Effects of Using Problem-Based Learning Digital Game on Problem-Solving ability for Science subject of Primary Students

ผลของเกมดิจิทัลการศึกษาแบบใช้ปัญหาเป็นฐานเพื่อเสริมสร้างความสามารถในการแก้ปัญหาในวิชาวิทยาศาสตร์สำหรับนักเรียนประถมศึกษา

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Abstract

        This research aimed to compare problem-solving ability of Science before and after using problem-based learning digital game. The subjects were 60 Prathom 6 students. By purposive sampling, there were 30 students from Prachaniwet School, which was public school under OBEC in Bangkok, Thailand and another 30 students from Kaseampitaya, which was private school in Bangkok, Thailand. Problem-based learning digital game and Science problem-solving test were used as research instruments. The statistics was analyzed by means, standard deviation, and t-test dependent. The result were found that the comparison between before using problem-based learning digital game with both two groups of students were not significant difference (p < 0.05) and the posttest averagescores by two groups of students were higher significantly than pretest average score (p< 0.05)

Keywords: Problem-based learning digital games, Problem-Solving ability for Science subject

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บทคัดย่อ

การวิจัยครั้งนี้มีวัตถุประสงค์เพื่อเปรียบเทียบความสามารถในการแก้ปัญหาวิชาวิทยาศาสตร์ก่อนและหลังเรียนด้วยเกมดิจิทัลการศึกษาแบบใช้ปัญหาเป็นฐาน กลุ่มตัวอย่างที่ใช้ในการวิจัยครั้งนี้คือนักเรียนระดับชั้นประถม ศึกษาปีที่ 6 จำนวน 60 คน โดยผู้วิจัยได้เลือกกลุ่มตัวอย่างแบบเฉพาะเจาะจง (Purposive Selection) จากโรงเรียนประชานิเวศน์ ซึ่งเป็นโรงเรียนประถมศึกษาสังกัด สพฐ. จำนวน 30 คน และโรงเรียนเกษมพิทยา เอกชน ซึ่งเป็นโรงเรียนประถมศึกษาสังกัดเอกชน จำนวน 30 คน เครื่องมือที่ใช้ในการวิจัยประกอบด้วย เกมดิจิทัลการศึกษาแบบใช้ปัญหาเป็นฐาน และแบบทดสอบความสามารถในการแก้ปัญหาวิชาวิทยาศาสตร์ สถิติที่ใช้ในการวิเคราะห์ข้อมูลคือ การวิเคราะห์ค่าเฉลี่ย ส่วนเบี่ยงเบนมาตรฐาน และ t-test dependent ผลการวิจัยพบว่า ผลการเปรียบเทียบคะแนนความสามารถในการแก้ปัญหาในวิชาวิทยาศาสตร์ก่อนเรียนของกลุ่มตัวอย่างทั้ง 2 กลุ่ม พบว่า กลุ่มตัวอย่างทั้ง 2 กลุ่มมีคะแนนการทดสอบก่อนเรียนไม่แตกต่างกันอย่างมีนัยสำคัญทางสถิติที่ระดับ .05   และ ผลการเปรียบเทียบค่าเฉลี่ยของคะแนนในการทำแบบทดสอบก่อนเรียน และคะแนนแบบทดสอบหลังเรียนของกลุ่มตัวอย่างทั้ง 2 กลุ่ม พบว่า คะแนนเฉลี่ยของคะแนนในการทดสอบหลังเรียนของกลุ่มตัวอย่างทั้ง 2 กลุ่ม แตกต่างจากคะแนนเฉลี่ยของคะแนนในการทำแบบทดสอบก่อนเรียนอย่างมีนัยสำคัญทางสถิติที่ระดับ .05

คำสำคัญ : เกมดิจิทัลการศึกษาแบบใช้ปัญหาเป็นฐาน**,** ความสามารถในการแก้ปัญหาในวิชาวิทยาศาสตร์

Introduction

Digital games had been used for education in the late of 20th century that direct lecture was the most popular teaching method teachers used. This method influence learning quality which caused students lack of effective learning and felt bored on learning Albert (1988 cited in Prensky, 2001) stated that learning from teacher's explanation would help learner achieve learning only 20-25 percent. It was related to Papert (1998) commented that the reason students did not want to learn not came from a lot of tasks or homework but came from teaching method that could not encourage students to enjoy learning. By observation of primary students' behaviors, it was found that primary students enjoy playing more than learning through lecture for many hours (Acredolo, 2007). By above reasons, direct lecture by teachers was not support and encourage learning style for primary students. It also separated fun world from learning world. Hence, it enlightened an idea to combine fun world and learning world together through digital game. It would change students' attitude that learning tasks would be hard and difficult became learning would be more fun. It was the first step to bring games for instruction (Prensky, 2001).

Concept of using digital game-based learning started by using computer games both offline and online for instruction. Most games were parts of knowledge, challenges, and attractive players; especially, the same age (Squire, Giovanetto, Devane, and Durga, 2005). While Malone (1981) found that components which made games were popular were challenge, imagination, and curiosity. As a result, games became effective instructional tools. Betz (1995) said that games and learning are similar. While playing games, players were not only fun with game, learning new vocabulary and main concepts, but also learn how to thinking method which would facilitate on academic learning (Squire, forthcoming cited in Squire, et al, 2005). In addition, Egenfeldt – Nielsen (2005) found that students who play games tried to comprehend basic and how to play the game and some hidden things in the game. These interesting concepts enhanced students' learning. Prensky (2001) also supported that computer games were attractive players very much, then using games could be attractive with the boring contents with these reasons;

1. Learning through computer games should be suitable for needs and learning model in present and future time.

2. Learning through computer games encouraged students because of fun

3. Learning through computer games was useful, it could be adapted to all subject matters including correct information and learning skills.

Moreover, it was found that games could be used as learning materials for primary students (Singh et al, 2008; Shiratuddin and Zaibon, 2011). General characteristics and needs of primary students (6-12 years old) (Wannika Chalalakbang, 2004) consisted of learning by doing, being curious, exploring everything around themselves, learning through experiences, having short attention, learning by playing. Playing was nature of children that made them fun and comprehended learning. Competition was interesting because it could encourage students' attention. Showing off and showing performance also encouraged students because children liked respect, needed achievement and position in society. These requirements pushed student to do many activities, tried to work well or tried to work hard. It showed that learning with digital games could support learning natural and needs of primary students. As a result, students could learn by doing, learning through direct experiences, having various activities. Students learned through playing which was relate to nature of children that made students fun and learned, competed with friends, competition could encourage students' attention because of respect from society.

Nowadays, educators tried to develop games to enhance players to learn (Gee, 2003) and used the gamed in teaching through players' experiences under conditions of useful knowledge such as problem solving idea in different situations (Bransford, Brown, & Cocking, 1999 , Gee, 2003 , Squire, 2003 cited in Squire, Giovanetto, Devane, and Durga, 2005) The study of using games in teaching to develop problem solving skills as White (2000) studied about using computer game for learning Physics to improve problem solving skills for Junior students. The results revealed that computer games could increase students' problem solving skills which was accordance with Kim, Park, and Baek (2009) that used games to fix social problems that students could cope with the social problems. Moreover, it was accordance with Gee (2003) that stated capability of game on problem solving thinking process which helped students to find out variety of solution for each problem. As above, using digital games in teaching could improve problem solving abilities.

Problem solving skill was important for daily life as Britz and Richard (1993) explained that problem solving skill was basic ability for lifelong learning because it was the ability that children needed to acquire knowledge in order to have comprehensible and meaningful learning. It was related to Welker (2006) who said that thinking on problem solving and making decision were important for learning. When students could think for solving the problems, they could have self- sufficiency when they grew up. From all these reasons, thinking on problem solving was important because it was the necessary ability for lifelong learning and solved any problems that they had to face with such as studying, acquiring knowledge including working and daily life. Problem solving process was also important and necessary for all students to learn and comprehend, could think and cope with any problems in order to adapt these process in their real lives, Due to practice of problem solving, students could have metacognitive and systematical thinking, reasonable thinking, and making clever decisions. Problem solving needed the process which required knowledge, thoughts, and previous experiences to make comprehension with the problem and look for the best solution with below four steps (Weir, 1974; Guildford, 1967; Treffinger, Isaksen and Dorvel, 2000)

1. Defining the problem was the ability of consideration, review and situation analysis to explore and comprehend the problem.

2. Analyzing causes of the problem was the ability to analyze causes of the problems, discriminate and look for relation between problem and surrounding.

3. Providing solution was ability of problem solving thought that was related to the analyzed problem and made decision to select the most suitable solution for the problem which could be one or more solutions.

4. Evaluating the solution was the ability of consideration to set criteria for solution evaluation and discussed the predicted results after using that solution.

From the change of society both ideas and technology, it caused people had more complex in daily life. They had to cope with many problems and whoever could solve problem faster and cleverer, that person would be reach the achievement in society well. Hence, problem solving skills was important ability for living nowadays. Results from national

conference by OBEC, Kenan Institute Asia and IPST to "improve basic science education quality B.E. 2555 (A.D.2012)" during 26 -27 August 2012. There were many teachers came to discuss and analyze PISA scores that were very low because they lacked of problem solving skills. Moreover, IMD ranked educational competition in 2011, it was shown that Thailand was at 51 of 57 countries. It was lower rank from rank 46 in 2007. In addition, Program for International Student Assessment (PISA) focusing on science and mathematics scores, it was found that Thailand was at the based rank while other ASEAN countries were in higher ranks. It reflected quality of science education in Thailand that used the traditional teaching style that could not encourage students' learning (Bangkokbiznews, 2012). To improve students to have problem solving skills would be necessary objectives of education because problem solving skills was the thinking ability from people who had experiences and practice until being mastery. This skill was required to use frequently. For a person who had problem solving skills, he/ she should practice their thinking of problem solving, have some experience to solve problems. Those experiences came from practicing in school. Providing education should revolute learning process to develop people and fulfill humanity for being able to think, do, solve problems, and collaborate in society which was related to real life (Prawet Wasi, 2001)

Science was important in real world nowadays because science was related to everyone' s life such as daily life, works, technology, tools and products that people made for being facilitators. Those things combined science knowledge and creativity that help people to improve thinking skills including reasonable thoughts, creative thinking, criticize, information gathering skills, solving problems systematically, making decision with many sources of information. Science focused on students linking their knowledge with science process, having inquiry skills and using various problem-solving skills while encouraging students participate all

steps of learning though variety of activities and suitable for student's level. Finally, students can learn by doing (Bureau of Academic Affairs and Educational Standards, 2009).

From above data, problem solving ability was an important goal of instructional design nowadays; especially, learning science. It should be support students to have this skill because this skill was necessary for students' daily life. Using games in teaching science was an interesting tool that could improve effective teaching, increase students' problem-solving skills. Researcher designed to study effects of using problem-based learning digital game on problem solving ability for science subject of primary students, which the results could use as guidelines for designing problem-based learning digital game that would more suitable for students. It could improve students' learning and be a solution to help students having problem solving ability on science much more.

Research questions

Do students who learn with problem-based learning digital game have posttest score higher than pretest?

Research objective

This research aimed to compare problem-solving ability of science subject before and after using problem-based learning digital game.

Research hypotheses

Prathomsuksa 6 students would have problem solving score after using problem-based learning digital game higher than before using problem-based learning digital game significantly (p <0.05).

Scope of the research

The population is Prathomsuksa 6 students.

Research samples are the subjects were 60 Prathom 6 students. By purposive sampling, there were 30 students from Prachaniwet School, which was public school under OBEC and another 30 students from Kaseampitaya, which was private school.

Research design

The research design is Quasi-experimental research by two treatment groups as following (Sirichai Kanchanawasi, 2009)

Treatment Group 1	R_1 O_1 X_1 O_2
Treatment Group 2	R_2 O_3 X_1 O_4

When R_1 was group 1 students

R_2 was group 2 students

O_1, O_3 were pretest

X_1 was treatment of using problem-based learning digital game

O_2, O_4 were posttest

Research tools and methods for research tool development

The research tools for problem solving score comparison both pretest and posttest for using problem-based learning digital game consisted of

1. Problem-based learning digital game which title was "Trash and disposal management" by a variety of multimedia combination such as texts, photos, graphics, animations, sounds with hyperlinks that would help students access to information easily through RPG maker software. Its details were followed below;

1.1 Tell the game rules: Game started the scene with the big green field and then would show the game's rules, how to move, how to use any commands to ask for help from facilitators in the game (angels) and how to evaluate and tell about important related conditions.

1.2 Present the game objective: In the game, there would be shown the pop up about situation that students had to go to science camp to practice science processes in 7stages; after that, students would assume as the head of Prathomsuksa 6 to help school doing trash management in school.

1.3 Register the game: Students had to put nickname in the game by using English up to 10 letters, then click "OK".

1.4 Review previous knowledge about science processes and knowledge about trash.

This game name was "Fight for School" the synopsis of this game started with the competition of Zero waste project in students' province and students' school was an applicant. The winner of this competition was the school where were the best trash management. The criteria to win the project were not only good at trash management but

also higher making value from the trashes. School director encouraged students by showing the real situation in school that was full of trashes and never had serious trash management, then asked students to participate for being winner of this project with creativity and useful problem- solving ideas. Content and missions that students had to do in this game consisted of 5 stages as follow;

Stage 1 Provide the problem

School director tell teachers and students that school would be competition of Zero waste project. The winner of this project would be the school where had the best trash management. After that, school director set Prathomsuksa 6 students as players who were the head of the trash management project in school. These players had to walk around the school such as restrooms, canteen, playground, classrooms, garden, building, and library to observe trash problems, which concerned about which trash problem was, what were causes, and then analyzed the solution in urgent and which trash problems needed to fix first with asking from people in school or reading janitor's daily notes. The difficulty of this stage was to find out the problem for passing this mission

Stage 2 Explore the causes

Player had to walk around the school to look for trashes and look for causes. To find the causes, player had to survey from people in school and then analyzed the causes of the problems. The difficulty of this stage was to look for the causes of problem to pass this stage.

Stage 3 Find out the solutions

Player would present solutions for trash management to teachers and school director. Player should present the best solution which was useful and valuable to school. Player could look for more information from books in library or by asking teachers, janitors, or friends. The difficulty was to look for the best solution to manage the trashes.

Stage 4 Evaluate the solution

Player would evaluate the solution that was offered to school director and teachers by telling the solutions and predicting the results from the solutions and presenting how to make money from the trashes. Player had to do real experiments, find out the results and answer the school director and teachers.

Stage 5 Fight for school

Player had a mission to manage the trashes by choosing a place in school to manage the trashes following with selecting the activity for trash management. If player choose correct activity, school will get one point.
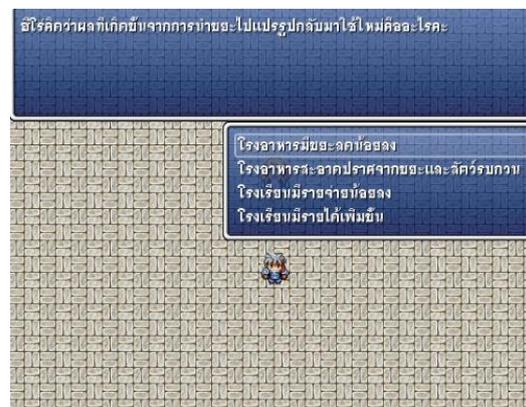
2. Science problem-solving test for pretest and posttest which developed as following steps

2.1 Literature reviews was done from textbooks, journals, and related researcher papers about Science problem-solving test design on "Trash and disposal management" for Prathomsuksa 6 according to the Basic education core curriculum B.E. 2551 by Ministry of Education.

2.2 Topic content areas were analyzed with another instructor and then made the test items according to scope of research and operational definitions.

Operational definition was problem solving skill referred to the way that people used knowledge, critical thinking and previous experience for solving problems in a situation through making appropriate decisions which consisted of four sub skills; to identify problem, to analyze the problems, to present solutions, and to check problem results as following detail

1) To identify problem meant to tell or describe the problems from given situations

2) To analyze the problems meant to identify causes of the problems correctly

3) to present solutions meant to present or show suitable solutions or ideas to solve the problems

4) To check problem results meant to analyzes, examine, and discuss the results from the selected solutions

2.3 Research designs the table of Science problem-solving test structures and numbers of test items in Accordance with the operational definitions.

Table 1 Science problem-solving test structures

Test objectives	Item No.	Total
1. To identify the problems	1, 5, 9, 13, and 17	5
2. To analyze the problems	2, 6, 10, 14, and 18	5
3. To present solutions	3, 7, 11, 15, and 19	5
4. To check problem results	4, 8, 12, 16, and 20	5
Total		20

2.4 Researcher made and developed the Science problem-solving test on "Trash and disposal management" for Prathomsuksa 6. The test items were multiple-choices with four choices. Daily life situations were used as questions. Each correct answer would receive one point, either zero for wrong answer. The test papers consist of two tests, five situation each with four questions.

2.5 The test papers were checked accuracy and content comprehension by advisor and improved as advisors' suggestions

2.6 Researcher asked 3 experts to check validity of test papers, operational definitions, and test specifications. The criterias of expert selections were 1) experts who were specialist on problem-based learning, 2) experts who were specialist on teaching science for primary students, and 3) experts who were specialist on teaching Thai language for primary students (details in appendix A). The test papers were checked and edited by item-objectives congruence, after that IOC analysis was used for checking items validity and selected the test items that were passed IOC index, which item had IOC index higher than 0.5, that item was selected (Sirichai Kanchanawasi, et al., 2001). The IOC index results of both test papers were between 0.67-1.00 which were higher than 0.5 that could accepted for test item validity and the test quality analysis was found that most of test items were included the test objectives as test specification but some items should improve language for easier comprehension, make problem situation more clear, less complicated, improve distracters to be better distracters.

2.7 Researcher edited the test papers according to experts' suggestions. The test papers were checked content validity and improved the items' texts as experts gave suggestions.

2.8 The test papers were tried out by 29 students who had similar characteristics with the samples to find out reliability by KR-20, Kuder and Richardson. The realiability of two test parer were 0.72 and 0.80, repectively. The dificulties were 0.33-0.60 while discrimation of the test papers were between 0.25-0.56.

2.9 Concurrent Validity was checked with F-test. It was found that concurrent validity was similar. Moreover, the equality of variation by F-test was found that the paper test was not significant ($p>0.05$), it meant that both of tests were not different significantly as results in table 2 and 3.

Table 2 The comparison of parallel test of both test papers

	Test paper 1 (20 items)	Test paper 2 (20 items)
1. Difficulties	0.478	0.472
2. Discrimination	0.384	0.386
3. Reliability	0.80	0.72
4. Mean	9.59	9.45
5. Variation	14.47	19.18

Table 3 The result of Concurrent Validity

		Mean	Variance	Levene's test		t-test	P
				F	sig		
Problem solving test	**paper 1**	9.59	14.47	.395	.532	.128	.899
papers	**paper 2**	9.45	19.18				

Data collection

Data was collected as followed;

1. Students from both groups had to do pretest which had 20 items in 50 minutes.

2. Both groups of students learned with problem-based learning digital game in 3 hours which had details below;

2.1 Students learned science process 1 hours.

2.2 Students learned science content of "Trash and disposal management" 2 more hours.

2.3 Students did posttest after learned with problem-based learning digital game which test paper had 20 items for 50 minutes.

3. Students were collect data on frequency of playing game by counting students times to choose games guidance. Moreover, pretest and posttest scores were collected to analyze statistics in further.

Data analysis

The statistics for score comparison on problem solving skills on Science before using problem-based learning digital game with both two groups of students was analyzed by means, standard deviation, and t-test dependent.

Results

Table 4 Mean ($\bar{x}$) standard deviation (S.D.) and t score (t-test independence) of the pretest
score for Prathomsuksa 6 students from private school and public school

Samples	n	$\bar{x}$	S.D.	t -test	Sig.
Prathomsuksa 6 students from private school	30	10.80	2.61	-1.941	.057
Prathomsuksa 6 students from public school	30	11.93	1.86		

*p<0.05

From the table 4, the result was revealed that mean, standard deviation, t score of both groups of students on pretest were not different significantly at 0.05 level. For Prathomsuksa 6 students from private school, they had average score at 10.80 and standard deviation was 2.61 While Prathomsuksa 6 students from public school had average score at 11.93 and standard deviation at 1.86.

Table 5 Mean ($\bar{x}$) standard deviation (S.D.) and t score (t-test independence) of the pretest and posttest score for Prathomsuksa 6 students from private school and public school

Samples		n	$\bar{x}$	S.D.	t-test	Sig.
Prathomsuksa 6 students from	Pretest	30	10.80	2.61	-5.645	.000[*]
private school	Posttest		12.97	2.44		
Prathomsuksa 6 students from	Pretest	30	11.93	1.86	-7.290	.000[*]
public school	Posttest		15.10	1.83		

*p<0.05

The result was shown that mean ($\bar{x}$) standard deviation (S.D.) and t score (t-test independence) from posttest for both two groups of students were higher significantly at level 0.05 than pretest score. Prathomsuksa 6 students from private school had pretest average score at 10.80, standard deviation was 2.61 and posttest average score at 12.97, standard deviation was 2.44. ForPrathomsuksa 6 students from public school had pretest average score at 11.93, standard deviation was 1.86 and posttest average score at 15.10, standard deviation was 1.83.

Discussion/ Conclusion

1. The results of score comparison on problem solving skills on Science before using problem-based learning digital game with both two groups of students were not significant difference (p < 0.05).

2. For the results of score comparison on pretest and posttest score. It was found that the posttest average scores by two groups of students were higher significantly than pretest average score (p< 0.05).

The research study results proved that problem-based learning digital game could enhance students'problem solving skills for Science of primary students which was conformed to above hypotheses. Due to problem-based learning digital game, it consisted of 8 components, 43 indicators. game missions that students would cope with the given problem and gave students' chances to practice problem solving skill, and giving reason skill on critical thinking and making decision in different situations through repeated processes. The process consisted of 8 steps which improved students' problem-based skill for Science systematically from learning the game rules, preparation, providing problem situation, setting the scope of study, collecting   information, presenting solutions, evaluating the results, and giving conclusion and students' evaluation in accordance with works of Micheal & Chen, 2006; White, 2000; Lynam, 2005; Siriwan Rueksanan,2006; and ArnonAur-umakul, 2006 that were found the students' learning improvement after learning with problem-based learning digital game which were higher significantly than before learning with problem-based learning digital game.

Acknowledgements

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