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Designing Digital Card Game Environment to Promote Students' Conceptual Improvement in Newton's Laws of Motion

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Abstract: Nowadays, digital games are famous around the world, among the several of digital game genres used for educational purposes sits the one genre of digital game is Digital Card Games (DCGs) that is the modern expression of Card Games (CGs). Digital gaming and digital technology are everywhere, which digital games compiled of amazing and sophisticated images and sounds, alongside textual communication, it's called a king of constructivist-based active learning environment. This study presents a way to design DCG to enhance the improvement of students' conceptual development in physics regarding their misconceptions. To develop the environment, 104 tenth-grade students, age between 15-16 years, have been investigated their initial conceptions on Newton's 1st, 2nd, and 3rd law of motion using selected Force and Motion Conception Evaluation (FMCE) items. The result shows that most students held incomplete conception and misconception about Newton's laws of motion in various patterns of existing understanding. To facilitate their learning in physics of the laws, a mobile digital game integrated with DCG, named "The Mystery Force", is creating by the present researchers in order to enhance the students' conceptual improvement by inducing their conceptual change process. In addition, the researchers would employ a series of designed learning events as a basis to create a prototype of the game to support their conceptual improvement. To motivate the conceptual learning, series of DCG have been created and the cards provide a special option to increase character ability in digital card games, processing by scanning QR-cord through card games and then receive the input into the main game. Furthermore, the cards also provide significant scientific information and learning challenges for students.

Keywords: Digital game, game-based learning, inquiry-based learning, physics concept, secondary education

1. Introduction

Newton's laws of motion are played attention such a fundamental role in explaining physical phenomena in daily life that these laws. And have been taught at many levels of education, such as in primary schools, secondary schools, college and in university level (Sornkhatha & Srisawasdi, 2013). However, students also remain have misconceptions about newton's laws of motion. According to the research reported that most students have misconceptions about newton's laws of motion from any previous time (Obaidat & Malkawi, 2009; Saglam-Arslan & Devecioglu, 2010). Conceptual understanding and conceptual change in physics education are purposed to supporting several pedagogies, instructional models and teaching techniques for enhancing the learning of physics concepts (Kanyapasit & Srisawasdi, 2014).

In recent years, there are several pedagogies was developed to promote physics conception such as an interactive computer-simulated laboratory to supported newton's laws of motion (Sornkhatha & Srisawasdi, 2013) and problem-based gaming to supported electric current

(Dontrisanor, Srisawasdi, & Kanjak, 2015). Which those pedagogies can develop student's conceptions. Furthermore, also have any pedagogies to supporting learning physics conceptions.

Digital games such as on computer games, game players or mobile games become the main demand of students because it provides enjoyable, relax and challenges the students to control game on their own. Actually, games incorporate particular attributes related to the way students learn, they necessarily exploration and reflect on their prior knowledge, solve problems, and transfer knowledge during the game process (Oblinger, 2004). The one genre of digital game is digital card games (DCGs) that is the modern expression of Card Games (CGs) (Gousiou & Kordaki, 2015). Digital card games which have been designed for educational purposes and to underline the several aspects of educational digital card games in direction to approach them as effective learning environments from several aspects (Kordaki & Gousiou, 2017). Therefore, using digital card game can engage students paid attention to learning and support conceptual understanding and conceptual change in physics learning of newton's laws of motion. This study presents a preliminary result on investigating secondary school students' existing conception about newton's laws of motion, and then a design of DCG for promoting their conceptual improvement on the physics concepts

2. Literature Review

2.1 Digital Game-based Learning

Presently, digital gaming and digital technology are everywhere. Digital games include of amazing and sophisticated images and sounds, alongside textual communication. Players get engaged, which is both enjoyable and challenging (Dontrisanor, Srisawasdi, & Kanjak, 2015). Digital game common role to provide relaxed, fun and exciting because the game can challenge the players to mission completes in those games. As a result, educators are interested in how to use the game to simplify and enhance teaching or learning in subject matters (Kanyapasit & Srisawasdi, 2014). The educational digital games maintain players immersed in digital worlds, knowledge, information, and ability improvement become increasingly accessible outside the limits of formal education (Castell, Jenson, & Taylor, 2007).

The game is a system in which players engage in an artificial conflict, described by rules, that results in a quantifiable outcome (Salen & Zimmerman, 2004). The educators have developed games for three objectives consisting: (i) student can learn from playing the game; (ii) the component of game can support learning; and (iii) students have been motivated to learn when they are learning by playing the game (McNamara, Jackson, & Graesser, 2010). Of course, the game that must include of challenge, curiosity, fantasy and control can motivate persistence and enjoyment (Toro-Troconis & Partridge, 2010). Additionally, an effective educational computer game should have five characteristics: (i) built on learning principle; (ii) provide personalized learning opportunities; (iii) provide more engagement for the learner; (iv) teach 21th century skills; and (v) provide an environment for authentic and relevant assessment (McClarty et al., 2012).

Game-based learning is a king of constructivist-based active learning environment. According to the learning research found that using game in classroom made a change of teaching from teacher-centered learning environment to student-centered learning environment (Watson, Mong, & Harris, 2011). In additions, there were numerous researches presented that digital games can promote students' learning and their positive attitudes (Sung & Hwang, 2013), creativity (Annetta, Cheng, & Holmes, 2010), and support development of critical thinking (Squire, 2006).

2.2 Digital Card Games

Nowadays, digital games are famous around the world, among the several of digital game genres used for educational purposes sits the one genre of digital game is Digital Card Games (DCGs) that is the modern expression of Card Games (CGs) (Gousiou & Kordaki, 2015). Card games started a wide variety of games that have been around for centuries; actually, back into the 10th century the historians have drawn playing cards and the most game taxonomies consist the vast class of card games (Crawford, 1982). Specifically, historians have reported that card games also having been used for educational purposes since the period of Piaget (Kamii & DeVries, 1980).

Card games have been also used to apply basic aspects of developmental psychology and support students understand and especially the stages of Piaget's theory of cognitive development (Weisskirch, 2003). Therefore, Card games have been used for educational purposes as well as for enjoyment. Gosper and McNeil (2012) said that actually simple rules and basic equipment made educational card games suitable for beginner players, so as to motivate and engage them in the game-based learning process, which through the integration of the instructional content into the game framework of a well-designed card games (Kordaki & Gousiou, 2017). Moreover, constructivist methodologies have been suggested for the design of educational digital card games acknowledging problem-solving and student misconceptions (Kordaki, 2016).

3. Methods

3.1 Participants

From explored misconceptions on the topic, the participants in this study were of 104 tenth-grade students, age ranging from 15-16 years, in a local public school in the Northeastern region of Thailand. They were attending a physics course for basic education level. Regarding to prior learning experience, they have no experience yet using digital card games learning in physics.

3.2 Research Instrument

The instrument in this study is a conception questionnaire about Force and Motion Conception Evaluation (FMCE) 12 items which adapted from Thornton and Sokoloff (1998). The total of FMCE was validity and reliability in research of Ramlo (2008) and used for analysis in research by Smith and Wittmann (2008). By has selected only concept of newton's law of motion, newton's 1^{st} law 1 item, newton's 2^{nd} law 4 items and newton's 3^{rd} law 7 items. From the English version, an identical version in Thai was constructed, and one expert was recruited to identify communication validity of the items.

3.3 Procedures and Data Analysis

All participants took 30 minutes to complete the series of a conception questionnaire about Force and Motion Conception Evaluation (FMCE) items. Following this, content analysis was the primary method for analysis of students' answers, responses to the FMCE, represented students' conceptual understanding and conceptual change about newton's law of motion. This research analysis students' conception follow method of Satchukorn and Srisawasdi (2017) to the category, analyzed, interpreted, and classified their responses into four categories i.e. scientific conception (SC), which refers to the responses that provides correct answer and appropriate reasoning in science; incomplete conception (IC), which refers to the responses that provides either correct answer or appropriate reasoning in science, without anything wrong; misconception (MC), which refers to the responses that provides incorrect answer and inappropriate reasoning in science; and no conception (NC), which refers to no response or the responses that provides not clear conception in science. The investigators have designed a series of digital card games for simplifying mechanism of change and improve of students' alternative conceptions of newton's law of motion into scientific conception.

4. Results and Discussion

The results displayed that there are many types of students' existing conceptions related newton's laws of motion concepts, as illustrates in Figure 1-4.

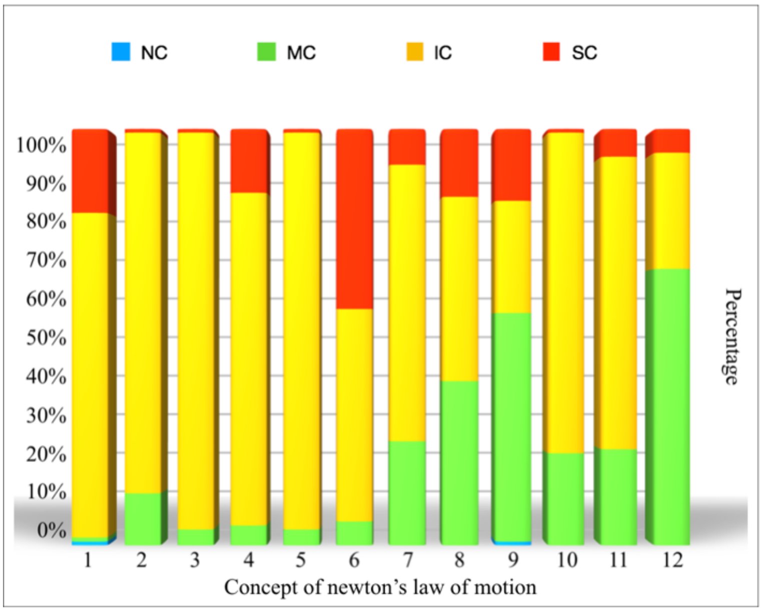

Figure 1. Distribution of students' misconceptions on newton's law of motion concept.

Figure 1 was displayed data investigate of newton's law of motion concept 12 items which based on the four categories (SC, IC, MC and NC) interpreted students' unscientific conceptions, the percentages of quantities of a combination between students' alternative and misconceptions and their no conceptions.

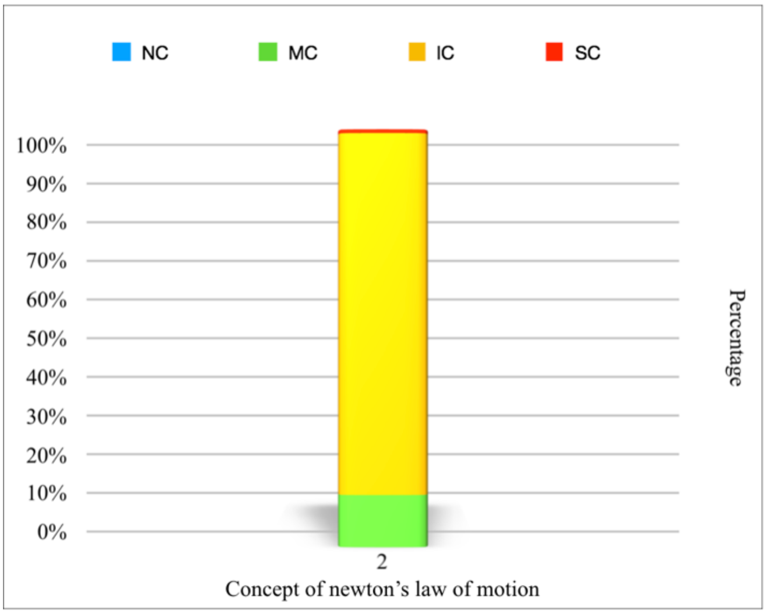

Figure 2. Distribution of students' misconceptions on newton's 1st law.

According to figure 2, present only item number 2, the percentages for combination of incomplete and misconceptions of incident of newton's 1st law were 86.54% and 12.50%, respectively. The percentages of scientific conceptions of newton's 1st law was 0.96%. However, no conception disappears on this item.

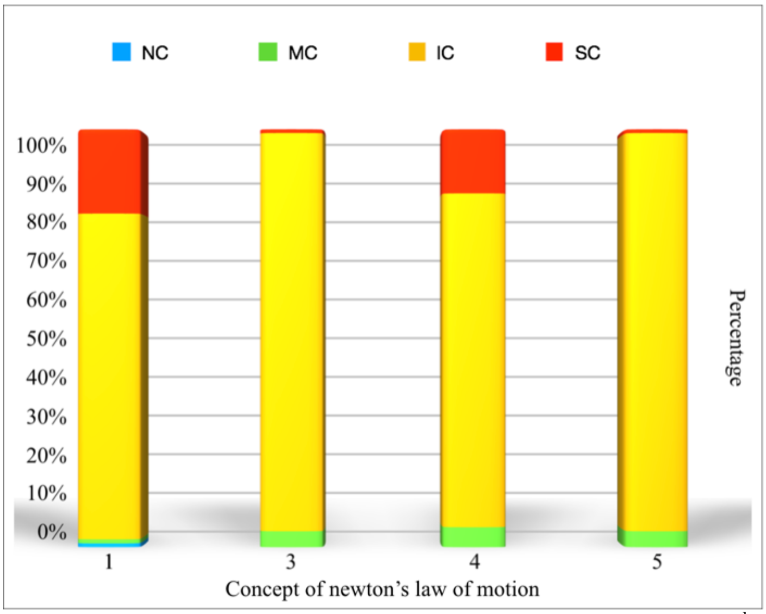

Figure 3. Distribution of students' misconceptions on newton's 2nd law.

As seen figure 3, present item number 1, 3-5, the percentages for incomplete conception of newton's 2nd law were 77.88%, 95.19%, 79.81% and 95.19% respectively, and misconceptions of incident of newton's 2nd law were 0.96%, 3.85%, 4.81% and 3.85% respectively. The percentages of scientific conceptions of newton's 2nd law was 20.19%, 0.96%, 15.38% and 0.96% respectively. In addition, no conception was appeared on item 1 was 0.96% but other items disappear. In other word, vast students are incomplete conception of newton's 2nd law.

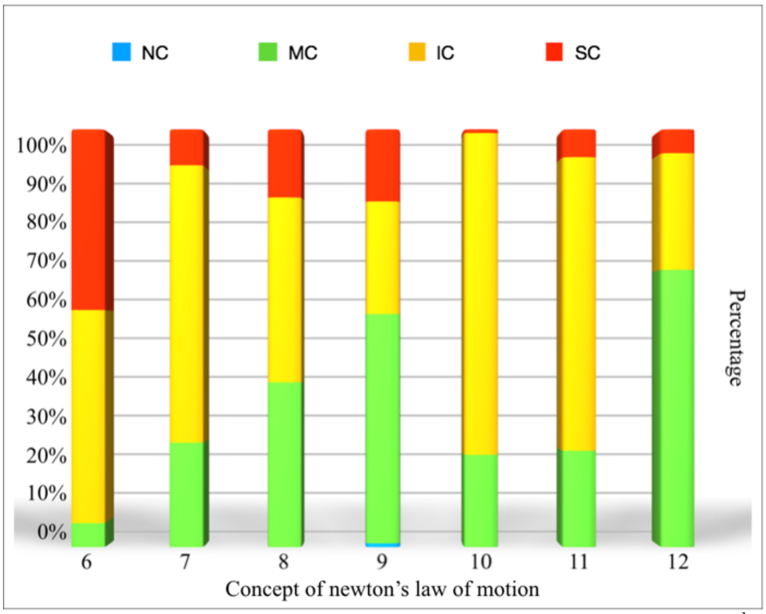

Figure 4. Distribution of students' misconceptions on newton's 3rd law.

According to figure 4, present item number 6-12, the percentages for incomplete conception of newton's 3rd law were 50.95%, 66.35%, 44.23%, 26.92%, 76.92%, 70.19% and 27.88% respectively, and misconceptions of incident of newton's 3rd law were 5.77%, 25.00%, 39.42%, 54.81%, 22.12%, 23.08% and 66.35% respectively. The percentages of scientific conceptions of newton's 3rd law was 43.27%, 8.64%, 16.53%, 17.33%, 0.96%, 6.73% and 5.77% respectively. In addition, no conception was appeared on item 9 was 0.96% but other items disappear. In conclusion, on item 6 were highest percentages of scientific conceptions, however, vast students remain are incomplete conception and some part also are misconceptions about newton's 3rd law.

5. The Proposed Design of Digital Card Games about Newton's Laws of Motion

According to the investigation result showed that students have an incomplete conception and misconceptions on newton's law of motion, Thus, research goal is design, digital card game to support on conceptual understanding and conceptual change of students. Developing the digital card games which simplify process of conceptual change, the researchers employed the designed learning events as a basis to create a prototype of "The Mystery Force ". This game consists of newton's 1st law, newton's 2nd law and newton's 3rd law which each concept will represent during every action of the character as figure 5, 6 and 7 respectively, an illustrative the action of the game playing with the mysterious force.

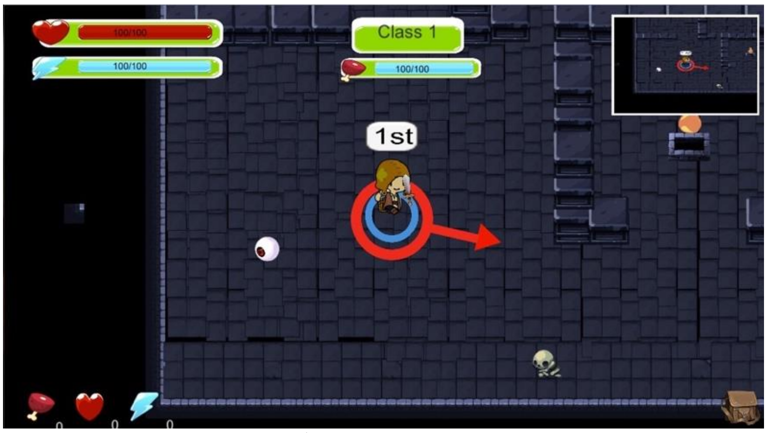

Figure 5. An illustration of newton's 1^{st} law represents on the current status of the character.

As seen figure 5, displayed the status "**1st**" of character during activities or phenomena follow the newton's 1^{st} law. The status "**1st**" of character is general status, represent when moving at a constant velocity or standstill and using regenerate skill.

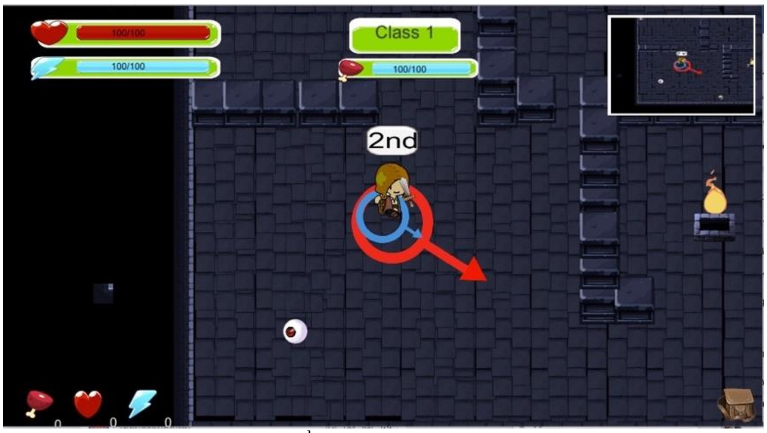

Figure 6. An illustration of newton's 2^{nd} law represents on the current status of the character.

According to figure 6, displayed the status "**2nd**" of character during activities or phenomena follow the newton's 2^{nd} law. The status "**2nd**" of character is action status, represent when moving at speeding up (run) or using an active skill to damage an enemy.

Figure 7. An illustration of newton's 3rd law represents on the current status of the character.

As seen figure 7, displayed the status "**3rd**" of character during activities or phenomena follow the newton's 3rd law. The status "**3rd**" of character is action and reaction status, represent when the character was damaged by special action of an enemy or reflected by barriers and using reflection skill to reflect damage an enemy.

Specially, the card provides a special option to increase character ability in digital card games. The process by scanning QR-code through card games. Furthermore, the card also provides significant information for learning of players as a figure 8.

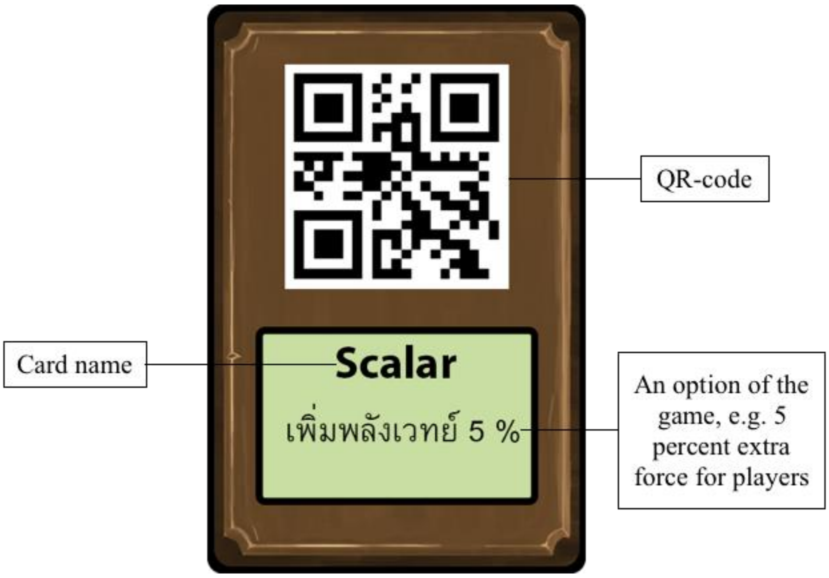

Figure 8. An illustration of card game provides QR-code, name and a special option.

According to figure 8, card provide QR-code and the name, while was scanned card also provide a special option to increase character ability. Which each card also there are different ability such as a card in figure 8, increases magic point 5 percent. Moreover, card game also provides significant information for learning and additionally explain name of those card games.

Card game have participated while the players discovers the mystery box at somewhere in digital game. Mystery box is key to direct they find card game, when they discover the mystery box there are the questions or hint displayed then they use those key words to find a card game is matching. The players have chance 3 times to scan a card game for match with questions or hint, if card game doesn't match the box will be closed and locked. Therefore, they must to critical thinking and realize to discovers the match card games. This constraint will monitor them and decrease misconception and incomplete conception.

6. Conclusion

In this study, an educational digital card game environment was designed to promote students' conceptual improvement in newton' laws of motion with an inquiry-based learning approach to facilitate students' conceptual learning in science considering their existing conceptions, researcher has been proposed digital card game environment to improvement approach specifically. From the investigation results, it was found that students hold a numerous conceptual status, such as incomplete conception, misconception or even no conception. Thus, the development of the educational digital card game must be aware and consider on the status of student' conceptions or understanding. In additional, any situation in digital card game also can't improve the student' misconceptions which it's limitation of this game. And hope that the proposed approach can be applied to other development of digital learning materials and strategies. Which one of our future research plans is to apply the approach follow collaborative open inquiry pedagogy, called Student-associated Game-based Open Inquiry (SAGOI) (Meesuk & Srisawasdi, 2014).

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