Development of Mathematical Connection Skills of Grade II Students by Using Problem-based Learning with GeoGebra Program

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Abstract
The proposes of this study were 1) to develop the students' mathematical connection skills in order to pass the criteria of 50 percent of full score, 2) to study the relationship between the students' learning achievement and mathematical connection skills, and 3) to study the students' satisfaction toward the problem-based learning with GeoGebra program learning activities. The target group was 45 students of grade II student in academic year 2017 from Sarakhampittayakhom School, Muang, Mahasarakham. The research methodology is classroom action research which consists of three cycles. The research instruments were: 1) 12 lesson plans of the problem-based learning with GeoGebra program, 2) the mathematical connection skills test, 3) the learning achievement test, 4) the observation form, 5) the interview form, and 6) the satisfaction toward learning activity test. The data was analyzed by using mean, percentage, standard deviation and Pearson Correlation Coefficient.
The results were as follows
1. The students' mathematical connection skills mean scores in the first, the second, and the third cycle were 45.45, 57.47 and 62.76 percent respectively.
It obviously be seen that the students' mean score passed the criteria of 50 percent of full score in the second cycle.
2. The relationship between students' learning achievement and mathematical connection skills in the first, the second and the third were 0.85, 0.87 and 0.81 respectively. It could be seen that there were highly positive relation in each circle.
3. The level of students' satisfaction toward problem-based learning with GeoGebra program learning activities was in high level.

Keywords: Mathematical Connection skills, GeoGebra program, Problem-based Learning, Thailand

Introduction

Mathematics are very important in developing thinking ability, creative thinking and thinking logically. Moreover, mathematics can be integrated with science, technology and another fields (Ministry of Education, 2008, pp. 56.) In Thailand, mathematics consist of 5 skills which are 1) Problem solving skills 2) Reasoning skills 3) Mathematical expression skills 4) Mathematical connection skills and 5) creative thinking skills. Especially mathematical connection skills, it is very essential for students because these skills will make them understand and to be able to combine many mathematical knowledges together in everyday life problems logically (Ministry of Education, 2008, pp. 47). It is according to the concept of program for international assessment (PISA). PISA test is designed to assess the ability to understand the problems, the ability of integrating knowledges to solve problems and finding the solution properly (OEDC, 2017).

In 2015, the average score of PISA test for Thai student was 415 points out of 1,000 points, which was categorized to be under the average group by the score from students around the world at 490 points. It can be seen obviously that Thai students lacked of mathematical abilities when compared to another countries. Therefore, in order to confirm this problem, the researchers assessed the mathematical connection skills for grade II students in Sarakham Pittayakhom school, the number of all students were 45. The score for this test has been set to 5 levels which are very good, good, fair, pass and under criteria level. The results showed that no student in very good and good level but there were 4 students in fair level, 4 students in pass level and 37 students in under criteria level. Therefore the researchers want to find solutions which can improve mathematical skills especially mathematical connection skills of these students.

The researchers have studied many concepts and theories about learning activities that enhance the mathematical connection skills. We found that the way to develop the mathematical skills are 1) Giving students to solve the problems by themselves with a little guide from teacher 2) Using group activity to create interaction, discussion and help each other to solve the problems (IPST., 2003, pp. 172-173). It is according to the problem-based learning activity (PBL), PBL lets student to engage the problems by themselves and interaction among group which can lead to the clearly understanding and be able create several ways to solve the problems (Kammanee, 2016, pp. 137-138). Moreover, learning mathematics is sometime hard to understand because mathematics consist of many abstract knowledges. In order to make mathematics more concrete, we used technologies in modern day like mathematical programs which can be seen widely such as The Geometer's sketchpad program (GSP), MatLab program, Maple program and GeoGebra program. From the programs that mentioned, GeoGebra is the program we were interested because this program is widely used by teacher all over the world and GeoGebra program is also a free program or freeware which means no need to pay money for using it (International GeoGebra Institute, 2017). In GeoGebra program, there are many tools that provide teacher to construct the introduction media very easily for example 3D tools, conic section tools, and calculus tools.

As mentioned before, the researchers want to develop the mathematical connection skills of students in Sarakhampittayakhom School to be in pass level (More than 50

percent of full score) or above by using problem-based learning activity with GeoGebra program.

Research Purposes

1. To develop the students' mathematical connection skills in order to pass the criteria of 50 percent of full score.

2. To study the relationship between the students' learning achievement and mathematical connection skills.

3. To study the students' satisfaction toward the problem-based learning with GeoGebra program learning activities.

Target group

The target group was 45 students of Grade II student (Room 6) in academic year 2017 from Sarakhampittayakhom School, Muang Mahasarakham, Thailand.

Research Instruments

1. 12 lesson plans of the problem-based learning with GeoGebra program.
2. The mathematical connection skills test.
3. The learning achievement test.
4. The observation form.
5. The interview form.
6. The satisfaction toward learning activity test.

Methodology

This research is classroom action research, there are 4 steps in each cycle which are 1) Planning, 2) Action, 3) Observation and 4) Reflection. Which was detailed as the following.

1. Planning

1. Observing students who have problems with mathematical connection skills by using mathematical connection skills test that were adopted from Atchanee Chuchuaisuwan's mathematical connection skills test (2009, pp. 94-112). We only observed in the first cycle, for the next cycle we analyzed results from the reflection step form previous cycle in order to improve the next cycle.

2. Constructed the research instruments including 1) 12 lesson plans of the problem-based learning with GeoGebra program, 2) The mathematical connection skills test, 3) The learning achievement test, 4) The observation form, 5) The interview form and 6) The satisfaction toward learning activity test. After finished constructing, all research instrument were examined by experts to ensure the instruments were capable for using with the target group.

2. Action

1. We applied the problem-based learning with GeoGebra program lesson plans to the target group. The lesson was vector in 3 dimensions as showed in table 1.

Table 1 Problem-based learning with GeoGebra program lesson plans in each cycle.

Cycle	Lesson	Title	Time
1	1	3 Dimensional scene coordinates	1
	2	Length between two points in 3 dimensional scene coordinates	1
	3	Vector	1
	4	Adding and subtracting vector	1
	5	Vector multiplication by scalar	1
2	6	Vector in 2 dimensional scene coordinates	1
	7	Vector in 3 dimensional scene coordinates	1
	8	Length of vector in 2 dimensions	1
	9	Length of vector in 3 dimensions	1
3	10	Unit vector in 2 dimensions	1
	11	Unit vector in 3 dimensions	1
	12	Directional cosine	1
Total			**12**

3. Observation

1. We used the observation form to observe students during learning activities in each lesson plan.

2. We used the interview form to interview students for those who passed the 50 percent criteria and under 50 percent criteria. In order to compare the differences and causes for improving the next cycle.

3. We used the mathematical connection skills test and the learning achievement test to assess the mathematical connection skills and find the relationship between mathematical connection skills and learning achievement. After finishing all cycles, we used the satisfaction forward learning activity test to assess the satisfaction of students about problem-based learning with GeoGebra program learning activities.

4. Reflection

We analyzed the results from the mathematical connection skills score compared to the 50 percent criteria, the observation form and the interview form. From all results, we improve the learning activity to be effective enough to make the target group pass the criteria. Lastly, after all student passed the criteria, we analyzed the relationship between mathematical connection skills and the learning achievement.

Conclusion

The mathematical connection skills score after using problem-based learning with GeoGebra program compared to the criteria was showed in table 2.

Table 2 The mathematical connection skills score after using problem-based learning with GeoGebra program compared to the criteria.

Student No.	Mathematical connection score					
	Cycle 1		Cycle 2		Cycle 3	
	Percent	Assessment	Percent	Assessment	Percent	Assessment
1	40.91	Under	54.55	Pass	63.64	Fair
2	50.00	Pass	63.64	Fair	63.64	Fair
3	45.45	Under	54.55	Pass	54.55	Pass
4	50.00	Pass	63.64	Fair	59.09	Pass
5	45.45	Under	54.55	Pass	59.09	Pass
6	40.91	Under	54.55	Pass	54.55	Pass
7	45.45	Under	63.64	Fair	59.09	Pass
8	54.55	Pass	54.55	Pass	63.64	Fair
9	40.91	Under	54.55	Pass	68.18	Fair
10	40.91	Under	40.91	Under criteria	68.18	Fair
11	40.91	Under	54.55	Pass	63.64	Fair
12	54.55	Pass	63.64	Fair	72.73	Good
13	45.45	Under	40.91	Under criteria	68.18	Fair
14	50.00	Pass	59.09	Pass	59.09	Pass
15	45.45	Under	68.18	Fair	68.18	Fair
16	59.09	Pass	63.64	Fair	54.55	Pass
17	50.00	Pass	68.18	Fair	59.09	Pass
18	40.91	Under	40.91	Under criteria	59.09	Pass
19	36.36	Under	54.55	Pass	63.64	Fair
20	50.00	Pass	63.64	Fair	77.27	Good
21	40.91	Under	63.64	Fair	54.55	Pass
22	40.91	Under	59.09	Pass	63.64	Fair
23	27.27	Under	54.55	Pass	72.73	Good
24	40.91	Under	50.00	Pass	68.18	Fair
25	31.82	Under	45.45	Under criteria	63.64	Fair
26	45.45	Under	45.45	Under criteria	72.73	Good
27	36.36	Under	59.09	Pass	63.64	Fair
28	31.82	Under	63.64	Fair	63.64	Fair
29	40.91	Under	63.64	Fair	54.55	Pass
30	45.45	Under	63.64	Fair	68.18	Fair
31	50.00	Pass	59.09	Pass	54.55	Pass
32	45.45	Under	68.18	Fair	54.55	Pass
33	45.45	Under	63.64	Fair	63.64	Fair
34	54.55	Pass	54.55	Pass	63.64	Fair
35	50.00	Pass	54.55	Pass	59.09	Pass
36	59.09	Pass	68.18	Fair	54.55	Pass
37	68.18	Fair	54.55	Pass	68.18	Fair
$\overline{X}$	45.45	Under	57.47	Pass	62.76	Fair
S.D.	7.98	-	7.64	-	6.06	-

From table 2, the mathematical connection skills score in the first cycle was 45.45 percent when compared to the criteria in was in the under criteria level, the score in the second cycle was 57.49 percent when compared to the criteria it was in the pass level and the score in the third cycle was 62.78 percent when compared to the criteria in was in the fair level. In conclusion, the mathematical connection skills was higher in every cycle after we applied problem-based learning with GeoGebra program lesson plans and all students obtained the pass level in the second cycle but the researchers want to ensure that the learning activities are compatible to escalate mathematical connection skills so we continue applying the third cycle.

The relationship between mathematical connection skills score and the learning achievement score of vector in 3 dimensions learning content was analyzed by using Pearson correlation coefficient. The results were categorized in to cycles as showed in table 3.

Table 3: The relationship between mathematical connection skills score after applying problem-based learning lesson plans and the learning achievement score about vector in 3 dimensions.

Student No.	Cycle 1		Cycle 2		Cycle 3	
	Mathematical connection skills percentage	Learning achievement percentage	Mathematical connection skills percentage	Learning achievement percentage	Mathematical connection skills percentage	Learning achievement percentage
1	50.25	52.13	55.82	61.12	65.27	66.17
2	65.43	63.28	63.56	66.67	67.83	73.35
3	56.72	51.26	59.74	63.34	65.87	62.34
4	43.26	45.11	51.25	56.89	58.13	63.94
5	41.43	47.23	52.00	46.15	57.65	61.45
6	32.76	37.84	45.68	55.35	57.38	60.42
7	45.78	55.32	47.41	50.27	55.43	59.82
8	56.32	51.34	65.13	69.13	68.84	73.25
9	50.00	65.46	56.74	58.44	68.92	73.25
10	43.45	47.65	56.71	61.82	64.18	65.28
11	32.16	40.12	52.13	55.26	65.74	64.13
12	41.28	45.38	56.72	59.95	64.56	67.94
13	48.82	50.67	57.87	60.86	67.58	70.35
14	54.83	56.82	67.88	66.12	70.12	70.72
15	55.34	57.82	65.76	68.23	54.23	57.85
16	56.49	60.49	65.33	68.83	62.34	67.56
17	51.28	53.48	65.33	63.34	65.54	61.12
18	40.32	45.39	58.18	61.12	63.15	67.56
19	37.45	40.94	58.59	61.12	62.83	62.42
20	36.78	41.45	55.61	58.44	58.94	62.42
21	41.93	47.63	56.72	55.35	64.51	67.85
22	52.67	55.39	65.78	68.55	66.72	65.28

23	45.89	47.73	57.89	56.21	65.27	67.94
24	43.37	45.24	58.19	56.89	63.47	64.13
25	29.21	35.65	48.34	55.12	58.75	62.34
26	45.78	59.26	55.76	55.26	61.23	64.13
27	41.12	42.13	58.92	61.12	65.67	67.94
28	45.32	47.68	56.33	59.9	58.82	62.12
29	32.11	40.68	53.12	56.35	56.79	60.72
30	56.73	61.23	67.89	66.84	65.27	64.13
31	43.56	39.45	58.79	61.12	63.46	64.13
32	46.57	47.82	57.28	61.12	62.92	67.94
33	41.19	45.86	56.82	58.44	65.35	66.82
34	42.13	43.32	54.72	56.82	57.30	61.65
35	34.47	37.19	45.67	47.67	58.79	61.65
36	45.89	50.82	56.72	56.35	57.84	60.19
37	52.82	48.16	60.12	63.89	65.43	64.45
r_{XY}	**0.85**		**0.87**		**0.81**	

From table 3 the correlation between mathematical connection skills score after applying problem-based learning lesson plans and the learning achievement score about vector in 3 dimensions in cycle 1, 2 and 3 were 0.85, 0.87 and 0.81 respectively, when compare the Pearson correlation coefficient with the criteria (Bartz, 1999, pp. 184 as cited in Srisa-ard et al, 2012, pp. 92) we found that the correlation was in high level.

The satisfaction toward learning activity of students after we applied the problem-based learning with GeoGebra program lesson plans were separated into 3 fields which are

1. The nature of work: how satisfaction student have with the learning activities for example the difficulty, contents, challenging and timing.

2. Workmate: How satisfaction student have with teamwork for example interacting, cooperation and good relation among group.

3. Reward: how satisfaction student have with the returns from the learning activities for example prolong memorizing, deeply understanding and mathematical connection skills.

The results were showed in table 4

Table 4: The satisfaction score toward problem-based learning with GeoGebra program learning activity of grade II students.

Item	**Question**	$\overline{X}$	**S.D.**	**Satisfaction level**
Field 1: The nature of work				
1	Student satisfies with the difficulty of the learning activities and it is suitable for student.	4.20	0.62	High
2*	Student feels that the learning activities are not suitable with the contents.	1.91	0.73	Low

3	Student satisfies that the amount of activities are suitable with time.	4.26	0.60	High
4*	Student thinks the learning activities are difficult and bored.	1.97	0.74	Low
5	Student likes the challenging of the learning activities that allow student to learn and solve the problem by yourself.	4.34	0.58	High
Field 1 average		4.18	0.66	High
Field 2: Workmate				
6	Student likes that the members work together very well.	4.29	0.61	High
7	Student likes that the members honor each other and listen to other's opinions.	4.26	0.65	High
8*	Student dose not satisfy that the members recommend each other to do improper things.	1.37	0.54	Lowest
9	Student likes that all members are friendly.	4.49	0.55	High
10*	Student dose like group working.	2.17	0.70	Low
Field 2 average		4.30	0.61	High
Field 3: Reward				
11	Student satisfies that the learning activities can enhance the abilities to connect the mathematical knowledges together to solve the problems.	4.40	0.60	High
12	Student likes that the learning activities help student to understand the contents easier.	4.60	0.49	Highest
13	Student satisfies that the learning activities make student understand the contents deeply and longer.	4.54	0.55	Highest
14	Student likes that the learning activities can make student constructs the knowledge by yourself.	4.49	0.60	High
15	Student satisfies with the score that student obtain after the leaning activities have applied.	4.43	0.60	High
Field 1 average		4.49	0.57	High
Overall average		4.32	0.61	High

* Negative question

From table 4 Students satisfaction toward learning activities overall score was 4.32 (S.D. = 0.61) which was in high level, when analyzed in the individual field we found that the satisfaction of students toward reward field had the highest score, average 4.49 (S.D. = 0.57) which was in high level. Next, the satisfaction toward workmate, average 4.30 (S.D. = 0.61) which was in high level and the satisfaction toward the nature of work, average 4.18 (S.D. = 0.66) which was in high level as well.

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