Effects of Concept Scaffolding Teaching Approach on Grade 7 Students' Conceptual Understanding and Problem Solving Performance in Mathematics

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Abstract
Teachers must encourage their students to embrace mathematics and study it as simple as possible because majority of the students consider mathematics as one of the difficult subjects. This study aimed to investigate how the conceptual understanding and problem-solving performance of the students in mathematics were affected by the concept scaffolding teaching approach on the topic domain such special products and equations and inequalities in one variable. 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 mean scores between the control and experimental groups on the conceptual understanding test. Similarly, a significant difference was observed on mean gain scores between control and experimental groups on the conceptual understanding test. The mean score on the problem solving performance test showed a significant difference on control and experimental groups as well. However, it was discovered that there was no significant difference on the mean gain scores between the control and experimental groups 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 scaffolding teaching approach has a favorable effect on the conceptual understanding and problem solving performance of students in mathematics. The study was unable to distinguish the difference in the mean gain scores on the control group and experimental group in the problem solving performance test.

Keywords: Concept Scaffolding Teaching Approach, Traditional Teaching Approach, Problem-Solving Performance, Conceptual Understanding

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 conceptual understanding and problem-solving performance of Grade 7 students in mathematics.

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

1. What are the conceptual understanding levels in the control group and experimental group of Grade 7 students before and after intervention?
2. Is there a significant difference in the conceptual understanding 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 problem-solving performance levels in the control group and experimental group of Grade 7 students before and after intervention?
4. 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?

Conceptual Framework

The effects of the independent variable on the dependent variables were involved in the investigation of this study. The concept scaffolding teaching approach and the traditional teaching approach are the independent variables. Conceptual understanding and problem-solving performance are the dependent variables. The research paradigm in Figure 1 illustrates the flow in which the independent variable influences the dependent variables. The arrows show that the instructional approaches in the form of concept scaffolding teaching approach and traditional teaching approach affect the students' conceptual understanding and problem solving performance. The research paradigm that illustrates the conceptual framework is shown in Figure 1 to illustrate the direction of the investigation and to show the links between the dependent and independent variables.

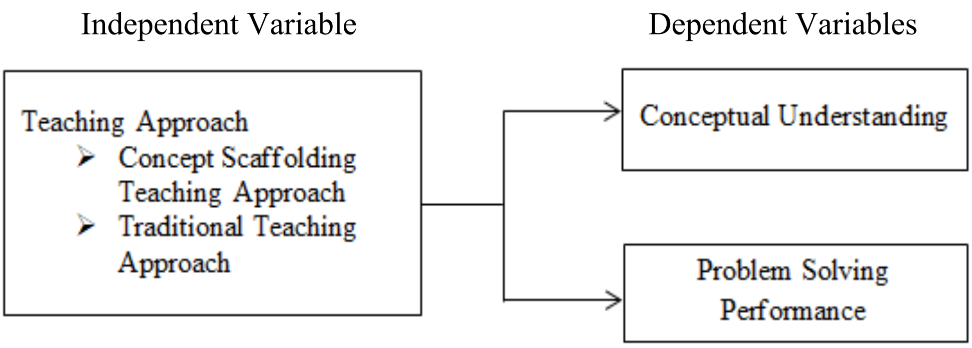

Figure 1: Research Paradigm

Scope and Delimitations of the Study

The scope of the study was limited to investigating how the concept scaffolding teaching approach affected the conceptual understanding and 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-Saguiaran Community High School of school year 2019-2020. 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.

Research Design

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 Conceptual Understanding Test and 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 concept 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 second quarter grade in mathematics for the academic year 2019–2020. 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 Conceptual Understanding Test, Problem Solving Performance Test, and other measurements. The concept 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 Conceptual Understanding Test, the Problem Solving Performance Test, and other measurements.

Locale of the Study

This research was conducted at the Mindanao State University-Saguiaran Community High School which is located in the barangay of Poblacion in Saguiaran, 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 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-Saguiaran Community High School for the academic year 2019–2020. The researcher chose Grade 7 students because the topic domains such as the special products, equations and inequalities are being taught in this level. 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.

Results and Discussions

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

What are the conceptual understanding levels in the control group and experimental group of Grade 7 students before and after intervention?

Table 1: Frequency count and Percentage Distribution of Students' Level of Conceptual Understanding in the Control and Experimental Groups

Level of Conceptual Understanding	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)
Well-developed	0 (0%)	0 (0%)	3 (13.6%)	11 (50%)
Developed	3 (13.6%)	5 (22.7%)	19 (86.4%)	11 (50%)
Less Developed	19 (86.4%)	17 (77.3%)	0 (0%)	0 (0%)
Total	22 (100%)	22 (100%)	22 (100%)	22 (100%)

Note: Raw Score: 31-40 – Well developed; 20-30 – developed; 0-19 – Less developed

As shown in Table 1, almost all students in the control group (86.4%) and experimental group (77.3%) had less developed level conceptual understanding prior to the instructional intervention. Very few students from control group (13.6%) and experimental group (22.7%) demonstrated a develop level of conceptual understanding. None of the students demonstrated a well-developed level of conceptual understanding from both groups. These findings appear to indicate that the majority of the students had little prior understanding of the subjects covered in the lecture, such as special products, equations, and inequalities, and this is to be expected. Obviously, students with no prior knowledge on the topic domains are defeated in problem-solving tasks. They have no pre-existing knowledge that they can utilize in solving the problem.

After the intervention, so few (13.6%) from the control and half (50.0%) in the experimental groups demonstrated well-developed level of conceptual understanding. Similarly, most (86.4%) of the students in the control group while half (50.0%) in the experimental group showed a developed level of conceptual understanding. None (0%) of the students in both groups showed a less-developed level of conceptual understanding. As seen in the post-test results following the intervention, many students from both groups increased their conceptual understanding levels. The experimental group, however, showed higher level of conceptual understanding than the control group.

Is there a significant difference in the conceptual understanding 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 shows the comparison of the groups on the conceptual understanding test mean scores before and after the intervention, as well as the mean gain scores. The .05 level of significance was applied to the t-test on independent samples. Prior to the instructional intervention, students in the both groups recorded lower mean scores (15.77 vs. 14.55), which were near to each other and thus not statistically significant ($p=0.38 > .05$). This indicates that both groups were initially comparable in their conceptual understanding on the topic domains of this study. Apparently, both groups of students had very limited or had no prior knowledge about the coverage of the third grading period in their mathematics before the intervention.

Table 2: Comparison of the Control Group and Experimental Group of Students' Conceptual Understanding Test

Period	Group	t-test for equality of means				
		Mean Score	Mean Gain Score	SD	t-value	p-value
Before Intervention	Experimental (n=22)	15.77		5.03	0.89	.38(ns)
	Control (n=22)	14.55		4.03		
After Intervention	Experimental (n=22)	30.45		5.14	3.80	.00(s)
	Control (n=22)	25.18		3.98		
	Experimental (n=22)		14.68	4.66	2.99	.01(s)
	Control (n=22)		10.64	4.28		

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

After intervention, the experimental group recorded a mean score that was higher than the control group (30.45 vs. 25.18), and the difference was statistically significant ($p=0.00<.05$) in the favor of the experimental group. The mean gain score of the experimental group is also considerably greater than the control group (14.68 vs. 10.64), and statistically significant ($p=0.01< .05$) with a t-value of 2.99 in favor of the experimental group. Evidently, the instructional intervention utilized with the experimental group showed to be effective in improving students' conceptual understanding. The use of scaffolding of concepts everytime they solved worded problems helped them in rehearsing and reflecting their understanding which is a constructivist way of learning. This is reasonable to expect because scaffolding is a metacognitive way of learning by guiding students as a technique of remembering.

What are the problem-solving performance levels in the control group and experimental group of Grade 7 students before and after intervention?

Table 3: Frequency count 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 3 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.

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?

Table 4: Comparison of the Control Group and Experimental Group of Students' Problem-Solving Performance Test

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 4 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.

Conclusion

Based on the findings of the study, the following conclusions were drawn. (1) Both the control and experimental groups of students had higher levels of conceptual understanding after using the concept scaffolding teaching approach but more students in the experimental group were able to advance from a less-developed to a well-developed level. (2) After the intervention, there was a significant difference in the mean conceptual understanding test scores between the control and experimental groups ($p= 0.00< .05$). The mean gain score on the conceptual understanding test for the students in the control and experimental groups also showed a statistically significant difference ($p= 0.01< .05$). This implies that the idea scaffolding instructional strategy improved the students' conceptual understanding of mathematics. (3) Moreover, both the 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. (4) Finally, 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.

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