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The Incorporation of Inquiry-based Learning into Digital Game: A Pilot Study on Gender and Learning Style Differences in Students' Perceptions

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Abstract: With the profitable and advancement of using technology in learning, digital game-based learning is one of effective tools to support and enhance students' learning performance and to promote students' learning attitudes. It is very important to integrate the teaching and learning process into the digital game-based learning environment for encouraging knowledge construction. Inquiry-based learning approach has been recognized as an excellent teaching strategy to engage students in constructing knowledge and to make learning more meaningful. This paper has proposed a digital game-based learning by incorporating with inquiry-based learning approach. In this vein, this paper addresses what gender and learning style differences in playing and learning the digital game are by investigating gender and learning style differences in perceptions toward the game, such as perceived ease of use, perceived usefulness, attitudes towards digital game use, and behavioral intention to use digital game. A pilot study has been conducted on a Thai primary school in general science course. The results from 79 students indicate that the proposed digital game can decrease the difference between male and female and between visual and verbal learners' perceptions, reasonably. This suggests a need to develop the digital game that can provide the opportunities for interaction on game screen and with peers.

Keywords: Technology acceptance, individual difference, science education, educational computer game

1. Introduction

In recent years, more researchers have investigated the issue of technology-integrated education. It results that technology tool has attracted much attention for educational context for both formal and informal classroom. In general, online learning communities are gradually altering traditional learning style because of the pervasiveness of internet. In the same time, educational game has been regarded as highly impacted learning procedures (Shin Sutherland, Norris and Solovay, 2012), including enhancement the value of instruction (Meesuk and Srisawad, 2014). For example, Dori, Panjaburee and Srisawasd (2015) reported that the digital game-based inquiry learning approach could enhance students' learning in physics better than the traditional teaching approach. Kiili (2007) revealed that authenticity and learning by doing, the most important characteristics of effective educational games, can enhance students' problem solving abilities. Although digital game-based learning approach seems to be an effective tool, researchers have pointed out that such approach could create negative impact, such as less learning outcomes, when it has been designed without proper teaching strategies or learning process (Chang Wu, Weng and Sung, 2012; Charsky and Ressler, 2011; Hoffman and Nadelson, 2010). Several researchers indicated that one great challenge of educational computer game development is to provide support and to guide the learners while keeping the balance between learning and gaming and between challenge and individual learners' abilities (Kickmeier-Rust and Albert, 2010; Charsky and Ressler, 2011). Therefore, it is important to provide suitable learning strategies or tools when developing digital game for educational purposes.

Among various learning-teaching pedagogies, inquiry-based learning have been recognized as an excellent teaching approach to engage students in constructing knowledge and to make learning

more meaningful (Benson and Bruce, 2001; Pedaste and Sarapuu, 2006). Consequently, the inquiry-based learning can be an instructional approach for stimulating students' thinking processes and promoting conceptual understanding (Lim, 2004; Looi, 1998). Although there are a number of researchers that developed the educational game integrated with inquiry-based learning approach showing that the game could help students improve learning performance, promote learning attitudes, and promote learning motivation (Dori, Panjaburee and Srisawasdi, 2015; Lin, Liang and Tsai, 2012). There is another human factor, which is learning style differences, is influences perceptions of ease of use, usefulness, and usage behavior of e-learning (Lu, 2012). However, the students' individual differences such as genders and learning styles, which are the key factors effecting learning, have not addressed yet. Therefore, in this pilot study, we has incorporated components of guided inquiry-based learning into the digital game and implemented into the force and motion topic. Moreover, to cope uninvestigated area of educational digital game, this pilot study aims to empirically evaluate there is interaction between learning styles (i.e., visual and verbal leaners) and genders (i.e., female and male) of students' perceptions about the developed digital game.

2. Relevant Research

Digital Game-based Learning (DBL)

Game consisted of challenge, control, curiosity and fantasy can be created persistence and enjoyment (Toro-Troconis and Patridge, 2010). Regards to its functions, many educational researchers and developers have developed games for teaching and learning in following three goals (1) Students can learn from playing the game; (2) the component of game can be supported the learning's ability and (3) students are motivated to learn via playing the game (Mcnamara, Jackson and Graesser, 2010). DGBL is a student-centered instructional approach, which incorporates learning content or learning principle into computer game to engage student and achieve the educational goals. In an educational game, learners are situated in gaming scenario to complete a series of tasks individually, collaboratively, or even competitively (Nelson, Erlandson, and Denham, 2011). The players need to be challenging enough to compete while acquiring educational goals according to specific rules and principles, contributing to the development of their cognitive skills and their construction of knowledge, while at the same time promoting their motivation (Erhel and Jamet, 2013; Huang, Huang and Tschopp, 2010). Moreover, DGBL can afford a meaningful environment for developing students' problem-solving abilities (Kiili, 2007; Kim, Park, and Baek, 2009).

In recent years, many studies have developed and reported that DGBL was able to promote students' learning interest and motivations (Ebner and Helzinger, 2007; Huang, Huang and Tschopp; 2010). For example, Huang, Huang and Tschopp (2010) survey 264 undergraduate students after playing online game, and found potential relationship between intrinsic motive and extrinsic rewards. Inal and Cagiltay (2007) further investigated the flow experience of children in an interactive game environment and found that the challenge and complexity elements of the games had a greater effect on the children's flow experiences than did clear feedback. Dickey's study (2011) investigated the impact of narrative design in a game-based learning environment and found that intrinsic motivation, curiosity and plausibility all benefited from game-like environment.

In addition, researchers have investigated the impact of DGBL from many aspects. For example, Lee and Chen (2009) studied the impact of different prompts and levels of prior knowledge on problem solving in non-routine mathematical situations, and reported that prior knowledge and comprehensive mathematical ability were important further related to the problem-solving effect. Kiili (2007) indicated authenticity, collaboration and learning by doing were the key factors of effectively conducting education game. Unlusoy, de Haan, Leseman, and Kruistum (2010) revealed that males show more interest in digital game than females. Paraskeva, Mysirlaki, and Papagianni (2010) and Dorji, Panjaburee, and Srisawasdi (2015) reported that the gender differences play the important role when playing digital game effecting the learning performance.

Inquiry-based Learning Approach

Inquiry based learning approach is a method that students are provided opportunity to carry out investigation to test their ideas and construct their own knowledge, making inquiries through experiment. It is based on constructivism theory of John Devery and Jean Piaget. This approach can help students to acquire scientific process skills. When engaging in inquiry, student describes objects and events, asks questions, constructs explanations, test the explanations against current scientific knowledge, and shares ideas with others. The students are asked to identify their assumptions, use critical and logical thinking, and consider attractive explanations. In this way, they actively develop their understanding of science by combining scientific knowledge with reasoning and thinking skill (NRC, 1996). Inquiry based learning could promote students to conceptualize a problem and then search for possible explanations related to that problem (Olson and Loucks-Horsley, 2000), so as for enhance their high-order thinking abilities and problem-solving skills. Ikpeze and Boyd (2007) indicated that it could encourage students to participate in explanations, reflections, and reinforcement of critical thinking abilities are significant in prompting inquiry for the high degree of complexity provided by nature problem-solving contexts. Therefore, appropriate learning situation are needed for students to perform tasks effectively (Endsley, 2000).

The progress of computer network technologies has provided the potential benefits of the inquiry-based learning (Ucar and Trundle, 2011). Many previous studies demonstrated positive impacts of technology-integrated inquiry-based learning environment on learning effectiveness (Hwang, Tsi et al., 2012; Kuhn et al., 2000). However when conducting inquiry-based learning activities in conventional classroom, it is a remain a dilemma to afford students the situations required to conduct meaningful inquiry activity (Lim, 2004).The classroom environment, using the traditional approach might not be suitable to facilitate student collection of the information necessary to carry an inquiry activities (Lee and Butler, 2003). Moreover, educators still face many challenges in designing inquiry activities in a computer and ill-structured learning environment (Lim, 2004). The inquiry based learning character, thus, has been more focused as it is originated in the scientific inquiry practices, engage student to investigate the scientific oriented questions, perform experiment, create explanations from evidence, evaluate the explanation, communicate to analyze the result possibility, justify and summarize the output (American Association for the advancement of Science, 1993). Among the different levels of inquiry based learning approach, this study has been basing on the guided inquiry-based learning approach. It has been characterized to be the guideline that teacher will provide problem/question, setup background and also determine the procedure/design and student have to perform the experiment based on the specified design, making the communication and conclude (Buck, et. al, 2008). The guided inquiry based learning approach will be used as the guideline to create and design the game environment in this study. Because in the purposing game, teacher has to make sure that student will have enough information to perform and summarize all information and concept from playing in game by themselves. The game stage and environment has to be design to guide and help student to get information until finish playing game.

3. The Incorporation of Inquiry-based Learning into Digital Game Approach

In this study, a digital game-based learning has been developed by incorporating the guided inquiry-based learning approach into gaming scenario for encouraging and promoting students' learning performance in physics course. The game has been implemented with Flash Maker. MySQL has been used as the system database. The 2D role-playing game has been chosen in this study because it is enough for presenting the game scenarios. It requires less computer power, which is supported in the most elementary school in Thailand. Moreover, researcher avoid situating elementary school students in a complex 3D interface, which may increase the difficulty for them to learn with the game (Hwang, Chiu, and Chen, 2015).

Figure 1 presents the structure of the game, which is composed of a main gaming interface, a communication interface and an assessment interface and a content management interface; furthermore, there are several database, consisted of a student information database, a test information database and a learning material database.

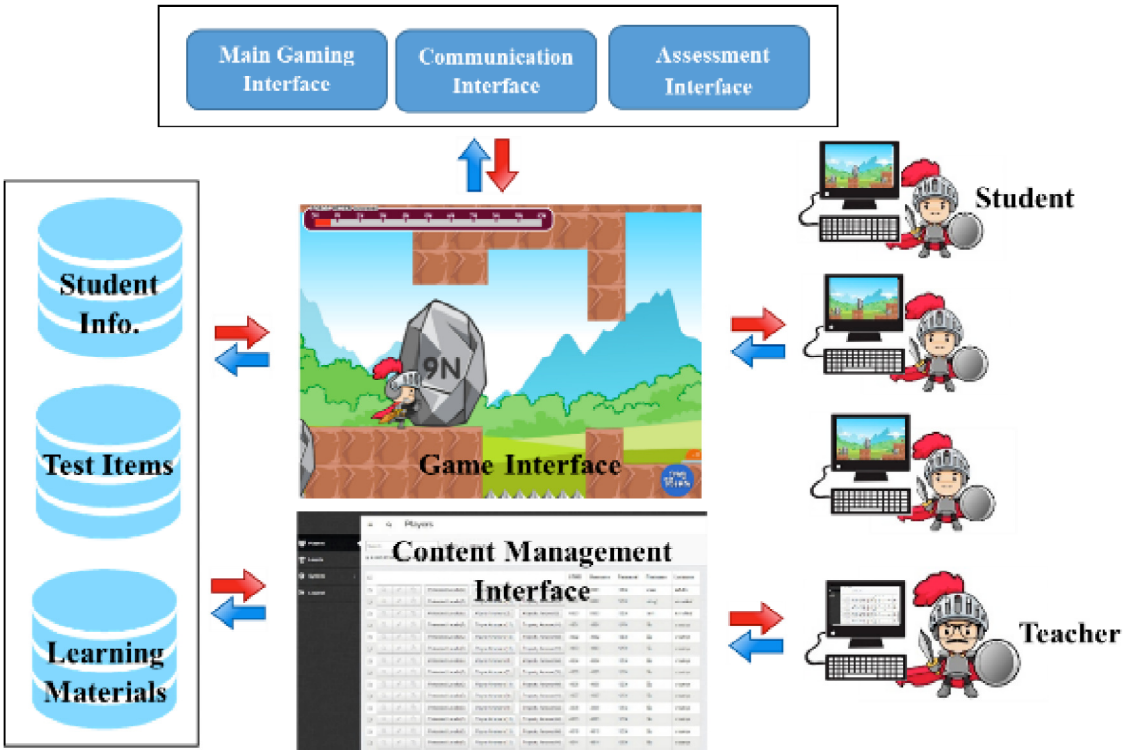

Figure 1. The structure of the digital game-based learning

The main gaming interface enables student to learn and explore in various gaming situation. The communication interface arranges some questions for student to deal with, so as, to enhance the collaboration between students and teachers. For instance, the students can see the answer from other students including hints or messages from teacher as shown in Figure 2. In this study, the "force and motion" of an elementary school physic course has been used to demonstrate the effectiveness of the proposed approach. In this game, the students need to learn the basic concept of force and motion and resultant force; moreover, they are situated in various stages embedded in the storyline of the role-playing game, so as, to explore and experience all stages, which may occur after answering the correct question in each stage.

The role-playing game is concerned with a story of an ancient kingdom in which the princess was caught and taken into the bad dragon island. The knight who was taking care of princess need to find and help the princess on that danger island. Therefore, the knight decides to go into the dragon island, which are in fact the context of force and motion concept to be explored in each stages to reach the princess. During the learning process, the students play the role of the knight to find the princess.

There are several barriers in five stages which student need to go through, magic beach, fire forest, trap hill, streaming cave and dragon henchman. Each stages were designed for each concepts. In addition, there are tests to ensure that the knight has power and concept enough to fight with the dragon. Once players finish the stage and answer question correctly, they are allowed to proceed to the next stage of the game. If the student fail the tests, the system will provide them some more information or illustrative examples.

Figure 2. The communication interface of other students and teacher

The game starts with the introduction to the background of the story. First stage, the knight stop the boat by the beach to get into the island. There are many obstacles with fire to deal with. The student will learn the characteristic of force and motion. Second stage, trap hill, there are many danger traps along the way. The knight need the big and huge stone to get across those traps. In this stage, the student will get the idea of force composition. Third stage, fire forest, the forest are burnt by the dragon. The knight get lost and need to escape by getting the fireball into an ancient jar to protect the forest. The concept of this stage is to understanding the direction of force. Fourth stage, streaming cave, the knight stuck in front of the big streaming cave. A big old log next to the stream is the key to get across and get out. The concept is the method to move the log and the same direction of forces accumulation. Moreover, the last stage, dragon henchman, the henchman are pulling to hide the key box which use to unlock and help the princess. The knight have to get that key. The student will face with the resultant force and understand the resultant force calculation from this stage. The students have to identify, explore and analyze those situations and record the data with the data grid provided during the game process, Figure 3. The role-playing is selected as the gaming type because it is to situate students in the authentic contexts of force and motion, so that the student can learn from exploring and solving the problems in context. Moreover, the students will be enabled to realize that the knowledge they have learned can be applied to some real-world contexts from this approach.

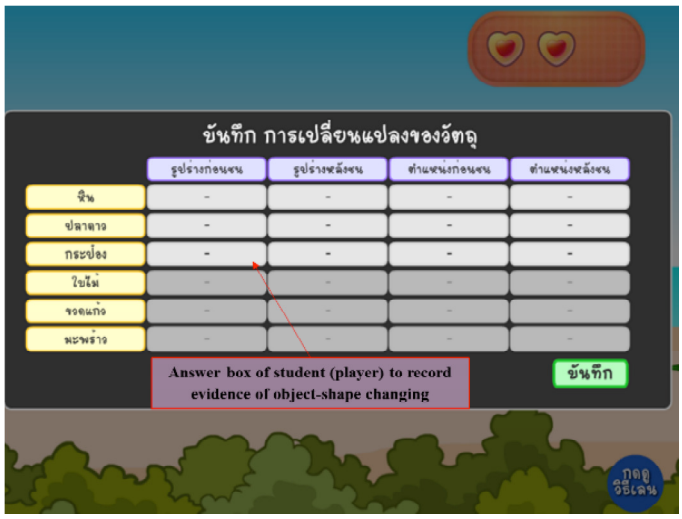

Figure 3. The data grid to be recorded during the game process

The learning system will be the same process in each stage, based on inquiry-based learning approach. And at the end of each stage, the system will have the formative assessment for student to

be ensure that the student have clearly understand the concept by selecting the prepared tests from item bank of that unit. Once an item was answered successively and correctly, it will move the student to the next unit and the counter is reset; however, if an incorrect answer is given, the accumulative total of counter is added and system retrieve new item. When the student fail to answer correctly a test item, the system does not provide the correct answer to them; instead, it show some information to guide the student to make further analysis. That is, the students are prompt to find the correct answers on their own. The six formative assisted items have been prepared for each unit.

4. Research Design

Participants

A total of 79 fourth and fifth graders of elementary school under Office of the Basic Education Commission in Central part of Thailand were recruited in this pilot study. The students individually participated in the developed game, and shared the result in the game with their friend to construct their own knowledge. After finishing learning activities in the game, they were asked to take a questionnaire to clarify the degree of their perceptions toward the game.

Measurement Tool

The perception questionnaire were adopted from Teo's (2009) technology acceptance model questionnaire and translated to Thai language by the authors in this paper. It consists of 11 items with a five-point Likert rating scale. It consisted of four dimensions, perceived usefulness (3 items), perceived ease of use (3 items), attitude towards digital game-based learning use (3 items), and behavioral intention to use digital game-based learning (2 items). In this questionnaire, students have to respond each item within 5-point rating scale (1-strongly disagree; 2-disagree; 3-neutral; 4-agree; 5-strongly agree). The Cronbach's α value of the questionnaire in Thai version was 0.91, showing acceptable reliability in the internal consistency. Moreover, the composite reliability values for the perceived usefulness, perceived ease of use, attitude towards digital game-based learning, and behavioral intention to use digital game-based learning dimensions were 0.84, 0.79, 0.76, and 0.82, respectively, showing good internal consistency of each construct (Panjaburee and Srisawasdi, 2016).

The perception questionnaire is related to the technology acceptance model specifying perceived usefulness, perceived ease of use, attitude towards digital game-based learning use, and behavioral intention to use digital game-based learning. Perceived usefulness refers to which a person believes digital game-based learning will help him or her to perform a certain task in an efficient and productive manner. In contrast, perceived ease of use refers to which a person thinks that the use of digital game-based learning will be relatively free of effort. Attitude refers to which a person has opinion and feeling toward the digital game-based learning. In addition, behavioral intention to use refers to which a person desires to use the digital game-based learning.

Experimental procedure

The experiment was conducted in an elementary school science course as shown in Figure 4. Before conducting the experiment, the students were introduced the game and story line by researcher, and the basic functions of the game. Following that, the students played the game and took a perception questionnaire. During the learning activity period of 40 minutes, the students were monitored and facilitated by teachers. Moreover, the students were asked to response the perception questionnaire for a period of 25 minutes.

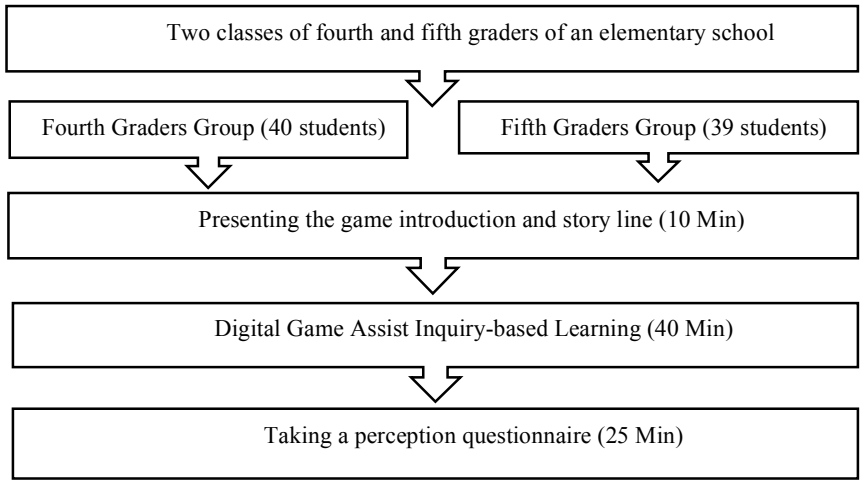

Figure 4. Experimental design for the learning activities

5. Research Results of Students' Perceptions

To understand interaction between learning styles (i.e., visual and verbal leaners) and genders (i.e., female and male) of students' perceptions about the developed digital game, the students were asked to response a questionnaire. Moreover, a two-way MANOVA was employed. The learning styles (i.e., visual and verbal leaners) and genders (i.e., female and male) were independent variables, while the questionnaire ratings of perceptions were a dependent variable. Before conducting the two-way MANOVA test, the assumption of Box's M test of equality of covariance matrices was performed. We found that the equality of covariance matrices was not violated with $F = 1.580$ ($p > .062$). Therefore, two-way MANOVA test can be used to analyze the questionnaire ratings of perceptions of the students. It is found that there is no a statistically significant interaction effect between gender and type of learning style on the perceptions about the developed digital game-based learning, $F_{(4, 72)} = .898$, $p = .470$; Wilks' Lambda = .952.

Table 1 shows the descriptive data on the questionnaire ratings of the perceptions about the developed digital game-based learning. It clearly demonstrates that when learning with the developed digital game-based learning approach, female and male students perceived usefulness, ease of use, attitude of use, and intention to use the digital game similarly. In addition, female and male students with different types of learning style perceived usefulness, ease of use, attitude of use, and intention to use the digital game similarly.

Table 1: The descriptive data of the perceptions of the students who have different types of learning styles

Dimension	Gender	Learning Style	N	Mean	SD
Perceived Usefulness	Females	Verbal	7	12.71	2.059
		Visual	37	13.92	1.920
	Males	Verbal	5	14.20	1.095
		Visual	30	13.83	1.533
Perceived Ease of Use	Females	Verbal	7	13.86	1.069
		Visual	37	13.62	1.320
	Males	Verbal	5	14.60	.548
		Visual	30	14.03	1.829
Attitude towards Digital Game-based Learning Use	Females	Verbal	7	13.00	1.155
		Visual	37	12.92	2.191
	Males	Verbal	5	13.60	2.191
		Visual	30	13.53	2.224
Behavioral Intention to Use Digital Game-based	Females	Verbal	7	7.43	1.134
		Visual	37	8.43	.987

Learning	Males	Verbal	5	8.80	1.304
		Visual	30	8.73	1.484

6. Discussions and Conclusions

This study analyzed the perception of an incorporation of inquiry-based learning into digital game targeted at primary school students' learning of physics course on force and motion topic. This study indicates that there is no difference between male and female and between visual and verbal leaners perceptions about the proposed design of digital game incorporated with inquiry-based learning.

Although Lu (2012) revealed that learning style difference influences perceptions of ease of use, usefulness, and usage behavior of e-learning, but the main findings of this study clearly highlighted that female and male students who learned with the developed digital game-based learning approach similarly perceived usefulness, ease of use, attitude of use, and intention to use the digital game. Moreover, the study also pointed out that female and male students with different types of learning styles who learned with the developed digital game-based learning approach similarly perceived usefulness, ease of use, attitude of use, and intention to use the digital game. These findings shown that the proposed digital game can reasonably decrease the difference between male and female and between visual and verbal leaners perceptions.

Consequently, we could suggest that the proposed developed digital game-based learning approach could be support learning and decrease gap between females and males and gap between learning style differences. It means that the game can provide opportunities for interaction on game screen and with peers.

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