Learning Differentiation Sub Topic In Mathematics Using An Educational And Casual Flash Based Game

Norhafiza Mohamad, Pusparini Dewi Abdul Aziz

Universiti Kuala Lumpur British Malaysian Institute, Malaysia

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Abstract

Proficiency in Mathematics becomes a critical skill for national growth nowadays. Despite this, there is a worrying decline in mathematics achievement among student population. Four-yearly study; Trends in International Mathematics and Science Study (TIMSS) in 2007, revealed Malaysia fell 10th in 2003 to 20th place in 2007. Among the main factors that may contribute towards this declination is lack of motivation that blocks the opportunity to solve the misconception. Students must be intrinsically motivated to learn about nature of the subject. Yahya, Ramli and Boon (2007) from their study, found a correlation between students' attitudinal commitment and their performance in mathematics. Research has shown that learning is much more effective when the students have fun and make them engaged to the subject. Digital Game Based Learning (GBL) is one such novel field in the learning area that holds considerable promise to engage students. In support to it, over the last ten years the growth in games has increased up to $7.4billions. The GBL combines motivational aspects of computer games with learning by bringing the fun in a natural way. It's also a platform that able to teach transferable skills, impart values and attitude. In this paper we present the preliminary output from a short term research grant's project to develop an educational, casual web based game prototype named Kalcoolusa using Adobe® Flash Player for the Mathematics subject focusing on the Differentiation sub topic. Further development of the game, additional studies and comprehensive usability testing are planned to obtain more conclusive results. It is expected the game has the potential to improve student learning in that specific topic.

Keywords: Digital game based learning, Differentiation, usability testing

INTRODUCTION

The usage of computer games as a learning resource has increased drastically in a variety of contexts, in schools, universities, workplaces and hospital. For example, since "Where in The World is Carmen Sandiego" that taught simple geography whilst playing a mystery game was adapted. Across the world, teachers/lecturers are increasingly becoming interested in the potential role of computer and video games to support the learning. With the advent of new technologies and strong growth in games for over the last ten years; increasing to $7.4billions, the way in which education and training is delivered has changed considerably. Games are now being considered as a platform that able to not only teaches specific skills, but also potent to teach transferable skills, impart values and attitude. Futurelab (2005) in its handbook agreed that by playing games, the players are equipping their practical competencies and social practices that are needed for 21st century workplace, communication and social lives. Apart from that, few studies have shown that playing with computer games can also enhance visual processing skills, including visual attention, and the ability to manipulate objects or mental images. Plus, more complex the game is, the students or players will be more creative and alert as the games normally will require them to learn taking information from multiple sources and make quicker decisions. Game Civilization 1 for instance, the players discover strategies for overcoming obstacles, and construct understanding of complex systems through experimentation in natural and unobtrusive ways.

Already knew that to conquer Mathematics, one should do lots of routine exercises in order to be familiar with rules or formulae apply. The boredom however will start to interrupt when the students find no 'exit' or solution to the questions attempt. This happens, when one concentrates on the misconceptions and confusion they have about, e.g. in the differentiation rule, the lack of motivation is blocking the opportunity to solve the misconceptions as being studied by Yahya *et al.* (2007). Found from the study, there is a correlation between students' attitudinal commitment and their performance in mathematics.

One of the issues raised by the teachers/lecturers in teaching Mathematics is the students are not always motivated to learn about the content and leads to failure This issue is strengthen via the result of four-yearly Trends in International Mathematics and Science Study (TIMSS) in 2007 reveals Malaysia's placing fell from the 10th place in the previous TIMSS 2003 to 20th placing. Since the assessment was conducted amongst secondary school students, one of the main issues highlighted by the general public, politicians and academicians alike for the decline was the ongoing controversy as to whether the teaching of science and Mathematics in English at schools should continue or revert to the mother tongue (Malay language). This may or may not be the contributing factor, but the glaring fact of the plummeting performance in mathematics remains.

Therefore, the aim of this short term research grant is to produce an educational aid in order to overcome the problem of understanding the basic rule in differentiation by developing a casual game name "Kalcoolusa" for differentiation topic in mathematics using Adobe Flash. In justifying the game's effectiveness, it is tested through the usability testing.

METHODOLOGY

A. Game Play Literature Review

There is numerous number of GBL in teaching Mathematics developed in all over the world. The game play concept for Kalcoolusa is food-time management. The concept portrays in food-time management is completing certain score to be promoted to the next level. Failure of doing that leads to game over or point's deduction. This concept of gameplay imparts the values of efficiency, increase level of alertness and not only delivers specific technical knowledge.

The famous game play under time management (among the earliest too) is on serving the burgers. Big Bobs Burger Joint for instance, the objective of the game is to serve burgers to customers by clicking oven and stove to cook buns and burgers. Shall the burgers are prepared completely; they will be sent to the customers and will be paid. The process repeats until the player accomplishes a level in order to achieve a daily target. Big Bobs Burger Joint has 22 levels that represent 22 days. As the level increases, it's getting tougher as more servings and more dressings are required. Scores (daily collections) are based on money paid by satisfied customers. Any burnt burgers or wrong orders will lead to money deduction. In summary, the player needs to be skillful to provide enough burgers hence meeting the daily target. The same game play is also adapted in Burger Restaurant whereby the players need to meet certain target. However, Burger Restaurant offers better graphic with vibrant colors and livelier game environment.

Another popular time management game is Korean Burger. The objective is to complete random burger orders that come with beverages by putting the ingredients in proper sequence at specific level. Comparing Korean Burger with the Big Bobs, there is timer in Korean styled whereby each order needs to be completed in three minutes. Despite of wrong orders, no marks will be deducted except they will be automatically thrown away. Doing the mistakes, only require players to fight harder against those three minutes.

There is also a similar game to Korean burger but played in French. The player of XXXL Burger needs to complete the burger order by putting the ingredients in the correct sequence (fixed order) according to the containers' color. If the burgers were completed correctly, it will automatically sent to the customers by an invisible machine to earn points. Wrong sequence or late orders will automatically be purged and points will be deducted.

B. Prototype Development by Employing Instructional Model for Digital Game Based Learning

The game development involves with five phases namely analysis, design, development, implementation and evaluation. All the five stages lie in instructional model or instructional design which the 'guru' in developing GBL. There are three basics learning theories under instructional designs; behaviorism, cognitivism and

constructivism. According to Schuman (1996) in his writing explained that behaviorism is based on the though process behind the behavior. Changes in behavior are observed and used as indicators as to what is happening inside the learner's mind. Cognitivism (Schuman, 1996) is based on the premise that constructs own perspective of the world through individual experience and schema while constructivism focuses on preparing the learner to problem solving in ambiguous situations (Schuman, 1996).

Comparing the three basics, behaviorism is the most closely related to human nature. There were many experiments done by the scholars in relating the theories with human psychology or behaviorism towards game engagement. Pavlov, Thorndike Watson, Skinner etc among the psychologists that studied behaviorism theory. They proved how humans react to the repetitive actions that soon be as a habit and mindset.

Kalcoolusa adopts the basic of behaviorism. The player needs to repeat the same actions accordingly throughout the levels. These actions represent the steps or the rules that should be followed theoretically, one by one in solving differentiation problems. Soon, by following and repeating all the actions/steps in correct sequence, the students are supposed able to solve any differentiation problems encounter. Different time is allocates and it depends on level(s) just to ensure player 'pick-up' or alertness is sharpen. More complicated equations are provided throughout the levels as the player should be more skillful in solving differentiation problems.

C. Preliminary Data Collection Through Usability Testing

Usability testing is a technique used in user-centered interaction design to evaluate a product by testing it on potential users. The test focuses on measuring a human-made product's capacity to meet its intended purpose. Examples of products that commonly benefit from usability testing are foods, consumer products, web sites or web applications etc. Normally the scopes of usability testing are on the usability, ease of use of a specific object or set of objects.

Usability testing is conducted by applying thinking aloud method and semi structured interview. Someren (1994) defined the Think Aloud Method as a method that consists of asking people to think aloud while solving a problem and analyzing the resulting verbal protocols. A simple example in applying this method is when finding a book whereby each step taken should be verbally justified. The vocalizing process is basic idea of thinking aloud method.

The pilot data collection for Kalcoolusa is expected to be done for Diploma and Bachelor students in Universiti Kuala Lumpur British Malaysian Institute. Subjects for the investigation are the students who are taking Technical Mathematics 2 (Diploma) and Engineering Mathematics 1 (Bachelor). As it is advisable for usability testing to be held in a small group to reduce the error, thus each group will consist of 15 students divided into three sessions. For each session, each student will be supplied with digital audio recorder to possible the 'think aloud' method while exploring the game. Upon completion the game, the students need to go through a semi structured interview with an instructor for furthered confirmation on the usability of the game, ease of use and engagement towards the game.

II. RESULTS & DISCUSSIONS

A. Kalcoolusa Game Play

"Kalcoolusa" is selected to depict calculus since differentiation is part of its branch. In the game, it refers to a deserted placed where a spaceship is landed on. Function of the player starts here. To be home, the player needs to serve local citizens of Kalcoolusa represented with 2D robots. The mission should be accomplished in five days which equals to five levels of the game. Each day has its own minimum target to be achieved. Similar to other games in time management, failing in meeting the daily target will make the player to be enslaved forever in Kalcoolusa. To be free from the all the robots and return to the earth, the player has to complete minimum daily target for each day and at the same qualifies for the next level. Once any levels are failed, they have to start from the zero with no accumulative scores. The educational objective for Kalcoolusa is to learn basic rule of differentiation through behaviorism theory of instructional design. Actual steps in differentiating the equations are visualized through three different thumbnails. These thumbnails are the visual helper by showing items that should be clicked. After playing Kalcoolusa, students should be able to memorize all steps in correct sequence for solving differentiation problems.

First level defines the easiest questions. Plus, the player is given ample time to solve the problems. With the longest time amongst five levels, it actually allows the player to understand the real operations happened in solving the differentiation problems.

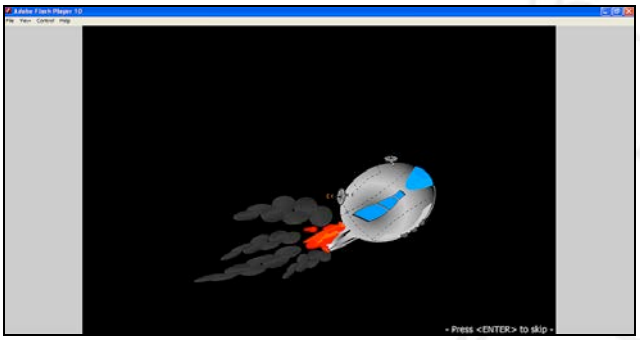

Figure 1: Starting game of Kalcoolusa - a stranded spaceship

Figure 2: Pop-up menus

To create better engagement towards the game, few options are given to the players. They can adjust the loudness of the music, to have low or high graphics as well as having the option to opt to the full screen size. The Options click button is shown in Figure 3.

Figure 3: Options click button

Tutorial is provided in "Help" click-button. This function is to help the player understands Kalcoolusa and familiarizes with the game faster. Help function is crucial as there will be always first time player. Clicking "Help" button will explain to the players on the icons available in Kalcoolusa, how-to-play it and multi styles of the thumbnail that will appear throughout the game. Different thumbnails are applied to differentiate different steps or actions done according to the theory. They also represent the actual steps or changes when differentiation takes place.

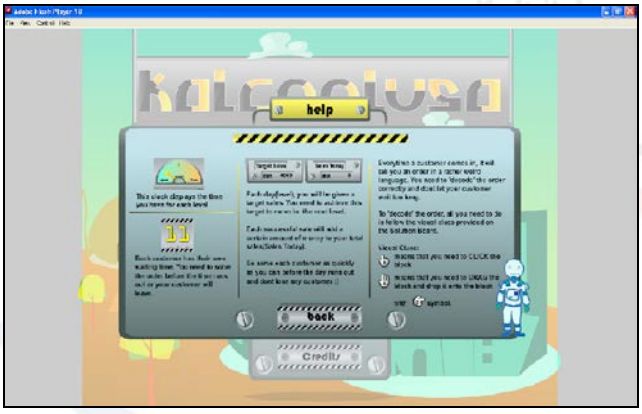

Figure 4: Help click button

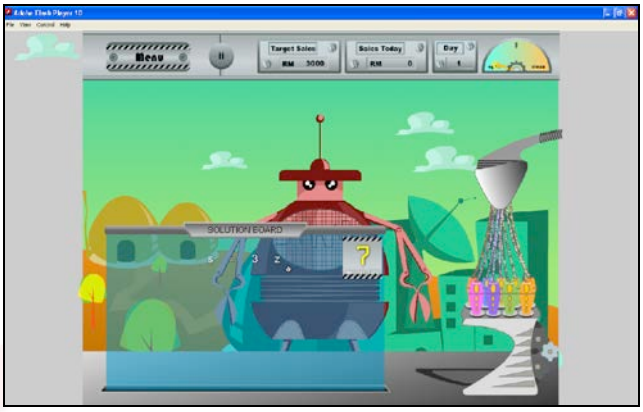

Figure 5: Level 1

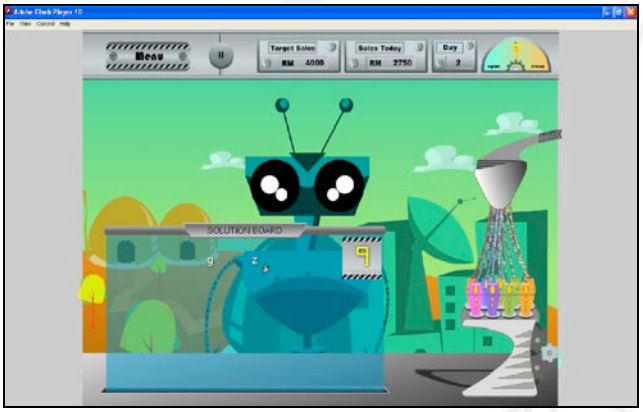

Figure 6: Level 2

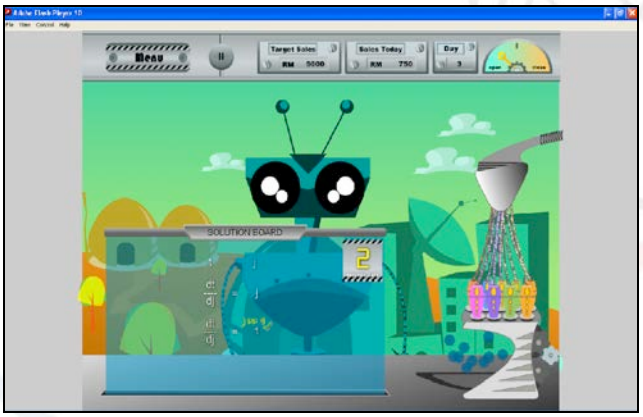

Figure 7: Level 3

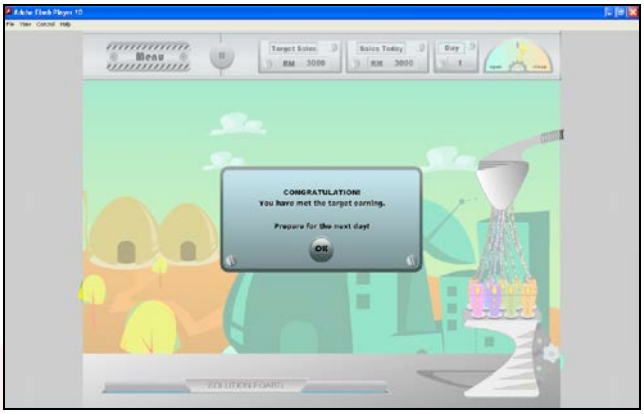

Figure 8: Congratulations page as respective level successfully ends

Although Kalcoolusa applies behaviorism instructional design that focuses on repetitive actions, its educational objective to aid students in understanding the differentiation's rule is still in foreground. To ensure this, via evaluation stage, each thumbnail clicks are supported with explanations of real operation involves in getting the answer. The operations are different and they're based on the equations.

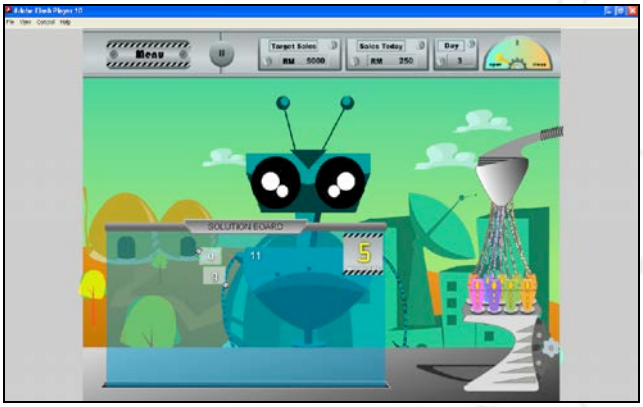

Figure 9a

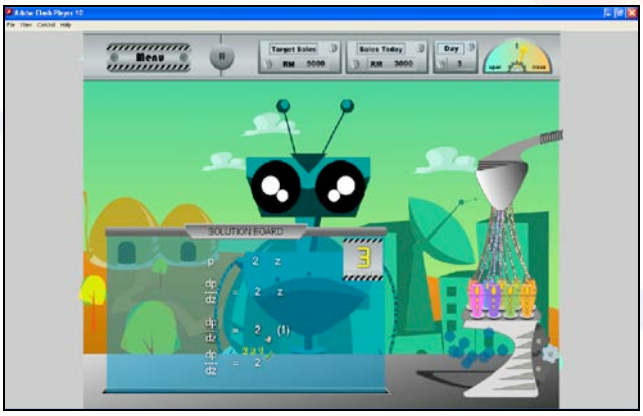

Figure 9b

Figure 9a & 9b: Few real operations show once correct answers obtain

B. Dicussions

It may take time to expect the digital GBL to be effectively and widely implemented in the local education system. And definitely there must be arguments raised so that the educational objective is achieved but at the same the fun-style concept is maintained. As stated by Huah, G.L (2007), teachers play a vital role to ensure that they allow for the paradigm shift of the teaching innovation rather than just accommodating the innovation. As Cece (2004) maintains, "a major challenge in professional development is helping teachers unlearn the beliefs, values, assumptions and cultures underlying schools' standard operating practices". McDowell and Hannafin deduced that insufficient time for planning as well as inaccessibility to computers or training prevents teachers from integrating technology (Huah, G.L. 2007). Therefore, these external barriers need first be addressed so as to grant more assurance of success. Prensky (2001), the 'sifu' of GBL stated in his book that U.S Military has embraced Digital Game-Based Learning with all the fervor of true believers because it works for them. If it was functioned even for a tough world like military, then the educational system should really consider GBL.

C. Future Works

As for future works, a comprehensive usability testing shall be conducted. As being explained in previous chapter, the usability testing will be conducted for 15 students each from Diploma and Bachelor level. Apart from that to ensure the optimum usability, the students selected will be given few differentiation questions that need to answer in certain period of time. After answering the questions, they students will proceed to play Kalcoolusa. Once they complete the game, the students then again need to answer the same questions. This practice can affirm is GBL able to help the students understand differentiation better or not but also time answering for pre-playing game and post-playing game is also monitored. This usability testing will muchly consider on the four factors that made the engagement to the games which are challenge, curiosity, fantasy and control.

The evaluation stage in developing this Kalcoolusa also recognized few items for improvements and shall be included for future works and research. The first item to be improved is to extend the equations to higher level of differentiation and at the same time to increase the difficulty for equations display. The times taken to complete level 4 and level 5 should be prolonged so that the player able to complete that level successfully without needs to repeat the whole level. Another option will be to increase mark of each correct answers obtain to remain time allocates. The chronicle of displaying the process of differentiation should be improved as well to avoid confusion especially for the new learners.

It is newly required in Universiti Kuala Lumpur to have interactive assessment via e-learning or academic portal. Thus, having Kalcoolusa to be part of the assessments can implement the requirement.

IV. CONCLUSIONS

In conclusion, the teaching and learning environment and educational approach would require constant research and updates in par with the new epoch of Information and Communications Technology (ICT) development. GBL is a promising new style of learning with lots of potential to be counted in. It can seriously be considered as primer teaching aid apart from conventional method. Therefore, it is necessary to exploit and explore its potential in being an effective learning technology or environment as well as for helping students accelerate their learning and retaining the understanding. However, as highlighted in the discussion, any technological innovation for teaching purposes needs to be accepted by the educators (teachers) before it can be productively used in educational systems; and the same goes for GBL. With further resources and time spend, this research could be expanded into a nation-wide project covering various other topics suitable with to be taught and learned. After all, as Inoue (1999) concluded, "twenty-first-century students must master sophisticated information-age learning media, having access to more powerful learning resources than students of today".

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