Journal Homepage: -www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI:10.21474/IJAR01/15829
DOI URL: http://dx.doi.org/10.21474/IJAR01/15829

RESEARCH ARTICLE

EFFECTS OF PROBLEM-BASED LEARNING TO GRADE 11 STUDENTS' CONCEPTUAL UNDERSTANDING AND PROBLEM-SOLVING SKILLS

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Manuscript Info

Manuscript History
Received: 05 October 2022
Final Accepted: 09 November 2022
Published: December 2022

Key words:-
Problem-Based Learning, Conceptual Understanding, Problem-Solving Skills

Abstract

This study had used Mixed Methods and pre-experimental design one-group pretest-posttest to determine the effects of Problem-Based Learning on student's conceptual understanding and problem-solving skills. This study was participated by 73 Grade 11 students from one of the laboratory schools in Albay and had covered nine (9) lessons that include the topics on hypothesis testing, correlation, and regression. The findings of the study revealed that the performance of the students in their pretest-posttest had increased wherein from the overall mean score of 16.41 in the pretest, it became 40.92 after the posttest which had a mean gain of 24.51. Hence, the computed overall proficiency level had increased from 33% to 83.02% after the posttest. It was also revealed that after computing its computed t-value the result was 38.62 and was interpreted as highly significant at 0.05 level of significance. This data indicated that the Grade 11 students' conceptual understanding was enhanced. On the other hand, the results of the performance of the students for problem-solving skills was computed through getting the 75% mastery level of every lesson presented to the students. It was found out that majority of the nine lessons had passed the 75% mastery level quota. This result implied that the students were able to solve the problems with proper solutions and had arrived at the expected answers as they were presented with the teaching strategy, Problem-based learningin their Statistics and Probability subject.

Introduction:-

The knowledge of Mathematics is an essential tool in our society (Baroody, 1987). It plays a significant role in every aspect of our lives. However, students tend to hate Mathematics, resulting in the decline on Mathematics achievement in schools. In addition, based on Gallup Youth Survey, the subject that the teenagers find most difficult in school is Mathematics (Furner, and Gonzalez-DeHass, 2011). As a result, the students had poor performance in this subject (Saad, 2005). They consider it as a difficult and boring subject (Zakaria et al., 2010). This kind of attitude that students had in their minds toward Mathematics happened when they are more exposed to formulas which require memorization and more problems which are constructed in an abstract and unrealistic manner. The students feel burdened when they are always asked to solve Math problems because they cannot see the essence of what they are learning in real-life. As a result, students perceive Mathematics as a task to surpass to complete their academic requirements. Hence, all too often students hold the belief that there is only one "right" way to approach and solve a problem (Cai, 2003). They learned Mathematics through following rules and procedures in solving

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problems wherein discovering and exploring alternative ways to solve mathematical problems have been neglected which is supposedly the great channel to lifelong learnings.

The teaching of Mathematics is not about providing rules, definitions, and procedures for students to follow and memorize. They should be engaged in a more active learning process so that they can be creative enough to construct meaningful ideas on their own ways (Posamentier et al., 2006). Thus, one of the major goals of Mathematics education is the acquisition of the skills of learning how to solve problems (Follmer, 2000). Problem solving was defined by Magat (2007) as a process and a basic skill. It is said that the goal of Mathematics is learning how to solve the problems, and that problem solving is a process of applying previously learned knowledge and it is a skill of using one's knowledge effectively and readily. When the students are exposed more to problem solving, their understanding about different mathematical concepts has a greater probability to be enhanced well and to become skilled in dealing with mathematical problems.

The Significance of Problem-Based Learning on Students' Learning Process

Hung (2013) had defined Problem-Based Learning as an instructional method which aimed to prepare students to face the real-world settings (p. 31). It was done through letting the students to solve problems as the main format of instruction. Problem-based learning enhances students' learning outcomes by promoting their abilities and skills in applying knowledge, solving problems, practicing higher-order thinking, and self-directing and reflecting on their own learning (p.31). For the students to learn, they are confronted with problems which are the fuel that initiates them to be active learners in their own learning. That is, learning begins with a problem to be solved, and it is posed so that students will explore and seek for solutions to gain new knowledge (Roh, K. H., 2003). In this study, this will be done through letting the students work on different real-life problems given in their activities before the start of the lesson proper. In this case, they will be able to discover and explore the problems on how they will approach and solve them properly.

Furthermore, Problem-based learning is a student-centered instructional strategy where students collaboratively solve problems and reflect on their experiences. It encourages students to take responsibility for their group and organize and direct the learning process with the help of the teachers. The students are confronted first with problems to be solved that are contextually constructed, then they are guided by their teacher, and as they are confident enough to work on their own, the teacher let them explore and identify the problem to find its solutions.

The Significance of Problem-Based Learning Environment

Problem-based learning environments typically had greater opportunities to provide problem solving activities that will cater students' potential to level up to such extent through thinking in critical way, presenting their own creative ideas and communicating them with peers mathematically. Through this method, students are expected to be skilled enough in problem solving, creative thinking and critical thinking (Roh, K. H., 2003) which supported the goals of Mathematics Education and the Department of Education in the Philippines.

Likewise, in Problem-based Learning environments, students act as professionals and are confronted with problems which are considered ill–structured. These kinds of problems are considered as the open–ended questions. These are the problems with no single right solutions where students are the ones to find the solutions in various ways (Sungur et al., 2006). As stated by Yager, everyone should be empowered to wonder, to suggest possible explanations, to propose ways to test personal or class hunches, to collect and interpret data gathered and to present the results and conclusions to others (Yager, 2000). This initiates students to pursue their own problem by exploring the problem, inquiring, gathering information, interpreting the results, and making conclusions after obtaining appropriate evidence that will support the claim of their answers or solutions.

Moreover, according to Dolmans et al., (2005), PBL is a complex learning environment in which different variables influence each other mutually. The students are confronted with problems where the problems serve as the driving force behind students' learning and are used to engage students actively in their own learning. The problems are also used to stimulate students to construct new knowledge actively which is strongly linked to their previous knowledge. Problem-based Learning according to Dolmans et al (2005) had four learning principles which supports its effective used in education. These principles are also referred as the modern insights on learning. These are constructive learning, self–directed learning, collaborative learning, and contextual learning. These principles are used in different ways which affect students' learning. Problem-based Learning in constructive learning has emphasized the active process in which students construct their own meaning and build personal interpretations of the world based

on their experiences and prior knowledge. It implies that the students should be actively engaged in the teaching–learning process so that they will have richer and deeper understanding and better use of their knowledge. As a collaborative process, students in Problem-based Learning should be exposed to collaborative tasks to interact with other students who share common goals and responsibilities because it will lead them to a positive influence in learning. As self–directed learners, the students play an active role in planning, monitoring, and evaluating the learning process. And most importantly, there is a need for reflection where students must share their thoughts about the experience that they had while learning. The last principle is contextual learning where it is said that learning takes place in a context. In this principle, learners should be confronted with realistic problems which drives them to learning. Exposing students to real-life problems with different perspectives stimulates the transfer of knowledge and flexibility with which the students can deal with new sets of events that will prepare them to future learning.

Objectives of the Study:-

This study aimed to enhance the understanding and skills of Grade 11 students in Statistics and Probability. Specifically, this study sought to answer the following problems:
(1) What are the effects of problem-based learning on students' conceptual understanding? and (2) What are the effects of problem-based learning on students' problem-solving skills?

Methodology:-

This study used Mixed Methods to determine the effects of Problem-Based Learning to Grade 11 students' conceptual understanding, and problem-solving skills. The study used a one group pre-test/post-test design with no control group since there were only two sections in the said level and they of different strands which cannot be compared: the ABM and STEM class. In this case, both served as the experimental group. Also, there were eight (8) sources of data in this study namely: (1) respondents, (2) students' journals, (3) observational checklists, (4) responses to questions in the group activities, (5) results in the Pretest and Posttest (conceptual understanding), (6) mastery level of the students per "evaluation", (7) content analysis from the responses of the students in journal entries (problem solving skills) and lastly, (8) focus-group discussion responses.

The Respondents

In this study, the respondents were Grade 11 students from one of the laboratory schools in Albay, Philippines. The total number of students was 73, they were the students who completed at least 80% of the attendance from the entire duration of the conduct of the study. These respondents have undergone the strategy Problem-based learning in their class discussions specifically, on hypothesis testing topics and on correlation and regression topics.

The Procedures

In conducting the study, the researcher had simultaneous procedures in gathering the data. There were two sections that were under the implementation of Problem-based learning from the Grade 11 senior high curriculum. The first process done by the researcher was to look on proper, current, relevant, and real-life problems suitable to the topics under hypothesis testing, correlation, and regression. Then, the researcher searches for the facts about the data of each problem because it functioned as a guide to make the data that will be presented in class more realistic since it was given to the students in a hypothetical way. After the conceptualization of the different problems, the researcher constructed the problems in a more compelling and appealing manner to the students' interests.

When the activity sheets were ready, the researcher developed the lesson plans with the use of Problem-based learning strategy. The format of the lesson plans was based on the four features of Problem-based learning by Dolmans et al., (2005). These features were collaborative learning, self-directed learning, constructive learning, and contextual learning. The researcher also used the "4-A's" format which consists of Activity, Analysis, Abstraction and Application as elements of the lesson plan to match all learning principles of PBL to the lesson plan format of the Department of Education.

The total number of the lesson plans that were developed using Problem-based learning was nine (9) with a time frame of 90 minutes per lesson as anchored on the schedule of the students in Statistics and Probability. Then, these lessons were validated by five jurors from different senior high school teachers in Albay, Philippines. Based on their ratings, the lessons made by the researcher got an average of 4.71 with an interpretation of very satisfactory.

The table of specifications for the pre-test/post-test questionnaires were prepared as aligned with the learning competencies set by the Department of Education to Mathematics Curriculum for Grade 11 students in their core subject Statistics and Probability. Thus, the pre-test and post-test questionnaires were validated by another group of validators from different senior high school teachers in Albay. From the ratings given by the jurors, the pre-test/post-test questionnaires got an overall average of 4.367 with an interpretation of being adequate.

The next process was the administration of the pre-test to Grade 11 students who served as the respondents of the study. Then, the researcher started the implementation of the nine lessons in their Statistics and Probability class which covers the topics on hypothesis testing with seven subtopics, plus the correlation and regression topics. In the activities that they had under Problem-based learning, the students worked collaboratively with their group mates in which they were able to construct new knowledge based on their prior knowledge and experiences that exposed them to real-life problems which were written in different contexts. Through this way, they were able to become self-directed learners who can solve problems independently.

After the implementation of the study for several weeks, the post-test was administered to the students to determine if there is significant difference between the results in their pre-test and post-test which was composed of 50 questions for conceptual understanding. In addition, the researcher computed for the mastery level per lesson to determine if the problem-based learning approach had helped students in enhancing their problem-solving skills. This was done based on the daily performance of the students in the formative assessment and was supported by their journal entries. The performance that was being referred in their formative assessment was the mastery level that they obtained every after the conduct of the lessons in which they should get at least 75% of the passing scores of the test. Additionally, the researcher collected the journals of the students and started to analyze and interpret the results of the entire study about Problem-Based Learning. Lastly, the researcher conducted a focus group discussion to selected students to deeply determine the students' feelings and point of views about their experiences and learnings in the different lessons and activities that they had during the implementation of the study. The interview had eight (8) questions and the students were able to answer them wholeheartedly and truthfully.

Results And Discussion:-

The developed lessons using Problem-Based Learning were on Statistics lessons under the core subject Statistics and Probability of Grade 11 students which include hypothesis testing with seven subtopics such as z-test with population mean, z-test with two sample means (testing the difference between two means), z-test for proportion, z-test for two sample proportions (testing the difference between proportions), t-test, t-test for independent samples, and chi-square (goodness-of-fit test and test for independence). Also, the last two lessons were about correlation and regression. These mentioned lessons were incorporated with identified real-life problems in the different activities which were said to be relatable and timely for teenagers as commented by the jurors. Through these lessons, the students were exposed to different real-life problems which were fascinating, entertaining, and enlightening as described by the Grade 11 students. The problems were drawn from real-life situations which enabled them to relate and see the bigger picture of what they were learning inside the four cornered classroom that they can apply in their future learning. In addition, the lessons made the students work collaboratively with their fellow classmates, solve problems on their own ways, construct meaningful ideas out of their sharing of ideas and expose them to problems in different contexts which stimulated them towards collaborative, self-directed, constructive, and contextual learning.

Effects of Problem-Based Learning on Students' Conceptual Understanding

The table below shows the performance of Grade 11 students upon the integration of problem-based learning in their Statistics and Probability subject particularly on their hypothesis testing, correlation, and regression lessons.

Table 1:- Performance of Grade 11 Students in the Pretest/Posttest on Understanding Statistics Concepts.

No.	Concepts	No. of Items	Mean Scores		Mean Gain	Computed t-value
			Pretest	Posttest		
1	Formulates the appropriate null and alternative hypotheses.	10	3.29	8.14	4.85	19.61

2	Identifies the appropriate form of the test statistic when: The population variance is assumed to be known. The population variance is assumed to be unknown. The Central Limit Theorem is to be used.	10	3.52	8.62	5.1	24.67
3	Identifies the appropriate rejection for a given level of significance when: The population variance is assumed to be known. The population variance is assumed to be unknown. The Central Limit Theorem is to be used.	5	2.16	4.11	1.95	9.98
4	Identifies the independent and dependent variables	1	0.49	0.75	0.26	3.56
5	Computes for the test statistic value	7	2.22	6.07	3.85	19.87
6	Draws conclusion about the population mean or proportion based on the test statistic value and the rejection region.	11	3.29	8.03	4.74	20.53
7	Interprets the calculated correlation coefficient.	1	0.29	0.88	0.59	6.06
8	Calculates the slope and y-intercept of the regression.	3	0.71	2.48	1.77	11.64
9	Predicts the value of the dependent variable given the value of the independent variable.	2	0.44	1.85	1.41	14.82
Overall		**50**	**16.41**	**40.92**	**24.51**	**38.62**

1.993 Critical Value; 0.05 Level of Significance; n=73

The table above revealed that the performance of Grade 11 students in their pre-test/post-test had increased in the mean scores on each Statistics concept. In the pre-test, it got an overall mean score of 16.41 and was increased after the post-test into 40.92 which had a mean gain of 24.51. Additionally, each of the competencies were tested through computing its computed t-values. It was reflected in the table that the performance of Grade 11 students resulted to be highly significant with an overall computed t-value of 38.62. This data means that the students were able to understand well the lessons in Statistics which had resulted to be highly significant after Problem-based learning was used in their Statistics and Probability class. Therefore, it can be concluded that there was significant difference from the result of the performance of the students in conceptual understanding conducted before and after the study at 0.05 level of significance. Also, this data indicates that the conceptual understanding of the students was enhanced.

The results in terms of the effects of Problem-based learning to students' conceptual understanding in this study was supported by the studies conducted by other researchers on Problem-based learning. According to the study of Sungur et al., (2006) students who are instructed with PBL earned significantly higher scores than those with traditionally designed instruction in terms of academic achievement and performance skills. Moreover, the study of Ajai et al., (2013) found out that students taught in PBL achieved significantly higher in the post-test than those taught using conventional method. These related studies supported the researcher's findings that using PBL in Statistics and Probability, the students' conceptual understanding was enhanced positively.

The problems in the activities helped me to enhance my conceptual understanding by aiding me to analyze and evaluate the questions. It develops my mathematical understanding and applying new methods in another form of problems.

Student's Sample Journal Entry

The plate above shows that the given problems had enhanced the student's conceptualunderstanding on the different Statistics concepts that were tackled in their class in which they were able to develop their mathematical understanding and they were able to apply new methods in another form of problems.

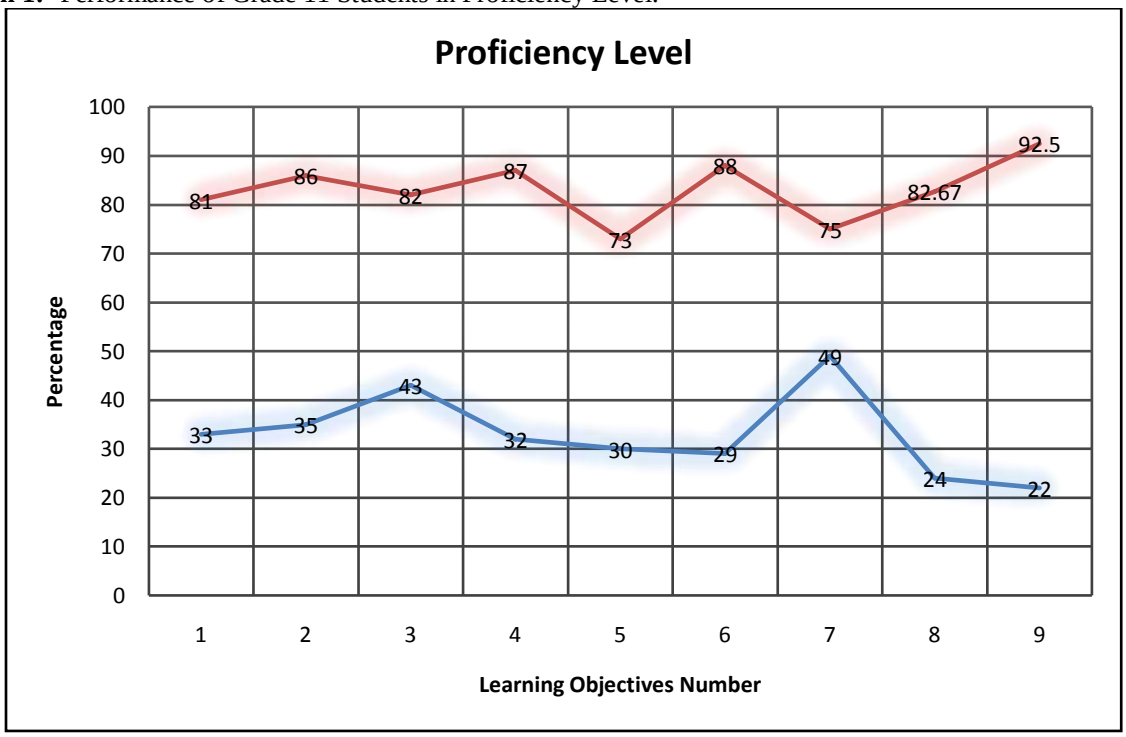
mind and logical thinking deeper. It helps us understand a situation more precisely down to the every bit of it. It exercises our brain to think deeper and enhances our capability to read between the lines. In that way, we are more able to interpret the data given and what is asked in the problem, making it easy for us to think of an easy process to solve the problem.

Student's Sample Journal Entry

Additionally, the plate above shows that the students were able to understand the given situationwhich had exercised their brains to think in a deeper manner and enhances their capability to read between the lines. Due to this fact, their conceptual understanding was enhanced. They were able to determine what is asked in the problem, interpret the data and lastly, they were able to think of an easy process to solve the problem.

The graph below shows the trend of the effects of Problem-based learning on students' conceptual understanding from the pre-test to post-test per learning objectives. The blue line represents the proficiency level of the students in the Pre-test while the orange line represents the Post-test results.

Graph 1:- Performance of Grade 11 Students in Proficiency Level.

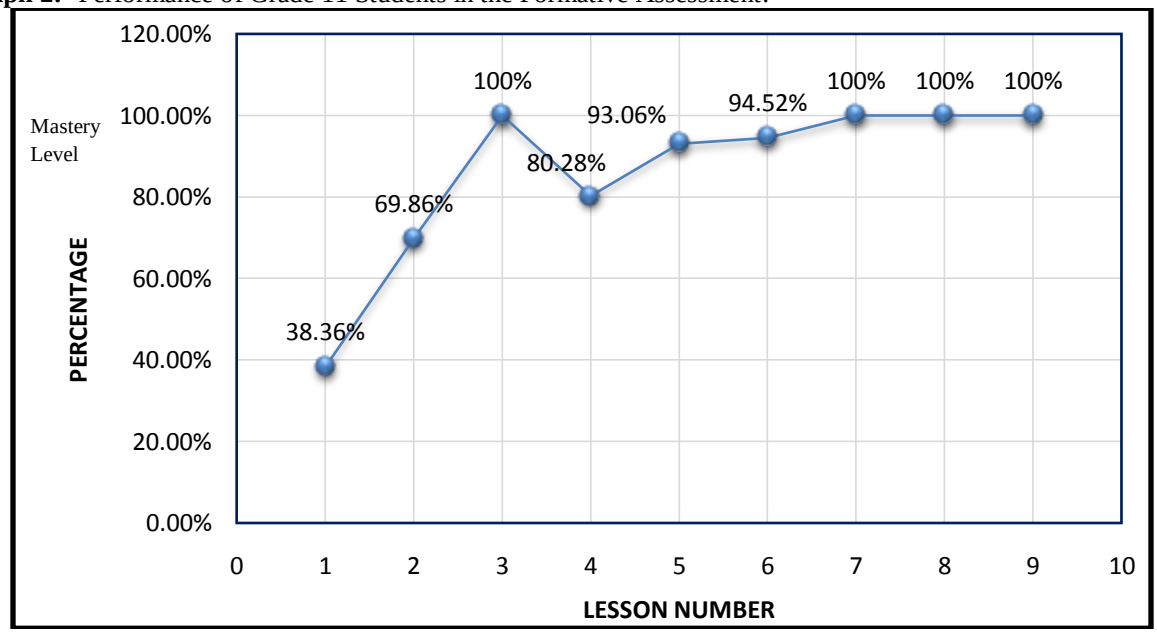


As shown in the graph from the previous page, the students showed progress from the pre-test to post-test in each learning competencies covered in the study in which they were able to have good performance in their Statistics and Probability class. The effects of Problem-based learning to Grade 11 students' conceptual understanding was evidently shown that their performance in the pre-test and post-test had increased. Whereas, in terms of overall proficiency level, it obtained a percentage of 33% to 83.02%. Additionally, the students' journal entries and responses from the Focus Group Discussion supported that the lessons incorporated with real-life problems and was developed under Problem-based learning had positive effect in their conceptual understanding on Statistics lessons. Moreover, this implied that the conceptual understanding of Grade 11 students was enhanced after the implementation of Problem-based learning in their Statistics and Probability.

Effects of Problem-Based Learning on Students' Problem-Solving Skills

The graph below shows the effects of Problem-based learning on students' problem-solving skills. This was done through getting the daily formative tests results of Grade 11 students and were supported by their responses in their journal entries and focus-group discussion. Also, the graph below reflected the students' progress in their formative assessment from the first until the last lesson on Statistics which were under the study.

Graph 2:- Performance of Grade 11 Students in the Formative Assessment.



The effects of Problem-based learning to Grade 11 students' problem-solving skills was evidently shown from the content analysis done by the researcher in which it was found out that from the daily evaluations conducted to Grade 11 students, they showed progress from the start of the lessons until the end of the topics in their Statistics lessons. The first two lessons did not reach the 75% mastery level which must be obtained in every end of class discussion. But from lesson number 3 until in lesson number 9, the mastery level of students' progresses, and it passed the 75% mastery level quota which even gained 100% from lesson number 3, lesson number 7 to lesson number 9. This result implied that the students had mastered the lessons and were able to solve the problems with proper solutions which arrived them at the expected answers. Likewise, the students supported that their problem-solving skills were enhanced since they were able to perform well the different skills needed to acquire as they were learning Statistics lessons. In addition, they were able to practice and develop well their analytical and critical thinking, logical reasoning, decision-making and creative thinking which had been a big help to them to solve the problems with correct solutions and conclusions. Finally, this indicated that their problem-solving skills were enhanced due to the lessons developed under Problem-based learning in Statistics and Probability.This improvement that they had in terms of problem-solving skills was reflected in the sample journal entries of the students shown on the next page.

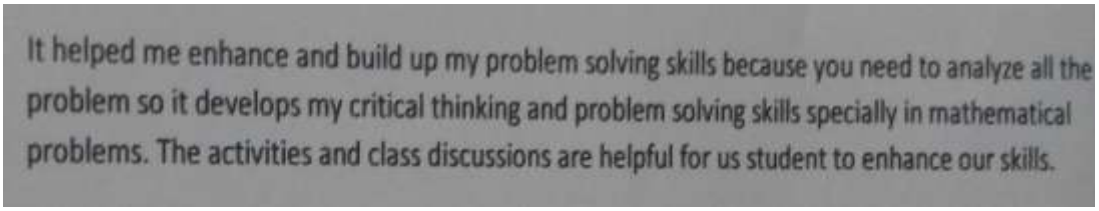
The plate on the next page reflects that the students' problem-solving skills were enhanced since the problems had helped them in enhancing and developing their skills in decision-making, problem-solving and analytical. Also,

through these skills, they were able to apply them in their research subject on handling their gathered data for certain problem that they were studying.

b. How did the problems in the activities and during the class discussions help you to enhance your problem solving skill?

Encountering such problems at first hand is a challenge to us because we're not that familiar to it. But, as time progresses, we are slowly unravelling the solutions to the given problem. Those problems helped us in enhancing and developing our skills in decision making, problem solving and analytical. Thus, knowing how to solve these things also helped us in handling data in our research subject.

Student's Sample Journal Entry



Student's Sample Journal Entry

Additionally, the plate above shows that the problems in the activities and class discussions helped them in enhancing and building up their problem-solving skills because it requires deep analysis and critical thinking skills. Hence, it was stated in the plate below that the activities they had, tested their logical thinking and problem-solving skills. Since the problems were based on real-life situations, to solve them one must immerse oneself into it. Solving hypothesis testing had given them a bigger picture of the essence of what they are learning in the four-cornered classroom. They realized that their learnings specifically in hypothesis testing will be of used in real-life situations which can affect an individual's daily life.

Activities in hypothesis testing mainly tests your analytical and logical thinking, and problem-solving skills. The problems are mainly derived from real-life experiences and/or situations. Hypothesis testing incorporates all the elements of the real world. To solve a problem, you must immerse yourself in the problem. Solving a hypothesis test problem involves skills that can be used in the real world, skills which you can hone to aid you in the future. Hypothesis testing cannot just be used inside the classroom, it can also be used in real-life applications. It can be used virtually anywhere that can affect an individual's everyday life, medical researches and studies, polling, surveys, and almost anything that uses comparisons and averages such as your grades.

Students' Sample Journal Entry

Furthermore, the problems given to the students in their activities helped them to enhance their conceptual understanding and problem-solving skills. They were able to identify the null and alternative hypotheses, state the claim, solve the problem, make proper graphic representation of the data, and make decision and conclusion for the given problem. Overall, they found the lessons with the integration of problem-based learning as fruitful and helpful in math and in real-life situations.

Conclusions:-

There were nine (9) lessons developed in Statistics and Probability using Problem-based learning with the following features: constructive, self-directed, collaborative, and contextual learning.Using Problem-Based Learning in Statistics and Probability to Grade 11 students, their conceptual understanding, and problem-solving skills were enhanced and were found significantly different. These conclusions were supported accordingly by the data presented in this article.

Recommendations:-

In view of the findings and conclusions, the following recommendations are proposed: Use Problem-based learning in Statistics and Probability as a strategy to enhance the students' conceptual understanding, and problem-solvingskills. Further studies can be conducted on the use of Problem-based learning to enhance students'

performance in other topics in Mathematics and in other subject areas using any of its four features of learning. Also, further studies can be done in determining the different skills of students other than problem-solving skills which are appropriate to 21st century learners through the implementation of Problem-based learning. Lastly, further studies about Problem-based learning can be conducted to any level.

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