypothesizes that the teacher's mastery of the technique's implementation is crucial. It does, however, imply that the students' learning abilities and techniques have a substantial impact on the teaching-learning process. Accordingly, full collaboration and a positive attitude from both students and the teachers in the teaching and learning process are highly suggested in order to get a beneficial result from the application of this method. Future studies can use an experimental research design.

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