GAME-BASED LEARNING INFLUENCE ON PRIMARY STUDENTS' LEARNING OUTCOMES IN BASIC SCIENCE

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ABSTRACT

In recent years, the interest in choosing game use in primary schools has increased and improved; this includes educational games, digital game-based learning, and applied games. Studies have revealed that students' learning motivation, performance, and efficiency can be enhanced through educational games, and the recent introduction of enhanced game elements has made such games increasingly popular. The purpose of this study was to ascertain if participating in an educational card game named Pictionary and Matching Games can help primary (5 and 6) school pupils learn science-related concepts. The researchers explored the pupils' perceptions/acceptance based on the incorporation of the game into science learning. A one-group pretest-posttest design was used with eighteen (18) primary five (5) and primary six (6) pupils from a single primary school. A pilot test was administered to twenty students. Reliability analysis of the pilot test results were =0.84 and 4 items in perceived usefulness, =0.66 and 3 items in perceived ease-of-use, =0.78 and 4 items in attitude towards usage, and =0.63 and 3 items in intention to use. The questionnaire included 14 question items, with a reliability coefficient of =.82. The pupils revealed positive attitudes toward the use of educational games in science learning. The result also established that educational card games help to motivate and improve the pupils' scientific knowledge.

Keywords: Game-based learning, Primary education, Learning outcomes, Science Learning, Pictionary, and Matching Games.

INTRODUCTION

Papert (2019) opined on the advancement of learning through real-life situations and the shaping of concepts through games. Technological applications are rapidly evolving; games and simulations are already widely integrated into the traditional educational process. They are integrated widely in the field of education, with an existing body of work investigating the relation between games and education. In recent years, many researchers have investigated the effectiveness of digital technology in promoting learning using games (Carenys & Moya, 2016). Incorporating games into education is effective than traditional teaching methods in improving students learning motivation, active participation, and concentration during the learning process. Games can enhance students' social skills and improve their skills in understanding and solving problems (Kirikkaya, Iseri & Vurkaya, 2018).

Game-based learning is becoming a significant area of research interest and has been applied in many science-related school subjects in developed countries. Yien, Hung, Hwang and Lin (2016) discovered that the game-based approach was more effective in enhancing students'

learning effectiveness and attitudes; than the conventional teaching approach. Through game-based learning, learners learn more actively and with greater interest, enabling the learned content to leave a deeper impression than would be possible using traditional approaches (Papastergiou, 2019). Most studies on game-based learning seem to have focused attention on digital game-based learning. The technological revolution and the Internet invasion urge students to build digital and collaborative skills for the twenty-first century through gaming. Also, the emergence of a participatory culture in education spurs researchers to get involved with digital games.

Digital games provide animated graphics and audio effects as well as immersive stimulation. In a research carried out by Lin and Liu (2019) on game mechanisms in typing practice using two groups of conventional approach and game-based approach learners, though the progress of these two groups was not significantly better than that of learners using the conventional teaching approach, their typing skills were significantly better than before the experiment. Lin and Liu (2019) also observed that learners in the game mechanism group spent considerably more time practicing typing than their counterparts in the conventional class. Their results demonstrated that game-based learning influences the learning motivation of students. In another study by Chiang, Lin, Cheng and Liu (2017), the researchers explored the influence of various computer games on the students' flow experience and positive emotions and discovered that vehement games did not induce vehement emotions or conduct in students. Furthermore, they found that both violent and non-violent games stimulate flow experience and positive emotions. As shown in these studies, digital games can enhance learning motivation and arouse positive emotions in students; however, a digital game environment cannot provide face-to-face interaction.

In a classroom situation, teacher-student interactions and student-student interactions employ an insightful impact on learning. Unlike interactions in digital games through computers, face-to-face interaction exposes students to human expressions, physical action, and verbal tones (Billinghurst & Kato, 2012). Therefore, using educational games as a medium for game-based learning could improve the direct interpersonal interaction between teachers and students as well as among students to a point unmatched by the sound and audio effects of digital games. Furthermore, learning through game-based has made an extensive impact on the learning process.

Statement of Problem

Studies have explored game-based learning in all forms of educational games. Games show mixed effects across so many areas, such as students' performance, engagement, and learning motivation (Liu, Lin, Hsiao, Chen & Hwang, 2009). However, there remains a gap in integrating games in the learning process as the issue of inculcating games efficiently in the educational process is often up to the instructor's discretion. It is hoped that the achievements of this study will ascertain the effectiveness of the game-based learning approach in promoting the learning outcome of learners through the learning process. Therefore, the researchers tend to explore the influence of game-based learning on academic outcomes of primary school pupils in science learning using specified games.

Research Objectives

The aim of this study is to develop a basis to allow instructors across disciplines to understand the benefits and drawbacks of games specifically to their pedagogical and instructional goals. Specifically, the researchers tend to;

1. explore the acceptance of primary school pupils towards educational Pictionary and Matching card games.
2. ascertain the influence of Pictionary and Matching card games on science learning achievement among primary school pupils.

Research Questions

The following research questions guided the study;

1. What level of acceptance do primary school pupils have on educational Pictionary and Matching card games for science learning?
2. To what extent do educational Pictionary and Matching card games influence science learning achievement among primary school pupils?

Methodology

Research Design

The research design was a one-group pretest-posttest design.

Research Population

In class distribution, twelve (12) primary five (5) and six (6) primary six (6) pupils were engaged in the study, totaling eighteen (18) participants. Ten 10 were female, while 8 were male.

Research Procedure

The total duration of the teaching experiment was 90 minutes. Before the official learning activity, a 20-minute pre-test was administered to the participants to assess science knowledge. The participants were randomly grouped into teams of 4 pupils following the pre-test. The rules of the game, Pictionary and Matching games, were listed and also explained within 20 minutes. The official learning activity with educational games listed commenced for 45 minutes. After the learning activity, a post-test (containing the same questions as the pre-test but now reordered), and learning satisfaction questionnaire, were also administered. The post-test and questionnaire required 25 minutes for completion.

Design of Science Educational Pictionary and Matching games

This study referred to the revised Bloom's Taxonomy established by Anderson and Krathwohl (2012) as the design standard for educational games. In the knowledge dimension of the revised Bloom's Taxonomy, knowledge is divided into four levels from concrete to abstract:

i. factual knowledge,
ii. conceptual knowledge,
iii. procedural knowledge, and;
iv. meta-cognitive knowledge.

Cognitive processes are divided into six levels from low complexity to high:

i. remember,
ii. understand,
iii. apply,
iv. analyze,
v. evaluate, and;
vi. create.

The researchers developed the primary scientific concepts for the game on the topic; Energy and Means of Transportation. The subject knowledge was divided as follows;

1. Remember - Factual knowledge: Pictures and text present the appearances and names of various forms of transport.
2. Remember - Conceptual knowledge: explain the amount of energy required by each type of transport.
3. Understand - Conceptual knowledge;

a. If a given form of transport consumes petroleum products (fuel, gas, diesel, or oil), then the game card will also show a pollution value, demonstrating the principle that the use of oil produces pollution. Transport modes that use electricity, wind power, or solar power, do not produce pollution.
b. Solar power energy cards can be used to replace other energy cards such as petroleum products to demonstrate the convenience and wide applicability of solar power.
c. Three forms of transport travel by land, sea, or air are included in the game. This helps students to understand the differences among various modes of transportation regarding their appearance and the environment in which they operate. In the game, ship transports can only travel by sea, land transports can only travel by land, and air transport limited air. This helps pupils to understand the limitations of each form of transport.
d. Problem cards require that pupils group transport modes according to an energy source, appearance, or function. Based on the answers provided by the pupils, appropriate feedback was given.

4. Understand - Meta-cognitive knowledge;

a. Event cards incorporate daily environmental concerns (such as vehicle and emissions testing) into the content of the game.
b. The event cards also include an 'Oil Crisis' card. When this card appears, all oil energy cards are useless, demonstrating that oil depletion will occur someday.

5. Apply - Procedural knowledge: Once the pupils understand the rules of the game, they can play the game smoothly according to a given procedure.
6. Analyze - Procedural knowledge: Two strategies were provided to score the games and pupils may adjust their tactics according to the circumstances of the game.
7. Evaluate - Meta-cognitive knowledge: In the course of the game, pupils learn by self-discovery and by evaluating the pros and cons of each transport mode.

Designing the educational game in this study, the researchers also referred to the seven design principles proposed by Liu (2017), which include:

i. Analyze the traits of the learners and understand their prior knowledge;
ii. Establish clear teaching objectives and select appropriate gaming equipment
iii. Combine the teaching objectives with the game content
iv. Remember that teaching is the primary goal and that the game is a supplementary tool
v. Take advantage of game characteristics to arouse pupils' interest
vi. Enable pupils to enjoy learning while they take control of learning and
vii. Periodically assess learning effectiveness and improve teaching.

The researchers also evaluated the game design according to the five keys proposed by Liu and Lin (2019);

i. Whether the game information is in accordance with the game,
ii. descriptions of the learners and the game include a learning theme
iii. Whether the pictures in the game are associated with the learning theme and can arouse student interest
iv. Whether the structure of the game is simple and operations are easy to learn
v. Whether the overall content of the game is interesting, and include many pictures for presentation and
vi. Whether the game provides instant feedback.

Referring to these principles, the researchers ensured that the game designed in this study conveys subject knowledge that is easy to learn and stimulates learners' interest.

Research Instruments

The researchers used two instruments for the study: Learning Satisfaction Scale and Basic Science Assessment.

Learning Satisfaction Scale

The researchers developed a satisfaction scale according to the structure of the Technology Acceptance Model (TAM) to evaluate the degree to which students accepted the educational card game using four constructs: Perceived usefulness, perceived ease-of-use, attitude towards usage, and intention to use.

The satisfaction scale went through construct and content validity. Three experts (two primary school science teachers and a scale development expert) validated the instrument to review the descriptions in the items.

Basic Science Assessment

The main objective of the science assessment tool was to gauge the understanding of primary school pupils concerning scientific concepts associated with Energy and means of transportation. The content of the assessment was based on the learning content in the pupils' scheme of work. In the development of the assessment, the researchers referred to problems and questions in textbooks used by the school. The assessment included eight true or false problems, six multiple-choice problems, and six matching problems, each contributing a total score of 100 points. The assessment was given to the participants before and after the learning activity, with the problems from the pre-test reordered in the post-test to reduce the effects of repeated exercise.

Reliability of the Instrument

A pilot test was administered to ten (10) students. Reliability analysis of the pilot test results were =0.84 for the four (4) items in perceived usefulness, =0.66 for the three (3) items in perceived ease-of-use, =0.78 for the four (4) items in attitude towards usage, and =0.63 for the three (3) items in intention to use. The questionnaire included 14 question items, with a reliability coefficient of =0.82. The researchers employed a five-point Likert scale in which the students answered strongly agree (5 points), mostly agree (4 points), agree (3 points), disagree (2 points), or strongly disagree (1 point) based on their learning satisfaction. In the same vein, the reliability coefficient of Basic Science Assessment was 0.88.

RESULTS

Research Question 1: What level of acceptance do primary school pupils have on educational Pictionary and Matching card games for Basic science learning?

Table 1: Mean and standard deviation of scores in the student satisfaction scale

	Mean	Standard Deviation
Perceived usefulness	4.14	1.08
Perceived ease-of-use	3.85	1.16
Attitude towards usage	4.00	1.10
Intention to use	3.85	1.21

Mean and standard deviation derived for each construct of the satisfaction scale are presented in Table 1. The results show that the students exhibited consistently positive responses to all constructs. Perceived usefulness and attitude towards usage had high scores, indicating that the pupils felt they could gain scientific knowledge by learning with the Pictionary and matching card game, and that it was useful to Basic Science learning. These results also show that game-based learning aroused student interest. The results in intention to use and perceived ease-of-use show that the pupils readily accepted this learning method and it facilitated learning and hoped to continue using this method in the future.

Research Question 2: To what extent do educational Pictionary and Matching card game influence science learning achievement among primary school pupils?

Table 2: Results of paired sample t-test on science assessment for primary pupils

	Mean	Standard deviation	T
Pretest	83.33	11.43	-3.32**
Posttest	92.13	8.80	

** $p<0.01$

A dependent sample t-test was performed to ascertain whether the participants improved in the science assessment after playing the educational card game. The results indicated that the post-test scores of the pupils (M=92.13, SD=8.80) were significantly higher than the pre-test scores (M=83.33, SD=11.43) (t=-3.319, $p<0.01$), as shown in Table 2. According to these results, the researchers deduced that the scientific card game designed in this study, Pictionary and Matching card games, can assist students in gaining knowledge regarding forms of transportation and energy.

DISCUSSION

The discussion was based on the findings of this study. The participants displayed positive attitudes toward using educational card games and confirmed that the games contribute to their learning outcome. The majority of the pupils accepted this learning method and are willing to continue using this approach in the future. The pupils also stated that learning with the educational card game could assist them to gain scientific knowledge and that the game-based learning method increased their interest in forms of transportation and energy. The pre-test and post-test results demonstrated that the card game significantly increased the pupil's scientific knowledge related to energy and forms of transportation. These results correspond to the use

of digital games in game-based learning in previous studies by (Lin et al., 2019; Papastergiou, 2019; Siegler & Ramani, 2018; Yien et al., 2016). Moreover, the use of educational card games promotes game-based learning and also enhanced learning motivation and learning effectiveness.

CONCLUSION

Based on the purpose of this study, that was to explore the influence and readiness of primary school pupils on the use of games for learning. The findings have established that educational card games promote students' learning outcomes and enhanced learning motivation and learning effectiveness.

RECOMMENDATION

Following recommendations were made after the study;

1. Future studies should conduct in-depth surveys on student attitudes towards learning using card games to identify the elements that arouse interest and how knowledge is acquired from playing games.
2. Future studies should conduct further analysis on the learning process and student-student interaction during educational card games and investigate how they influence game-based learning.
3. Primary school teachers should create and use educational card games for teaching.

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