PROBLEM-BASED LEARNING: ITS' EFFECT ON THE STUDENTS' MATHEMATICAL SKILLS JOANA MAY C. ALVAREZ

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ABSTRACT

PBL is anchored by Students Centered Learning (SCL) concepts that follow constructivist learning theory principles. The study specifically evaluated the effect of problem-based learning on the mathematical skills of students. The research subjects were 143 grade eleven senior high school students taking academic strand. The research design used in this study are quasi-experimental research design for determining the mathematical skills of the students before and after the exposure to Problem-based Learning and descriptive research design in describing the level of the Problem-based Learning using the criteria from a questionnaire. The research instrument was a validated questionnaire about the Problem-based Learning also the test about Mathematical Skills, and the data were analyzed by using two ways t-test and Pearson R. The research found that the test of difference between before and after the exposure to Problem-based Learning of the respondents resulted that there is a significant difference in the level of the mathematical skills. Furthermore, this research also found that there is no significant effect of problem-based learning approach to the students' mathematical skills.

Keywords:

Problem-based learning, Collaborative, Constructive, Contextualized, Self-Directed, Mathematical Skills, Critical Thinking, Problem Solving, Analytical Thinking

INTRODUCTION

While developing the student's capacity to recognize and apply mathematical concepts in real world contexts was not a top priority, the goal of teaching and studying mathematics was primarily centered on deriving mathematical concepts and abilities. Understanding and using mathematical ideas was crucial when learning the subject. It was a whole and integrated science in terms of mathematics, with every idea, guiding principle, and method tied to one another. Mathematical connections infuse learning with purpose and serve as the motivation for pupils to study the topic. The capacity of pupils to connect the mathematical concepts and issues they learned in mathematics class with issues or circumstances they encounter every day is known as mathematical connection. Many students struggle mentally with arithmetic, which negatively affects 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 lives, many scientific and technological sectors rely heavily on mathematics.

The researcher sought to answer the following questions to determine the effect of PBL on the students' Mathematical Skills:

1. What is the level of Problem-Based Learning in terms of:
    1.1. Collaborative;
    1.2. Constructive;
    1.3. Contextualized; and
    1.4. Self-Directed?

2. What is the level of students' Mathematical Skills before using the Problem-Based Learning in terms of:
    2.1. Critical Thinking;
    2.2 Problem Solving; and
    2.3 Analytical Thinking?
3. What is the level of students' Mathematical Skills after using the Problem-Based Learning in terms of:
    3.1. Critical Thinking;
    3.2 Problem Solving; and
    3.3 Analytical Thinking?
4. Is there a significant difference in Mathematical Skills before and after using Problem-Based Learning?
5. Is there a significant effect of Problem-Based Learning on the students' Mathematical Skills?

REVIEW OF RELATED LITERATURE

As has been seen, PBL is an instructional student-centered approach that allows students to conduct research and incorporate theory into practice. It involves knowledge application, and skills development to solve real life problems according to Savery (2015). Similarly, Hmelo-Silver (2015) described Problem-based learning (PBL) in small groups, is a well-known and cutting-edge pedagogic approach with many dimensions, good practices, and proven efficacy in many countries, for many different subjects and education/training programs, and in varied situations.

Bosch (2019) mentioned that when creating a lesson for collaborative learning, which is an organized method of learning, it is crucial to keep the principles in mind. Remembering that cooperation is about empowerment is important for educators. Through the support and confidence that they acquire, students are given the ability to 'develop to their fullest potential'.

According to Olusegun (2015), constructivism maintains that learning is a personal activity for each learner. According to this hypothesis, people will attempt to make sense of all the information they take in, and as a result, each person will "construct" their own meaning from it. One of the key concepts in education is constructivism. It has huge effects on how educators educate students and train new instructors. Teachers must put their pupils first if they want to succeed in transforming education for all kids. The most significant contribution of constructivism to date may very well be its emphasis on student-centered learning.

Contextualized Teaching and Learning (CTL) Approach was defined by Wang, et al. (2017) as a diverse group of instructional methodologies intended to connect the acquisition of foundational skills and academic content consistently by emphasizing teaching and adapting firmly on concrete applications in a setting that is significant to the students. Through a few different configurations of a rule, contextualization has been operationalized.

Tseng (2013) stated that self-directed learning entails independent or autonomous learning, either alone or in collaboration with others, where the learner controls and assumes responsibility for the learning process by establishing learning objectives, choosing resources and instructional approaches to support learning, and assessing the results of the learning process.

A procedure for problem-solving starts with the initial encounter with an issue and concludes when a solution is discovered in the context of a specific piece of knowledge according to Olaniyan et al., (2015). To find a resolution to a particular problem, solving an issue requires the use of several higher order thinking techniques involves contemplating, assessing, forecasting, reasoning, analyzing,

and interpreting. In addition to fostering intellectual curiosity, problem-solving. It also thought to be crucial for facilitating the transfer of knowledge through the providing of opportunity for pupils to connect the topics they learn as well as the current learning task mentioned by Esan (2015).

According to Aswin et al. (2022), a person's capacity for mathematical critical thinking comprises a mental process that seeks to get to a reasoned conclusion about what to do or believe will happen. Many variables, such as intrinsic motivation and intrapersonal intelligence, affect pupils' capacity for mathematical critical thought.

As mentioned by Muniri (2022) students' capacities for comprehending and resolving issues analytically have not been formally assessed. It is difficult for educators to make changes in choosing the best learning technique for a subject since they still don't understand how students approach difficulties utilizing an analytical thought process.

METHODOLOGY

Research Design

This study used quasi-experimental research design for determining the mathematical skills of the students using a test before and after the exposure to Problem-based Learning and descriptive research design in describing the level of the Problem-based Learning using the criteria from a questionnaire. According to Nassaji (2015) descriptive research is the research design in which data is collected in a qualitative manner and analyzed using quantitative procedures. The quantitative method was implemented in the research that uses figures and measurable forms such as questionnaires and survey assessment. This approach is used to recognize past events to explain quantitative data to extract the student's perspective on their experiences with the integration of Mathematics to assess its influence on the learners' academic achievement to expand on previous research using proven tools.

Respondents of the Study

This study is implemented to selected Grade 11 students (143) of San Pedro Relocation Center National High School Landayan Annex during the First Semester of school year 2022-2023. The researcher used purposive sampling techniques in getting the respondents to determine the Effect of Problem-Based Learning on the students' Mathematical Skills. They were given the test before being exposed to Problem-based Learning and another set of tests after exposed to Problem-Based Learning. According to Creswell (2012), purposive sampling means that to learn or understand the essential phenomenon, a researcher selects individuals and sites intentionally.

Research Procedure

The researcher will propose and defend a title to the panel members. After acceptance, the researcher revises Chapters 1-3 considering the suggestions and adjustments made. The study will begin with a letter of consent from the School Division City of San Pedro for conducting research and an authorization letter to the principal to do research in the school. A letter of request must be signed by the adviser, subject specialist, and Coordinator of GSAR (Graduate Studies and Applied Research), as well as the Dean of the College of Teacher Education, as permission to collect data and administer research instruments. The researcher will ask for the approval of the School Head
and Admin of the Schools Division Office of City of San Pedro will be firstly needed in conducting this study to garner initial scores of the pre-test. A questionnaire which is validated from the subject specialist

and other panelist will administer to test the Mathematical Skills of the students in the experimental and control group. Pre-test will be given before the researcher perform the experiment which is teaching by using the Problem-Based Learning post-test will be administer after the teaching and learning process.

The researcher will disseminate a survey checklist to establish the number of respondents to be utilized in the study to assess the Problem-Based Learning. The dissemination of the questionnaire will take place after the students completely answer the before and after exposed in Problem-Based Learning.

Research Instrument

To gather the relevant data on this study, the research instruments were constructed parallel to the design of the study. Since this research is a quasi-experimental design that focused on conducting and evaluating the effectiveness of a treatment, the following instruments were utilized.

Survey Checklist is used to determine the mean level of Problem-Based Learning to be evaluated by the Grade 11 students at San Pedro Relocation Center National High School Landayan Annex. The Likert Scale is used for the interpretation of the corresponding values guided in interpretation of data gathered from the survey checklist. To test and determine the mean level of Mathematical Skills of Grade 11 students, the researcher will be using the constructed tests administered to the students before and after exposing Problem-Based Learning in the Mathematics class.

Rating	Scale	Evaluation of Problem-based Learning		Scale	Mathematical Skills	
		Description	Interpretation		Description	Interpretation
4	3.26-4.00	Strongly Agree	Highly Evident	9-10	Outstanding	Advanced
3	2.51-3.25	Agree	Evident	6-8	Very Satisfactory	Proficient
2	1.76-2.50	Disagree	Less Evident	3-5	Satisfactory	Developing
1	1.00-1.75	Strongly Disagree	Not Evident	0-2	Needs Improvement	Beginning

Statistical Treatment

This study will use appropriate statistical treatment to determine the effect of Problem-Based Learning on the students' Mathematical Skills.

The statistical treatment that employed in this study are the following:

The mean and standard deviation, to determine the level of Problem-Based Learning in terms of Collaborative, Constructive, Contextualized and Self-directed.

The mean and standard deviation, to determine the level of students' Mathematical Skills before and after using the Problem-Based Learning in terms of Critical Thinking, Problem Solving and Analytical Thinking

Paired T-test were used to determine significant difference on the Mathematical Skills before and after using the Problem-Based Learning.

Pearson R Correlation were used to find significant effect of Problem-Based Learning on the students' Mathematical Skills.

RESULT AND DISCUSSION

Table 1. Respondent's Level of Problem-Based Learning in terms of Collaboration

Being exposed to PBL…	Mean	SD	Remarks
Develop my teamwork that shares common goals and communication.	3.31	0.61	Strongly Agree
I am now able to show my mathematical skills and solve problems through interaction with my peers.	2.89	0.66	Agree
I actively participate in group activities and solve complex problems with the company of others.	3.01	0.73	Agree
Makes me aware of adapting ideas and strategies to solve mathematical problems.	3.08	0.66	Agree
It helps me to improve my self-esteem and decision making.	3.07	0.76	Agree
Overall Mean : SD	3.07 : 0.45		
Verbal Interpretation	Evident		

As shown in table 1, the respondents agree that the collaboration in PBL were able to show their mathematical skills and solve problems through interaction with my peers, participate in group activities and solve complex problems with the company of others, makes them aware of adapting ideas and strategies to solve mathematical problems, and to improve their self-esteem and decision making which all gained the highest (M=3.08, SD=0.66). This implied that Collaborative learning in PBL leads to increased student engagement and motivation, deeper understanding of subject matter, and improved problem-solving skills. On the other hand, the respondents also strongly agree that the collaboration develop their teamwork that shares common goals and communication which gained (M=3.31, SD=0.61). This meant that students were able to promote deeper learning and develop important skills for success in school and beyond.

It also reveals that the extent of Problem-Based Learning in terms of Collaboration was evident supported by the grand (M=3.07, SD=0.45). This means that Problem-based Leaning in terms of collaboration was applied to the lesson during Mathematics Class.

Table 2. Respondent's Level of Problem-Based Learning in terms of Constructive

Being exposed to PBL…	Mean	SD	Remarks
I can present information, findings, and arguments clearly, concisely, and logically in the class.	3.04	0.61	Agree

I can develop ideas and use styles appropriate to the purpose and learning	2.99	0.64	Agree
tasks.			
I can construct and reconstruct my knowledge about the lesson.	3.05	0.61	Agree
Encourage me to ask and answer critical questions to relate issues and discuss contradictions to deeper learning.	3.08	0.66	Agree
It activates my prior knowledge by asking what I already know.	3.12	0.61	Agree
Overall Mean : SD	3.05 : 0.43		
Verbal Interpretation	Evident		

Table 2 shows that the respondents agree that the constructive in PBL were able present information, findings, and arguments clearly, concisely, and logically in the class, develop ideas and use styles appropriate to the purpose and learning tasks, construct and reconstruct their knowledge about the lesson, encourage them to ask and answer critical questions to relate issues and discuss contradictions to deeper learning, and activates their prior knowledge by asking what I already know which all gained the highest (M=3.12, SD=0.61). This implied that PBL in terms of constructive has shown to promote deeper levels of understanding and retention of knowledge, as students are actively engaged in the learning process.

It also reveals that the extent of Problem-Based Learning in terms of Constructive was evident supported by the grand (M=3.05, SD=0.43). This means that Problem-based Leaning in terms of constructive was applied to the lesson during Mathematics Class.

Table 3. Respondent's Level of Problem-Based Learning in terms of Contextualized

Being exposed to PBL…	Mean	SD	Remarks
I am engaging in task drive relevant context to stimulate transfer of learning.	2.98	0.67	Agree
It centers all learning on complex, build defying task and order from simple to complex.	3.07	0.54	Agree
I understand the authentic word problem in real-life situation presented by the teacher.	3.02	0.60	Agree
It emphasizes learning should happen in multiple meaningful contexts.	3.10	0.57	Agree

It cultivates my attitude to learn and motivates me to persist.	3.20	0.55	Agree
Overall Mean : SD	3.07 : 0.39		
Verbal Interpretation	Evident		

As seen in Table 3, respondents agree that the contextualized in PBL were able to engage in task drive relevant context to stimulate transfer of learning, centers all learning on complex, build defying task and order from simple to complex, understand the authentic word problem in real-life situation presented by the teacher, emphasizes learning should happen in multiple meaningful contexts, and cultivates their attitude to learn and motivates them to persist which all gained the highest (M=3.20, SD=0.55). This implied that PBL in terms of contextualization has been shown to promote deeper levels of understanding and retention of knowledge, as learners are actively engaged in the learning process. It also reveals that the extent of Problem-Based Learning in terms of Contextualized was evident supported by the grand (M=3.07, SD=0.39). This means that Problem-based Leaning in terms of contextualized was applied to the lesson during Mathematics Class.

Table 4. Respondent's Level of Problem-Based Learning in terms of Self-Directed

Being exposed to PBL…	Mean	SD	Remarks
I have the initiative in identifying my learning needs, learning goals, learning strategies.	3.13	0.61	Agree
I am responsible and well prepared for complex problems.	3.05	0.62	Agree
Develop my self- confidence and a voice speaks my mind.	2.97	0.63	Agree
Increases my intrinsic motivation for successful teamwork.	3.10	0.62	Agree
I monitor my progress in self-evaluation and identify the skills needed to develop to improve learning.	3.06	0.61	Agree
Overall Mean : SD	3.06 : 0.40		
Verbal Interpretation	Evident		

As reflected in Table 4, respondents agree that the self-directed in PBL were able to have initiative in identifying their learning needs, learning goals, learning strategies, makes them responsible and well prepared for complex problems, develop their self- confidence and a voice speaks in mind, increases their intrinsic motivation for successful teamwork, and monitor their progress in self evaluation and identify the skills needed to develop to improve learning which all gained the highest (M=3.13, SD=0.61). This

implied that PBL in terms of self-directed emphasizes the importance of learners taking an active role in the learning process. Learners are encouraged to take ownership of their learning by identifying problems and questions that interest them and by exploring these in depth.

It also reveals that the extent of Problem-Based Learning in terms of Self-Directed was evident supported by the grand (M=3.06, SD=0.40). This means that Problem-based Leaning in terms of self directed was applied to the lesson during Mathematics Class.

Table 5. Before and After test scores of the students in terms of Critical

Thinking Scores	BEFORE		AFTER		Interpretation
	f	%	f	%	
9-10	0	0.00%	9	6.29%	Advanced
6-8	4	2.80%	62	43.36%	Proficient
3-5	99	69.23%	64	44.76%	Developing
0-2	40	27.97%	8	5.59%	Beginning
Total	143	100.00%	143	100.00%	
Mean	*3.20*		*5.56*		
SD	*1.36*		*1.93*		

It is seen in table 5 that the respondents scores in the mathematical skills in terms of Critical Thinking before and after being exposed to PBL. The scores obtained by the grade 11 students in scale of 9-10 before being exposed PBL has 0.00% and after being exposed to PBL, they show a result of 6.29% with score scales of 9-10 under the level of Advanced.

The overall result of before and after test scores of the students in terms of Critical Thinking was very satisfactory supported by the grand (M=3.20, SD=1.36) in before and (M=5.56, SD=1.93) in after. Research has shown that PBL can improve students' critical thinking skills in several ways by presenting students with complex, real-world problems, PBL helps to develop their ability to analyze, evaluate, and synthesize information from multiple sources.

Table 6. Before and After test scores of the students in terms of Problem

Solving Scores	BEFORE		AFTER		Interpretation
	f	%	f	%	
9-10	0	0.00%	12	8.39%	Advanced
6-8	0	0.00%	113	79.02%	Proficient
3-5	108	75.52%	18	12.59%	Developing
0-2	35	24.48%	0	0.00%	Beginning
Total	143	100.00%	143	100.00%	
Mean	*3.29*		*6.98*		
SD	*1.09*		*1.34*		

In table 6 that the respondents scores in the mathematical skills in terms of Problem Solving before and after being exposed to PBL. The scores obtained by the grade 11 students in scale of 9-10 before being exposed PBL has 0.00% and after being exposed to PBL, they show a result of 8.39% with score scales of 9-10 under the level of Advanced.

The overall result of before and after test scores of the students in terms of Problem Solving was very satisfactory supported by the grand (M=3.29, SD=1.09) in before and (M=6.98, SD=1.34) in after. Problem-Based Learning (PBL) has been shown to have a positive effect on students' mathematical skills, particularly in terms of problem solving. PBL involves presenting students with complex, real-world problems that require them to apply critical thinking and problem-solving skills to arrive at a solution.

Table 7. Before and After test scores of the students in terms of Analytical Thinking

Scores	BEFORE f	BEFORE %	AFTER f	AFTER %	Interpretation
9-10	0	0.00%	0	0.00%	Advanced
6-8	4	2.80%	47	32.87%	Proficient
3-5	74	51.75%	85	59.44%	Developing
0-2	65	45.45%	11	7.69%	Beginning
Total	143	100.00%	143	100.00%	
Mean	*2.71*		*4.86*		
SD	*1.54*		*1.64*		

As seen in table 7 that the respondents scores in the mathematical skills in terms of Analytical Thinking before and after being exposed to PBL. The scores obtained by the grade 11 students in scale of 6-8 before being exposed PBL has 2.80% and after being exposed to PBL, they show a result of 32.87% with score scales of 68 under the level of Proficient.

The overall result of before and after test scores of the students in terms of Analytical Thinking was satisfactory supported by the grand (M=3.29, SD=1.09) in before and (M=6.98, SD=1.34) in after. PBL helps to develop their ability to analyze and interpret information. This is a crucial aspect of analytical thinking, as it requires students to break down complex information into smaller parts to better understand it.

Table 8. Test of Difference between the Before and After Test in Mathematical Skills of the students

Mathematical Skills	Groups	Mean	SD	t	Sig.	df	Interpretation
Critical Thinking	Before	3.20	1.36	-12.78	0.000	142	Significant
	After	5.56	1.93				
Problem Solving	Before	3.29	1.09	-26.76	0.000	142	Significant
	After	6.98	1.34				
Analytical Thinking	Before	2.71	1.54	-11.63	0.000	142	Significant
	After	4.86	1.64				

**significant at .05 level of significance*

As seen in table 8 the test of difference between the Before and After Test in Mathematical Skills of the students shows a significant difference with computed t-test of -12.78, -26.76 and -11.63 as observed on the assessment given to the students for three indicators. Furthermore, with the value of P Value lies at 0.000, respectively.

Table 9. Effect of Problem-Based Learning on the Mathematical Skills of the Students

Problem-Based Learning	Mathematical Skills	r	Sig.	Interpretation
Collaboration Constructive Contextualized	Critical Thinking	0.142	0.091	Not Significant
	Problem Solving	-0.009	0.914	Not Significant
	Analytical Thinking	0.218	0.127	Not Significant

Problem Solving -0.011 0.900 Not Significant
Critical Thinking 0.082 0.328 Not Significant Analytical Thinking 0.124 0.141 Not Significant
Problem Solving -0.129 0.126 Not Significant
Analytical Thinking -0.037 0.664 Not Significant Critical Thinking 0.130 0.122 Not Significant

Critical Thinking 0.231 0.005 Significant
Self-Directed Problem Solving 0.073 0.387 Not Significant Analytical Thinking 0.069 0.414 Not Significant

Table 9 presents the effect of Problem-Based Learning on the Mathematical Skills of the students. The data were statistically treated using Pearson R Correlation. The table shows the p-value of each indicator that resulted to not significant except Problem-based Learning in terms of Contextualized and Mathematical Skills in terms of Critical Thinking that have a significant effect with the p-value of 0.005 that is less than to the level of significance.

Based on the data, it is shown that there is no significant effect of Problem-Based Learning to the Mathematical Skills of the students at 0.05 level of significance. It shows that the null hypothesis stating that "There is no significant effect of Problem-Based Learning on the students' Mathematical Skills" is accepted, it can infer that there is "no significant" effect between them.

CONCLUSION

The level of Problem-based Learning as to Collaborative, Constructive, Contextualized and Self-Directed resulted Evident to the students.

The test of difference between the Before and After Test in Mathematical Skills of the respondents resulted that there is a significant difference in the level of the mathematical skills as to Critical Thinking, Problem Solving and Analytical Thinking.

The test of significant effect of the Problem-based Learning to the Mathematical Skills of the students shows that there was no significant effect of using problem-based learning on the mathematical skills obtained by the students before and after the treatment was given in all the questionnaire given to the respondents.

RECOMMENDATIONS

1. Students may spend their time practicing solving word problem to have mastery and join in the activities that will enhance their mathematical skills.
2. Teacher may use and find different mathematical teaching approaches.
3. Create an opportunity to extend the continual learning of the students by giving webinars to the teachers in all learning key areas which would help the students to learn and improve their Critical Thinking, Problem Solving and Analytical Thinking.

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