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Enhancing Problem-solving Skills of Learners Through Problem-based Modular Approach with Execution and Representation

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Abstract:

Word problems played a vital role not just in mathematics subjects but also in the whole education system. Mathematics problem-solving skills are significantly crucial in mathematics performance. The learners should be exposed to various worded problems to efficiently flourish their problem-solving skills. This quasi-experimental study aimed to determine the effect problem-based modular approach on the learners' problem-solving skills. In the experimental group, learners were exposed to problem-based modules with execution and representation, and the learners in the control group were exposed to non-problem-based modules without execution and representation (these modules were issued by the Department of Education). Results revealed that the problem-solving skills of learners were enhanced in both experimental and control groups. However, post-test scores of learners exposed to problem-based moduleswith execution and representation are statistically higher than those of learners exposed to problem-based modules without execution and representation. Thus, problem-based modules are an effective teaching platform to enhance the learners' problem-solving skills. Recommendations were made for reflection to be able to address the struggling learners in problem-solving.

Keywords: *problem-based learning, problem-solving skills, problem-based modules, mathematics education*

Introduction:

Mathematical problem solving is an important factor in mathematics, the teaching of mathematics, and the learning of mathematics. It has insinuated mathematics curricula around the world with emphasis on the development of problem-solving skills to be engaged in the teaching of mathematics subjects through problem-solving. Students' problem-solving skills affect their success in mathematics; the students who do not have problem-solving skills perform badly in mathematics. In mathematics education, the purpose is to develop students' higher-order thinking skills, critical, creative, and divergent thinking skills. According to Schoenfeld (2007), problem-solving is the "skill" of coping with non-trivial problems for which the student lacks a known, routine solution approach but which presents opportunities for the student to develop unique solution strategies. It is a major focus in the teaching and learning of mathematics and also one of the components that should be emphasized in school mathematics. Problem-solving is at the heart of practice in everyday and professional contexts.

Problem-solving is a multifaceted mental process involving vision, imagination, abstraction, and knowledge connection. As a result, problem-solving as part of the mathematics learning process can help students improve and strengthen their abilities in areas such as application, analysis, synthesis, and evaluation (Anderson & Krathwohl, 2001).Problem-solving is a difficult cognitive process. According to Winkel (2007), one is said to have a problem in information processing when he has a goal but no "tool" to reach the aim. Problem solutions required a wide range of mathematical abilities. However, a huge majority of students have not learned the fundamental mathematical skills required (Berch & Mazzocco 2007).

According to Polya (1962), solving the problem doesn't give a contribution to students' mental development. Hebelieves that to provide the opportunity for students to develop high-order thinking in the process of understanding,analysis, exploration, and application of mathematical concepts, the non-routine problem should be employed. As one of the goals of the K-12 curriculum of the Philippines is problem-solving skills, teachers should innovate to address the gap.

There are at least two major limitations of those problem-solving experiences. First, students are usually taught to solve well-structured problems, even though most problems in everyday and professional practice are ill-structured. Second, students are generally unable to transfer problem-solving skills that they do develop to novel problems in different contexts. Problem representation is the key to problem-solving among novice learners as well as experts. Well-designed visual representations have the potential to assist pupils in developing the mental models required to answer routine and multistep word problems (Jitendra & Woodward, 2019). The construction of representation in the form of visualization can help students connect with a problem situation and facilitate students' ability to communicate their understanding of those problems (Abdullah, et al., 2014). The study by Widodo and Ikhwanudin (2018) claimed that the use of visual learning increases the ability to solve problems. Representation plays an important role in solving mathematical problems. It manifests in visual forms, diagrams, graphs, tables, schema, and symbolism. It is very effective in helping students understand the problem (Anwar, et al., 2019). In the problem-solving process, the most prominent mathematical representation of students is a visual representation (Arnidha, 2019). The study of Sahendra et al., (2018) suggests that teachers should pay attention to student representation as a consideration of designing innovative learning to increase the self-efficacy of each student to achieve maximum mathematical achievement.

Methodology:

The research was conducted using a quasi-experimental design. The sample consists of 60 Grade 10 learners which were divided into two groups: the experimental group and the control group. The experimental group was exposed to the modified problem-based modules withrepresentation and execution. On the other hand, the control group was given problem-based modules without representation and execution (Math PACKS) provided by the Department of Education. The interventions lasted for six weeks. The instrument was composed of 15 items of mathematical worded problems from the Mathematics 10 learning materials. The Table of Specification (TOS) was created to make sure that the items were anchored to the most essential learning competencies (MELCs) of the Department of Education. The instrument and the rubrics underwent validation and reliability test.

Results and Discussions:

The difference between the pre-test and post-test scores in problem-solving skills of learners exposed to problem-based learning moduleswithrepresentation and execution and those exposed to the problem-based learning moduleswithout representation and execution.

A paired-samples t-test was conducted to determine the difference in the learners' problem-solving skills in the pretest and posttest. There was a statistically significant increase in pretest ($M=10.80$, $SD=17.11$) and posttest ($M=92.37$, $SD=31.38$)scores of learners exposed to problem-based learning moduleswith representation and execution, $t(29) =-11.14$, $p<.000$ (two-tailed).Also, for learners exposed to theproblem-based modules without representation and execution, significant difference was also recorded from pretest ($M=10.77$, $SD=12.90$) and posttest ($M=61.73$, $SD=28.06$)scores in problem-solving skills, $t(29)= -9.11$, $p<.000$ (two-tailed). The study showed that there was an improvement in the problem-solving skills of learners exposed in both groups. This implied a great difference in the pre-test and post-test achievement of learners in the control group. The problem-based modules could also increase the problem-solving skills of learners even without the use of proper representation and execution.

Table 1

The Difference betweenthe Pre-Test and Post-Test Problem-Solving Skills of Learners Exposed to Problem-Based Learning Moduleswith Representation and Execution and Problem-Based Learning Modules without Representation and Execution.

	Mean	SD	Mean Difference	CI Lower	CI Upper	t	df	p
PBL Modules with Representation and			81.57	-96.54	-66.60	-11.14	29	0.000*

Execution								
Pretest	10.80	17.11						
Posttest	92.37	31.38						
PBL Modules without Representation and Execution			50.97	-62.37	-39.57	-9.11	39	0.000*
Pretest	10.77	12.90						
Posttest	61.73	28.06						

Difference between the post-test scores inproblem-solving skills of learners exposed to problem-based learning modules and non-problem-based learning modules

The comparison of post-test scores of learners in both groupsshows a significant difference in the problem-solving skills of the learners exposed to problem-based learning moduleswith representation and execution, *(M=92.37, SD=31.38)*and problem-based learning moduleswithout representation and execution *(M=61.73, SD=28.06), t(58)= -3.99 and p<.000* (two-tailed).This resultimplied that the problem-solving skills of learnersexposed to problem-based learning modules were higher than that of those exposed to non-problem-based learning modules. This implied that the problem-based modules with problem representation and execution are a better teaching platform to help improve the problem-solving skills of learners compared to the problem-based modules with no problem representation and execution. The new knowledge and skills acquired from the intervention are significant to understand the concepts and ideas to sort out worded problems. They were assisted in narrowing down their understanding to formulate appropriate mathematical computations. This finding is strongly abided with the study of Krawec (2012), instruction in visually representing math problems as part of the mathematics curriculum, thus, seems vitally important to the success of students in math problem-solving. This is in parallel to the study of Fagnant and Villasis (2013) which revealed that explicit learning of different forms of representations had a positive effect on each type of problem.

Conceptualizing a set of related mathematical representations has the potential to support students' rich and generative understandings of relevant content (Earnest, 2015). This is also supported by the result of the study of Booth & Davenport (2013) that problem representation and meaningful conceptual text improved both encoding and problem-solving performance.Multiple representations are advantageous to students when addressing problems, representational forms of problems affect student performance, and the use of representational learning strategies can lead to significant increases in problem-solving (Solaz and López 2008). Also, Sahendra et al., (2018) stated that the learners should be exposed to representation as a consideration of designing innovative learning to acquire maximum mathematical achievement. Zahner and Corter (2010) discovered that adequate visual representation can aid in probability issue solving.They show that external visual representations are commonly produced and used during the processes of mathematically defining the problem and devising a solution approach.

Table 2

The Difference between the Post-Test Scores in Problem-Solving Skills of Learners Exposed to Problem-Based Learning Modules with Representation and Execution and Problem-Based Learning Modules without Representation and Execution.

	Mean	SD	Mean Difference	CI Lower	Upper	t	df	p
PBL Modules with Representation and Execution	92.37	31.38						
			30.63	-46.02	-15.24	-3.99	58	0.000*
PBL Modules without Representation and Execution	61.73	28.06						

Conclusions:

Before the intervention learners simply showed that they had little knowledge of the concepts and ideas about the topics under study and their problem-solving skills are not fully widened so they need to be exposed to the new strategy or technique in dealing with such worded problems. They need to be harnessed in different teaching platform/s for them to maximize their desired learnings. After being exposed to problem-based modules with problem representation and execution appeared higher compared to those learners exposed to problem-based modules with no problem representation and execution. This implies that the learners exposed to problem-based modules with problem representation and execution had amplified their skills in solving worded problems and increased their ability in formulating and connecting mathematical concepts to come up with the appropriate and correct solutions. This clearly showed that problem-based modules with problem representation and execution are more effective than the problem-based modules with no problem representation and execution. This further implied that creating problem representation to solve worded problems in Mathematics provides the learner's opportunity to process the information, increase their spatial reasoning skills, and help them identify their goal of the problem. This improved also their ability in comprehending statements, and relate current problems to familiar mathematical ideas leading them to correct engagement of the task to come up with the correct answer.

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