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1 Slash 100%: gamification of mathematics with hybrid QR-based card game

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ABSTRACT

Mathematics is vital in our life and society. However, gamification of mathematics is rare for topics such as fractions and decimals. This paper presents the development of an educational mathematics game called *one slash one hundred percent (1 Slash 100%).* It is the hybridization of the conventional card game and quick response (QR). This research aims to study how the respondents explore the card game to master decimal, fraction and percentage. The testing was conducted among secondary school students in Kuching, Sarawak, Malaysia (n=12; age=14). The respondents were asked to answer a set of questions in pre-test and post-test question. The results are promising where the analysis showed a significant difference between pre-test (M=14.3, SD=2.103) and post-test scores (M=17.6, SD=2.234). Thus, gamification of mathematics using the hybrid card game increases their mastery of decimal, fraction and percentage.

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1. INTRODUCTION

Mathematics is an important subject and critical skill to master for us to function in a society [1]. It involves cognitive activities such as logical and reasoning through calculation [2]. The subject of mathematics is related to quantity, numbers, measurement and other related concepts. However, gamification of the mathematics subject is still rare, especially for topics such as Linear Algebra and fractions [3]. Thus, learning institutions such as schools should tap the power of mobile-learning to fulfil the current learning needs of the new millennial learners [4]. This paper presents the development of an educational mathematics game called one slash one hundred percent (1 Slash 100%). It combines the concepts of card games and quick response (QR) technology. It intends to help students to master fractions and decimal, based on the curriculum and assessment standards document (DSKP) produced by the ministry of education (MOE), Malaysia.

We intend to make it easier to form 3 students to understand and master the concept within a short amount of time. As fraction is one of the toughest syllabi for students [5], our main research question is to find methods that could combine both the conventional card game and QR to improve learning further. This paper is structured as follows: Section 2 discusses a brief literature review and related works. Section 3 describes the process of designing the QR card game. Meanwhile, section 4 presents the methodology of the evaluation method. Section 5 explains the results of the game testing process. Section 6 discusses the main challenges in designing our mathematics card game. Finally, Section 7 summarizes the project and presents future research opportunities.

2. GAMIFICATION OF MATHEMATICS

Card games have been around for hundreds of years. It was reported to have started in China during the Tang dynasty. Card games involve techniques, insights and discipline. The players need to develop their strategy to win. Educational card games introduce the students with the complex learning process at different levels of difficulties. Besides, card games are good to educate children about patience, sportsmanship, motor skills, listening skills and concentration. Therefore,card games may become an effective educational strategy to promote active learning. A study conducted by [6] suggested that embedding abstract mathematics strategy is an essential aspect of mathematics games. In this era, non-electronic math games still offer teachers and parents to have 'play talk' while playing as opposed to digital math games and apps [7].

Previous studies have emphasized that Game-based Learning (GBL) has positive motivational effect among students [8]. A study by [9] argued that positive mathematics experiences among students at an early stage might have a more prolonged effect on their mathematics performance. Any intervention such as GBL may provide educators with immediate diagnosis and correction tools. Researcher [10] supported this argument by suggesting that a simple, low-fidelity math card game may improve numerical skills, especially among 39 low-income children in their study. Game-based learning impacts students' enthusiasm, commitment, and enjoyment [11]. Besides, an app called 'DorDor' was developed by [12] to prove that Digital Game-Based Learning (DGBL) with Augmented Reality (AR) is useful in mathematics. An extensive qualitative study involving 3,202 participants revealed several reasons why learners enjoy learning gamification [13]: (i) it fosters enthusiasm; (ii) it provides performance feedback; (iii) it fulfils learners' needs for gratification; and (iv) it promotes goal setting.

Furthermore, it can also boost mutual relationships among the teachers and students in fun and enjoying way. A study by [14] found that 39 students in Indonesia faced difficulties in understanding mathematics problem out of fear and anxiety. Difficulty in understanding arithmetic, in general, is typical among children [15]. Thus, the mathematics card game is an alternative way to enhance the process of learning. It also motivates and helps them to understand better while enjoying the non-serious learning process as well as improve their learning performance [16].

Also, QR-based Math card games can innovate the learning process by providing a robust and competitive platform for students. Researcher [17] believed that competition and the urge to score points has the power to increase learners' engagement. Collaborative learning and social-based learning through mobile QR technology is an excellent alternative to conventional learning. Thus, more and more QR-based math game design models should be developed and validated based on established models such as the technology acceptance model (TAM) and technology readiness index (TRI) as done by [18]. The hybridization of physical and digital interactive mathematics card games could overcome the challenges related to learning performance [19]. This is because significant contributions of mobile learning technologies in recent years have successfully built the learners character, behaviour and interest [20]. Recently, reseacher [21] developed a mathematics board game called Mathboard that used Internet of Things (IoT) technology.

3. DESIGNING *1 SLASH 100%* QR-BASED GAME

In this card game, players are required to find the answer to question cards to win the game. There are power cards added to make the card game exciting and enjoyable. The instructions to play this card game is easy to understand. The players may find the hint for the question card provided at the bottom of the card. This card game covers three chapters starting from Form 1 to Form 3, which are decimal, fraction and percentage. In the deck, there are 56 cards, with 36 number cards and 20 power cards. Example of question cards is shown in Figure 1.

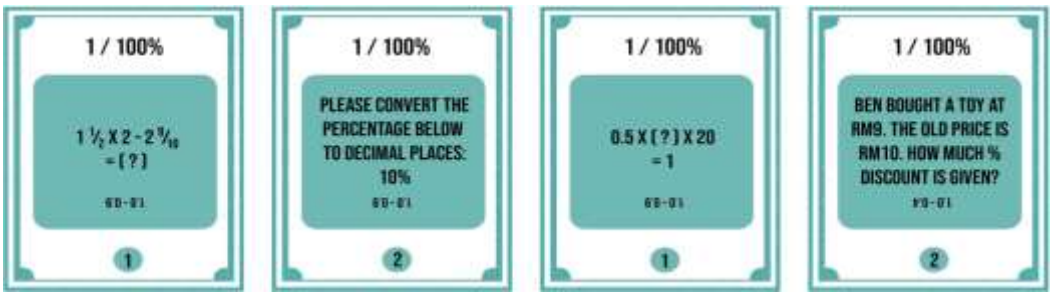

Figure 1. Question cards

Figure 2 shows the card game box design. The design is simple to attract students to focus on the educational content of the game. Figure 3 shows the QR codes embedded on the game package that links to the YouTube videos or channel. Figure 4 shows the QR codes that are linked to a YouTube channel. Short videos were created to explain various subtopics.

Figure 2. Game box design (back and front)

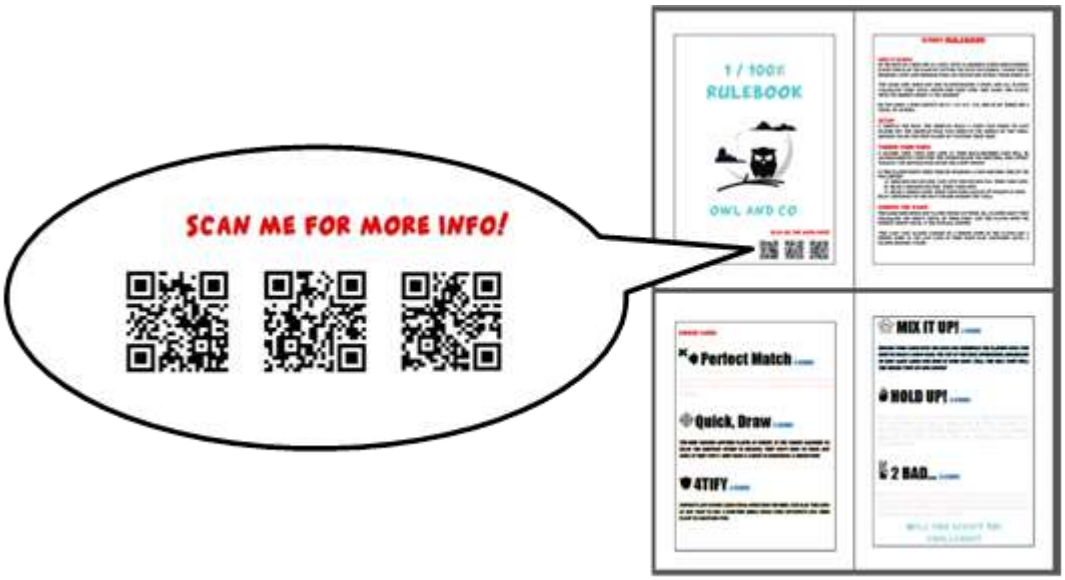

Figure 3. QR access code printed on the rule book, linked to the instructional videos

There are *Power* cards that can be seen in Figure 5 designed to make this game more challenging and fun:

- ***Perfect Match cards*** will enable the players to form a *Pair* with any *Number* card, but only points from the *Question* card will be calculated.
- ***2 Bad! cards*** will enable the players to force any other opponents to draw two cards.
- ***4tify* cards** will enable the players to prevent *Power* cards from affecting them, and it gives the players a shield from the opponents at any time.
- ***Mix It Up! cards*** will enable the players to reshuffle his or her cards and place it into the deck and draw three cards, regardless of how many cards he or she currently holds.

– **Hold Up! cards** will eliminate a target's *Pair* and forces them to discard that *Pair*, drawing one card from the deck and is playable at any time.

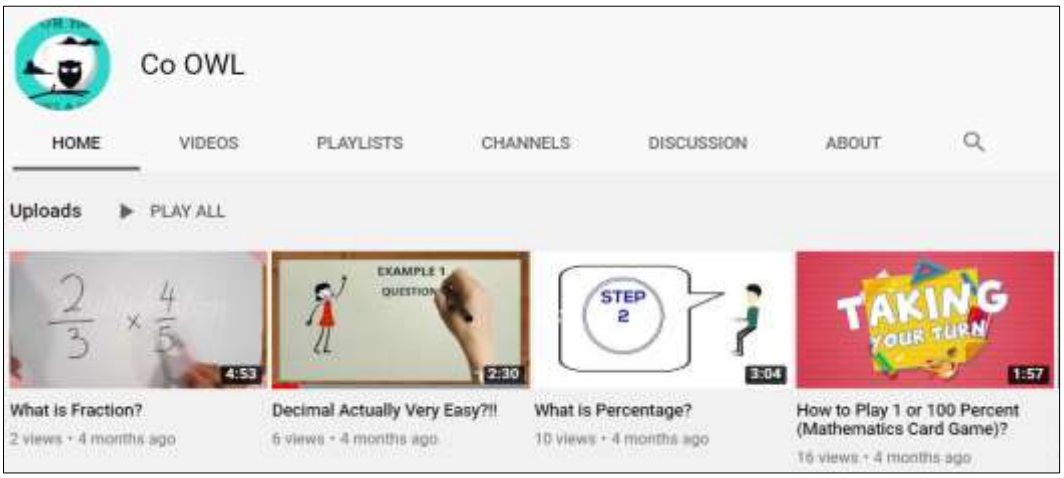

Figure 4. The QR codes are linked to a YouTube channel

Figure 5. Power cards

To start, a player must shuffle and distribute the cards. The shuffler will give five cards to each player (face-down) and put the shuffled deck in the middle of the table. The oldest player by default becomes the first player. Play turn by turn clockwise. All players must put the deck facing down, taking turns drawing cards and forming pairs, or preventing others from doing so. The game will end when any player has collected five pairs of cards. All players must calculate their total points for every pair they made. The player with the highest total point is the winner. Each *Question card* will be accompanied by a hint of the answer below the question, and a *point value* displays the *Question card's* point value. Next, the player will start their turn by drawing a card and does one of the following:

– Play and discard one card into the discard pile, and their turn ends.
– Play a *designated pair*, and their turn ends.
– Play a *power card*, and their turn ends unless the second *chance* card is used.

Then, the game will continue with the next person around the table. The game will end when any player forms a fifth *designated pair*. All players must then calculate the point total of their *pairs*, and the player with the highest point total is the overall winner. The last card played cannot use a power card. If the player has a power card as the last card in their hand, they must draw a new card.

4. GAME EVALUATION METHOD

Pre-test and post-test were the instruments used in the study. A user testing was carried out among 12 students (Age=14) at a school in Kuching, Sarawak, Malaysia (m=6, f=6). The objective of the testing session is to obtain feedbacks, comments and suggestions for improvements to our card game.

Before the testing started, we explained the objectives of the game and the function of the power cards that will be used to play the game. The students were divided into three groups. Firstly, the pre-test was conducted among the students. The test consists of of 20 questions. Each group took approximately 30 minutes to complete the game. After playing the card game, the students were given a post-test. The tests were conducted to evaluate their understanding. While playing the game, the students were able to learn about the topics indirectly. We also observed the players' behaviour that can be seen in Figure 6.

Figure 6. Instructing the students on how to play the game

5. RESULTS AND ANALYSIS

This section explains our findings based on our experience during the playtest session. After analyzing the results of both tests, it is concluded that the results of post-test were better than the pre-test. The results obtained are displayed in Figure 7. The analysis showed a significant difference between the pre-test (M=14.3, SD=2.103) and post-test scores (M=17.6, SD=2.234). The results suggest that the students' performance in the post-test was significantly higher than that in the pre-test. This proves that most of the respondents have improved after playing our QR card game by correctly solving more questions. Based on our observation, we noticed that the students enjoyed the game.

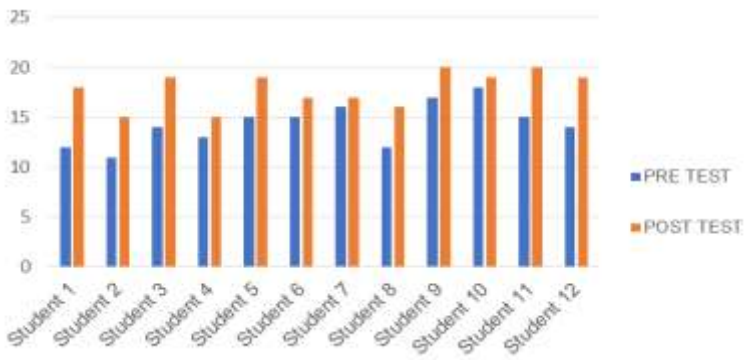

Figure 7. Pre-test and post-test results

For the discussion purpose, generally, we know that mathematics is quite a boring subject for students. This may be due to the conventional method of teaching math, which is somehow uninteresting. There is either no or little fun factor. Moreover, there is less or no interaction and competition among students, and there are only few or no exciting parts. The conventional way of chalk and talk makes the students to easily feel bored. Eventually, they would lose their interest. This traditional way of teaching mathematics using passive textbooks is seen as obsolete. Students cannot easily link the basic and advanced math concepts just by reading textbooks. They have been taught with the rote-learning approach for many years. They feel that it is hard to memorize abstract math concepts. Moreover, some students may have limited ability to understand abstract math concepts.

Therefore, to fix this problem, the hybrid (analogue+digital) math card game is a new and innovative solution. The math concept is presented in a fun card-game style. This innovation may attract the students to learn the subject in an exciting method. The learning process is more effective than the conventional way. With card games, the interaction and competition factor are fundamental and essential. Hence, students would be able to learn better and faster. It provides them with a new learning experience. Most importantly, while competing for high scores, students are actually learning the educational mathematics content. The learning outcomes are achieved. Mathematics card games would help the students to remember math formula better. Besides, this way of learning is more interesting, more fun and more unique.

Besides, our maths card game has an attractive design despite having challenging questions. Our design was supported by [22] who stated that game design should offer excellent and convenient control, as well as adequate information to the players. As a result, the students would develop more reliable memory on math topics. The gamification approach involves rewards and punishments. The gamified math card game would make the students fall in love with mathematics. They may improve their confidence in content mastery. Besides, math card game ensures the students apply the math concepts in solving the game questions. Our unique QR-based card game has successfully introduced fraction mastery to the students as competency in decimal and fraction is a basic for more complex calculations [5].

For the implication of this paper, teachers and educators are encouraged to deploy the QR-based math card game in their classroom. QR-based video embedded in our card game supports the statement by [23]. They mentioned that short duration videos with suitable music are favoured by students. This is because it will allow the students to memorize the learning content. Beyond QR-linked videos, educators may embed QR-based mathematics games using virtual reality videos [24]. However, we understand that more rigorous studies are needed to look into the usability of the proposed intervention and should cater to their cognitive loads [13, 25].

6. CONCLUSION

In conclusion, the gamification approach we used in designing has made *1 Slash 100%* an interesting and fun hybrid mathematics card. We believe that this card game would greatly benefit students and can be used as an effective learning material besides formal learning. Our card game managed to make learning mathematics more fun. In the future, we will extend our work to also include VR and AR technology. We also plan to explore other recent technologies such as IoT to relate to our hybrid card game.

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