

Enhancing Students' Problem-Solving Performance in Mathematics through the Concept of Scaffolding Teaching Approach

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Abstract- Teachers must encourage their students to embrace mathematics and study it as simple as possible because the majority of students consider mathematics as one of the difficult subjects. This study aimed to investigate how problem-solving performance of the students in mathematics were affected by the concept of scaffolding teaching approach on the topic domain such special products, equations, and inequalities. Quasi-experiment with pretest-posttest control group design was utilized. Participants were Grade 7 students from Mindanao State University-Saguiaran Community High School. The results revealed that after intervention, there was a significant difference on the control and experimental groups of students' mean score on the problem-solving performance test. However, it was discovered that there was no significant difference on the control group and experimental group of students' mean gain scores on the problem-solving performance test, even though the experimental group had a higher mean gain score than the control group. The results of this study showed that the concept of scaffolding teaching approach has a favorable effect on the problem-solving performance of students in mathematics. However, the study was unable to distinguish the difference in the mean gain scores on the control and experimental groups after intervention in the problem-solving performance test.

Index Terms- Scaffolding Teaching Approach, Traditional Teaching Approach, Problem-Solving Performance

I. INTRODUCTION

Mathematics is a subject that needs ample time to comprehend, especially in solving word problems in the textbook. Some of the problems are not easily visualized by the students and the situation being depicted. Students nowadays are continually undergoing changes. They are more interested on the context which they can visualize easily and relate the topic in a more practical situation. This can only be made possible if the teacher's approach in teaching his lesson is being guided and

contextualized according to the interest of his learners and their life circumstances.

One of the difficult subjects is regarded to be mathematics according to some research. Ganal & Guiab (2014) describe mathematics as difficult, obscure, and of little interest to students. According to Eduafo (2014), the ability to use mathematics effectively is essential for academic success as well as civic engagement, job success, and personal fulfillment. The Department of Education (DepEd) in partnership with the Mathematics Teachers Association of the Philippine conducts an annual competition in mathematics to build the competitiveness to both elementary and high school students. Most of the questions are problem solving which need an extreme analysis and time to solve the given problem. In the year 2017, one of the students in Bangasamoro Autonomous Region in Muslim Mindanao won a gold medal in an international mathematics competition. It is indeed inspiring to see students competing and excelling in such contest despite of the weakening status of mathematics education in the Philippines. The K-12 programs could further worsen high school students' results on the National Achievement Test (NAT) in both private and public schools. It is very dismaying because the result is very poor specifically in mathematics.

In the year 2006, most schools in the country have not reached the cut-off score which is 75% in mathematics. NAT scores below 50% indicate a low mastery of the subject. In the year 2011, the DepEd admitted that 67% of high schools fared poorly in the said test. Students sometimes struggle with answering math questions by applying formulae, properties, theorems, and/or laws improperly and failing to fully solve problems even when they follow the initial procedure correctly (Capate and Lapinid, 2015). Also, the poor achievement of students in mathematics is caused by four factors: the students, teacher, classroom management and evaluation (Andaya, 2014). In addition, out of 45 nations, the Philippines scored 42nd on the International Mathematics and Science Study (TIMSS) in mathematics. The Philippines' rank has not improved since 1999

and did not participate in the 2007, 2011, 2015 TIMSS. Hence, based on this stagnation, this simply implies that the education in the Philippines needs to improve specifically in mathematics.

Teaching strategies and other teaching techniques need to be improved and should fit the needs of the society if we are to address the need to improve learning outcomes in the schools that were categorized as having poor achievement and lower average rates. Its purpose is to enhance students' performance and motivate them to learn particularly in solving mathematical problem. It can be said that mathematics is a tool to train students enabling them to solve problems, building thinking process that will lead them to further ability in solving non-mathematical problems. One way to assess and examine the students' problem-solving abilities is to develop a method for teaching mathematics. This study sought to develop a highly recommended teaching approach. The researcher studied the effects of concept scaffolding teaching approach on problem-solving performance of Grade 7 students in mathematics.

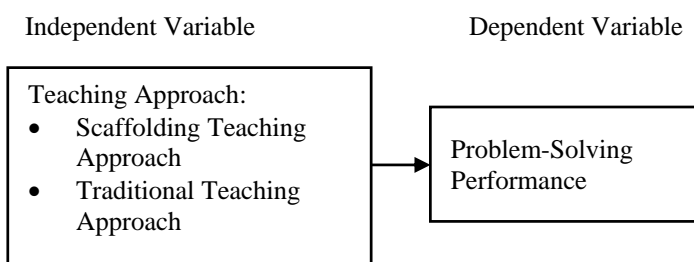
In general, the purpose of this study was to look into how concept scaffolding teaching approach affected the problem-solving performance of Grade 7 students in Mathematics. Specifically, it sought answers to the following questions:

1. What are the problem-solving performance levels in the control group and experimental group of Grade 7 students before and after intervention?
2. Is there a significant difference in the problem-solving performance test mean scores before and after intervention on the control and experimental groups of Grade 7 students, and in the mean gain score?
3. What are the perceptions of the Grade 7 experimental group of students on the concept of scaffolding teaching approach?

Conceptual Framework

The effects of the independent variable on the dependent variable were involved in the investigation of this study. The concept of scaffolding teaching approach and the traditional teaching approach are the independent variable. Problem-solving performance is the dependent variable. The research paradigm in Figure 1 illustrates the flow in which the independent variable influences the dependent variable.

Figure 1
Research Paradigm



Scope and Delimitations of the Study

The scope of the study was limited to investigating how the concept of scaffolding teaching approach affected the problem-solving performance of Grade 7 students in mathematics. Data were limited in the forms of test scores and declared views coming from two sections of Grade 7 students of MSU-Saguianan Community High School. The topic domains covered in the study were limited only on special products, equations, and inequalities. The focus of instruction was mostly on using guess and check to solve linear equations and inequalities in one variable, algebraically solving linear equations and inequalities, algebraically solving first degree inequalities in one variable, and solving absolute value equations and inequalities. Results of the study are non-conclusive in nature.

II. METHODS

This study employed both quantitative and qualitative research method. The quantitative part utilized the quasi-experimental research design. Two intact groups were used as recipient of instruction. The two groups were compared using their mean scores and mean gain scores in the Problem-solving Performance Test. The pretest-posttest control group design with matching-only was employed. The design is shown below.

Experimental	M	O	X	O
Control	M	O	C	O

The experimental group refers to the group of students who received instruction using the concept of scaffolding teaching approach while the control group refers to the group of students who received instruction using traditional teaching approach. The symbol M denotes for the matching of samples of students in the previous quarter grade in mathematics. The symbol O stands for observation. The first column of O's refers to the first observation which is the administration of the pre-tests for the Problem-Solving Performance Test, and other measurements. The concept of scaffolding teaching approach used with the experimental group is denoted by the symbol X as the instructional intervention. The control group or comparison group is denoted by the symbol C. The second column of O's refers to the second observation which is the administration of post-tests for the Problem-Solving Performance Test, and other measurements.

Locale of the Study

This research was conducted at the Mindanao State University-Saguianan Community High School which is located in the barangay of Poblacion in Saguianan, Lanao del Sur. The school is a part of Mindanao State University - Main Campus' High School Units. One of the most prestigious public high schools in Lanao del Sur, it is regarded as one the top external high school for Mindanao State University.

Participants of the Study

Participants in this study were the two intact groups of Grade 7 students who were formally enrolled at the MSU-Saguianan Community High School. There were three sections in the grade 7 who handled by the two mathematics teachers and a total of

119 Grade 7 students including the participants of the study such as the Grade 7 – Diamond consisted of 38 students and Grade 7 Emerald consisted of 40 students.

III. RESULTS

This section presents the data, its analysis and interpretation. The presentation of the data follows the sequence/order of the statement of the problem.

Problem-Solving Performance Levels in the Control Group and Experimental Group of Grade 7 Students Before and After Intervention

Table 1
Frequency and Percentage Distribution of Students' Level of Problem-Solving Performance

Level of Problem Solving Performance	Number (%) of Students before Intervention		Number (%) of Students after Intervention	
	Control Group (n=22)	Experimental Group (n=22)	Control Group (n=22)	Experimental Group (n=22)
High	0 (0%)	0 (0%)	0 (0%)	3 (13.64%)
Moderate	0 (0%)	0 (0%)	8 (36.36%)	16 (72.72%)
Low	22 (100%)	22 (100%)	14 (63.64%)	3 (13.64%)
Total	22 (100%)	22 (100%)	22 (100%)	22 (100%)

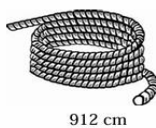
Note: Raw Score: 31-40 – High; 20-30 – Moderate; 0-19 – Low

Table 1 shows that prior to the intervention, neither the experimental group nor the control group of students had any students perform at the high or moderate level in terms of problem-solving performance. Both the control group and the experimental group of students perform low level of problem-solving performance. This implies that all students from both groups had no prior knowledge in the problem-solving performance test. After the intervention, few (13.64%) students from experimental group demonstrated high level of problem-solving performance while none (0%) from the control group. Moreover, more than a quarter (36.36%) of the students in the control group while closer to the three-fourths (72.72%) in the experimental group demonstrated moderate level of problem-solving performance. More than half (63.64%) of the students in the control group while few (13.64%) in the experimental group remained in the low level of problem-solving performance.

Below are samples of solutions of control group student 13 (CGS13) and experimental group student 13 (EGS13) in Problem 2 on Problem-Solving Performance Test before and after the intervention.

Figure 2
CGS13's Solution in Problem 2 Before and After Intervention

Problem 2: A student cuts a 912 cm piece of rope into two pieces for his math project. One piece is 120 cm longer than the other. How long are the pieces?



912 cm

SOLUTION

$$\frac{912}{2} = 456$$

1 piece = 120 cm longer

$$\frac{456}{12} = 38$$

Other piece = ?

$$38 + 120 = 158$$

$$38 + 456 = 494$$

1032 cm long are the pieces.

SOLUTION

$$x + (x + 120) = 912$$

$$2x = 912 - 120$$

$$\frac{2x}{2} = \frac{792}{2}$$

$$x = 396$$

One piece is 516 cm while the other piece is 396 cm

Before intervention, CGS13 tried to solve the problem 2 on the Problem-Solving Performance Test. Unfortunately, CGS13 did not show the correct solution. Notice that before the intervention, CGS13 use simple arithmetic in computation. This clearly shows that the knowledge of CGS13 in answering problem-solving was based on what he learned from his elementary level. Apparently, students' background is most important in developing knowledge especially in mathematics. This suggests that elementary mathematics background is very important in learning mathematics. As Prabawanto (2013) argued, the students' lack of mathematical problem solving was related to lack of their ability in their elementary level. After intervention, CGS13 improved his solution and got the correct answer. He marked 3 points since he did not elaborate all the necessary solutions.

Figure 3
EGS13's Solution in Problem 2 Before and After Intervention

SOLUTION

$$\frac{912 \text{ cm}}{2} = 456$$

② 120 cm longer than the other

$$456 + 120 = 576 \text{ cm}$$

SOLUTION

1st piece + 2nd piece = 912 cm

Let x be the 2nd piece

1st piece = 120 cm + x

2nd piece = x

$$(120 + x) + x = 912$$

$$120 + 2x = 912$$

$$2x = 912 - 120$$

$$\frac{2x}{2} = \frac{792}{2}$$

$$x = 396$$

120 cm + x = 516 cm

First piece = 516 cm

Second = 396 cm

Before intervention, EGS13 tried to solve the problem 2 on Problem-Solving Performance Test but did not find the correct answer and solution. However, EGS13 had an idea that the rope must be partitioned in order to get the two pieces because he

divided the total length of the rope by two. Cognition is very important in answering problem-solving in mathematics. As Tambychika and Meerah (2010) asserted, cognitive abilities in learning such as the ability to recall, memorize and perceive influence the efficiency of problem-solving. After intervention, EGS13 solved and showed the correct solution for problem 2. As can be seen the solution, EGS13 used the right equation and got highest score. Also, EGS13 showed the solution step-by-step by starting with representing a variable and concluding the final answer.

Significant Difference in the Problem-Solving Performance Test Mean Scores Before and After Intervention on the Control and Experimental Groups of Grade 7 Students, and in the Mean Gain Score

Table 2
Comparison of Control and Experimental Group of Students’ Problem-Solving Performance

Period	Group	t-test for equality of means				
		Mean Score	Mean Gain Score	SD	t-value	p-value
Before Intervention	Experimental (n=22)	9.73		4.50	1.83	.08(ns)
	Control (n=22)	8.23		4.20		
After Intervention	Experimental (n=22)	23.00		2.43	3.25	.00(s)
	Control (n=22)	18.73		2.99		
	Experimental (n=22)		13.27	5.16	1.92	.06(ns)
	Control (n=22)		10.50	4.39		

Note: s – significant at 0.05 level; ns – not significant at .05 levels

Table 2 shows that before intervention both the control and experimental groups of students poster lower mean scores (9.73 vs. 8.23), were closer to each other, and were therefore not statistically significant ($p=0.08>0.05$). This suggests that both groups of students were initially comparable on their problem-solving performance before the instructional intervention. In addition, this also suggests that students were lack of necessary knowledge skills to be used in solving worded problems under the topic domains of the study. This is natural to expect because students are already defeated before they attempt to solve the problems with no armory of knowledge to retrieve in solving the problems.

After intervention, the experimental group was higher the control group in terms of mean score (23.00 vs. 18.73), and this difference was statistically significant ($p=0.00<.05$) in favor of the experimental group. The mean gain of experimental group was also higher than the control group (13.27 vs. 10.50), but the difference is not statistically significant ($p=0.06>0.05$). This shows that teaching mathematics using a scaffolding technique has been found to be effective in assisting students in solving problems in mathematics. Furthermore, this also suggests that students from the experimental group improved their Problem-Solving Performance Test scores because during the intervention, they were exposed on the instructional intervention in which they

practiced worded problems with the guides and supports that could help them develop their problem-solving skills.

According to Lin and Singh (2016), some students were able to take advantage of the scaffolding supports provided and transfer their learning from the solution to the problem provided to solve the analogical problem. The use of scaffolding, which takes the form of written questions and step-by-step instructions, can help students in solving problems (Arifin et al., 2020). Apparently, this study found evidence on improvements of students’ Problem-Solving Performance Test scores after the intervention in favor of the experimental group. However, the study did not find sufficient evidence to detect significant difference between the control and experimental groups of students’ mean gain score even though, as a matter of fact, such an effect existed. Moreover, we cannot conclude that the concept of scaffolding in problem solving performance of students is not effective because the results could be accounted to the fewer number of sample ($n=22$) for each group and the short duration of the intervention done only for almost 7 weeks. According to Murphy et al. (2014), if the number of samples and effect sizes were increased and the criteria for statistical significance were more flexible, a test would have a higher level of p-value.

Experimental Group of Students’ Perceptions on the Use of Scaffolding Teaching Approach in Mathematics

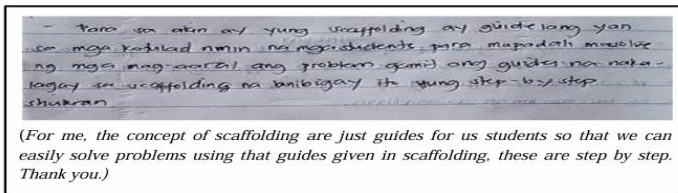
The students from experimental group were asked to write journals about their perceptions with the use of scaffolding teaching approach in mathematics at the end of the lessons. After the intervention, the teacher-researcher randomly selected students from experimental group for one-on-one interview. The findings generally showed that most of the students expressed their views and opinions regarding the use of the concept of scaffolding teaching approach in mathematics. The following themes were extracted from the responses of the students who were exposed to the intervention, based on their experiences with the concept of scaffolding teaching approach: (1) the scaffolding approach serves as a clear and effective guide that is easy to understand; (2) the scaffolding approach makes problem-solving tasks easier to answer; and (3) students prefer the concept pf scaffolding approach over the traditional approach in solving mathematical problems.

1) The scaffolding approach serves as a clear and effective guide that is easy to understand.

The following responses are the samples of students’ opinions regarding the concept of scaffolding teaching approach in mathematics specifically in answering problem solving test. Their views and opinions revealed that the scaffolding approach serves as a clear and effective guide that is easy to understand.

Figure 4

EGS8’s Answer to the Question: What can you say about the concept of scaffolding approach?



EGS19: All I can say is that it's enjoy and easy but not too easy because sometimes, I can't get it and I can't understand the question pero unu ulit ko pagbasa sa question para maintidihan kasi lagi sinasabi nang teacher ko at nang classmates ko na read the questions paulit-ulit until you get it and solve it. I like the guides of the concept of scaffolding because it's easy to use especially if you are answering fast. (All I can say is that it is enjoyable and but not too easy because sometimes I can't get it (understand) and I can't understand the question but I read the question again so I can understand it, because our teacher, and my classmates as well, to always read the question again and again so you understand it and solve it. I like the guides of the concept of scaffolding because it is easy to use especially if you are answering fast/quickly)

EGS7: It's easy and sometimes it's hard to understand because I feel that my brain is out and it's okay gumamit nang concept of scaffolding because it is step by step and have guides and it says in that will be have a conclusion and show your solutions. (It's easy and sometimes it's hard to understand because I feel that my brain is out and it's okay to use the concept of scaffolding because it is step by step and have guides and it says in that will be have a conclusion and show your solutions.)

EGS5: Para sa akin, scaffolding is easy and hard because may be the problem is easy for student or may be the problem solving is hard for student and also scaffolding is a variety of instructional techniques used to move student progressively toward stronger understanding and independence in the learning process. (For me, scaffolding is easy and hard because may be the problem is easy for student or may be the problem solving is hard for student and also scaffolding is a variety of instructional techniques used to move student progressively toward stronger understanding and independence in the learning process.)

The students understood that the concept of scaffolding is guide and support which could help them particularly in problem-solving activities. Experimental group student 19 (EGS19) enjoyed the scaffolding problem-solving activities as she revealed in the interview. She liked the concepts of scaffolding applied in the worded problems because she can answer fast. Also, she read the questions repeatedly to understand the problems which made her confused. Experimental group student 7 (EGS7) and experimental group student 5 (EGS5) felt that the concept of scaffolding is easy and sometimes hard. EGS7 declared in her journal that the concept of scaffolding was guided problem which has step-by-step solution. Similarly, EGS5 declared in her journal that scaffolding is just instructional techniques that could support her independently in learning process. Experimental group student 8 (EGS8) claims that the concept of scaffolding could guide her to easily solve the problems. Based on the responses and opinions of the students, it suggests that the concept of scaffolding in mathematics could be useful if the students understand the problems given to them. So, mathematics teacher should examine the learning materials used in the activities and modify some context of the worded problems found in book to understand it very well.

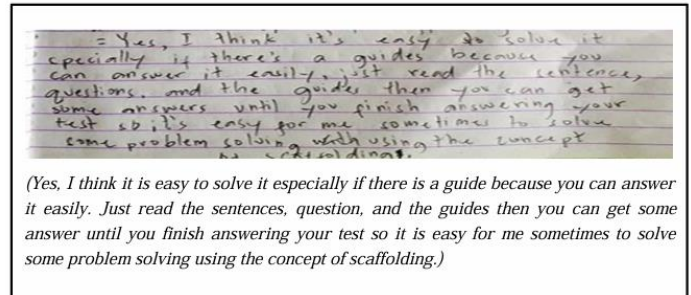
2) The scaffolding approach makes problem-solving tasks easier to answer.

The following responses are the samples from experimental group of students who were asked about the concept scaffolding approach if it is easy to use in answering problem-solving. The

students revealed that the concept of scaffolding approach makes problem-solving tasks easier to answer.

Figure 5

EGS21's Answer to the Question: Is it easy to solve problem solving with the use of scaffolding approach?



EGS3: Yes, for me because it is more challenging but try and try for me it is easy for the guide but if no guide I don't what I'm doing for me it's easy kasi may guide. (Yes, because it is more challenging but I have to try again. It is easy if there are guides, but if there are no guides, then I don't know how. It is easy because there are guides)

EGS9: Yes, It is easy to use scaffolding in answering problem solving because we can answer the question easily with help of scaffolding and you don't waste time.

EGS4: Yes, because if the teacher give a short time to finish answering the problem, you can use the rules of scaffolding to the problem to make you solve the problems easy and fast.

Some students revealed in their journal that concept scaffolding teaching approach is easy in answering problem-solving in mathematics. Experimental group student 3 (EGS3) declared in the interview that it is more challenging and it is easy to solve problems with the given guides. Similarly, experimental group student 21 (EGS21) can answer problem-solving easily if there are guides, she can use. Experimental group student 9 (EGS9) declared on her journal that with the help of scaffolding she can easily solve problems without wasting time. Moreover, experimental group student 4 (EGS4) revealed that he can solve problems with the use of scaffolding in a short time.

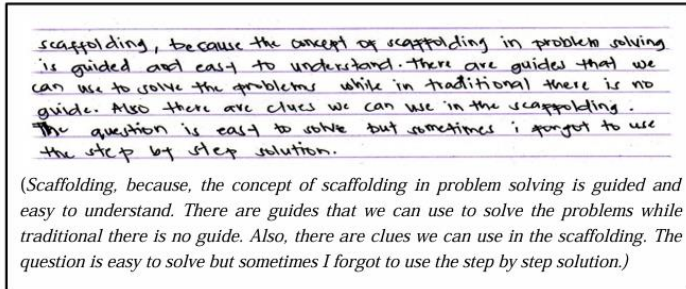
Based on the declared views of the EGS3, EGS21, EGS9 and EGS4, the concept scaffolding teaching approach is advantageous for the students because it supports and guides them in problem-solving. This suggests that math teachers should use different scaffolding strategies in mathematics that could help the students develop their problem-solving skills.

3) Students prefer the scaffolding approach over the traditional approach in solving mathematical problems.

The following responses are samples of the students' responses when they were asked about opinion in using traditional method or the scaffolding approach in answering problem-solving. The students revealed that the concept of scaffolding is more preferable than the traditional method.

Figure 6

EGS22's Answer to the Question: Which is easier for you in solving problem, the concept scaffolding approach or the traditional method?



EGS12: Mas gusto ko ang scaffolding because the concept of scaffolding is easy and we can answer the question easily for the help of scaffolding. (I prefer scaffolding because the concept of scaffolding is easy and we can answer the question easily with the help of scaffolding.)

EGS11: Concept of scaffolding ang gusto ko because madali ko masagot ang test or quiz at mabilis ako matapos and pass it early. (Concept of scaffolding is what I like, because I can easily answer the test or quiz and I can finish it quickly and pass it immediately.)

EGS2: For me I chose scaffolding because it is very useful to use especially when getting the area and volume of a shape. Also, it is very easy if you will understand the guides and the step-by-step properly.

Students chose the concept of scaffolding to solve problem-solving in mathematics. They preferred this concept because they can easily solve problems with the guides and support provided. Experimental group student 12 (EGS12) revealed during interview that she can solve problem easily with the help of scaffolding. Similarly, experimental group student 11 (EGS11) chose the concept scaffolding approach because she can answer and solve faster in the quiz or test. Experimental group students 2 (EGS2) and experimental group student (EGS22) chose the concept of scaffolding and revealed on their journal that they can easily answer the problems if they can understand guides and the step-by-step solution. EGS2 claims that scaffolding is very useful to use especially when getting the area and volume. EGS22 stated in her journal that there are clues and guides she can use in the scaffolding. The opinions of the students from the experimental group as they revealed in the one-on-one interview and students' journal are consistent with the results of the study of Ferguson (2013) and Anghileri (2006) that scaffolding is effective in learning mathematics. Also, the study conducted by Ihechukwu (2020) found that the use of an instructional scaffolding approach significantly improved secondary school students' achievement in mathematics compared to traditional teaching methods.

On the paper of Prabawanto (2017) investigated the enhancement of students' mathematical problem solving through teaching with

metacognitive scaffolding approach. He found out that under the scaffolding teaching approach and direct approach, there is a difference in mathematical problem-solving ability between students. Furthermore, he also found out that there is no interaction effect of teaching approaches and prior mathematical abilities toward the enhancement of students' mathematical problem-solving ability. Qualitative findings of Simons and Klein (2007) confirmed that the analyses of group notebooks have differences between students in the various conditions. Specifically, those in the scaffolding required condition produced more highly organized project notebooks containing a higher percentage of entries directly relevant to the problem. These findings suggest that scaffolds may enhance inquiry and performance, especially when students are required to access and use them. Results of Girgis (2015) revealed that students showed positive impact of the scaffolding strategy in their survey and the students expressed strong interest to further improve their problem-solving skills. Scaffolding is an appropriate approach to help students learn more skills and solve problems independently (Ismail et al., 2015).

IV. CONCLUSION

Based on the findings of the study, the following conclusions were drawn (1) Both control and experimental groups of students had an increase in their level of problem-solving performance, but more students in the experimental group were able to increase from a low to a moderate or high level. (2) The students' mean scores on the problem-solving performance test differed significantly between the control and experimental groups after the intervention ($p=0.00 < .05$). However, the students' mean gain scores on the problem-solving performance test showed no significant difference between the experimental and control groups ($p=0.06 > .05$). The study did not find sufficient evidence to detect a difference between the experimental and control groups of students' mean gain score in the problem-solving performance test. (3) The following themes have identified: (1) the concept scaffolding approach serves as a clear and effective guide that is easy to understand; (2) the concept scaffolding approach makes problem-solving tasks easier to answer; and (3) students prefer the concept scaffolding approach over the traditional method in solving mathematical problems.

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