Attractiveness Analysis of Quiz Games

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Abstract—**Quiz games are played on platforms such as television game shows, radio game shows, and recently, on mobile apps. In this study, HQ Trivia and SongPop 2 were chosen as the benchmark. Each game data have been collected for the analysis and the game refinement measure was employed for the assessment that focuses on different elimination tournament system for each sample. The results show that games such as HQ Trivia, which applies single-round elimination tournament, has a lower value of game refinement, in which the game is highly skillfull. Meanwhile, games that apply a round-robin system, such as SongPop 2 have a higher value of game refinement, in which the game is very stochastic. SongPop 2 and HQ Trivia both have more than 5 million downloads in Google Play Store. It is concluded that different types of quiz games which apply different kinds of tournament style have different game refinement value.**

Keywords—*Quiz games; game refinement theory; attractiveness*

I. INTRODUCTION

The Merriam-Webster dictionary defines knowledge as the fact or condition of knowing something with familiarity gained through experience or association [1]. Knowledge is usually acquired through experience or education by perceiving, discovering, or learning new things. Ricci et al. investigated the effects a gaming approach on knowledge and retention in military trainees, which shows that participants assigned to game condition scored significantly higher on a retention test than those assigned to the text condition [2]. This indicates that people receive information better within game condition compared to the usual paper-based question-and-answer form (test).

Nowadays, there are many educational games available on various subjects, ranging from historical mythology to science and technology [3, 4]. Through games such as Age of Mythology and Age of Empires, one can learn about the mythological figures and popular culture superheroes and their connection to history and society [5]. In terms of learning science, one can simply browse the Science Kids website, which offers experimental science and technology games for kids to learn science in interactive ways. Furthermore, machine learning [6–10], used within learning analytics, provides new insights into education processes. Currently, it is used to develop quiz games in order to make the educational processes in schools and universities more efficient for students and teachers.

One of the factors available in the quiz games that attract people into playing it applies to the game itself. Most of the quizzes offer a variety of categories of quiz questions, and the players may or may not choose a category of their liking. Some of them make the quiz game much more challenging by limiting the time, treating that as a goal to answer the questions as fast as possible. Another main factor is the offer of prize money to the winners, which gameplays mainly apply. For example, the television game shows attract people to participate and watch the players play by correctly answering the questions in the hope of winning the game and returning home with a huge sum of money [11]. It is believed that to maximize the entertainment factor of the game, game designers have to find a comfortable setting for the quiz game [12]. Hence, factors that attract the quiz game need to be identified, applied, and changed consecutively.

A previous study has used quiz games to identify the point of popularity that attracts people to play it. Quiz games have been played for so long – ever since the radio started broadcasting to the public. The questions that may be asked in the quiz games vary. For instance, there are quiz games specially made to test players' knowledge of music or television series. With respect to the root question of "Why are people playing quiz games for a long time?" the trend gained a lot of ground in the '70s with the original Jeopardy! Daytime game shows premiered in 1964 [13]. By applying game refinement theory to quiz games by using an appropriate game model, this study focuses on two main research goals: 1) to find the reason why quiz games have been popular for such a long time and 2) to identify comfortable settings of quiz games.

The rest of this paper is organised as follows. Section II addresses the background of study related to quiz games. Section III explains the game refinement theory for attractive analysis. The quiz analysis is presented in Section IV. This paper is concluded in Section V.

II. BACKGROUND OF THE STUDY

A. Historical Review

The period on which the term quiz was created is unidentifiable. The American Heritage Dictionary mentions that in 1782, quiz was apparently an unrelated slang word that meant an odd person or an eccentric person; this definition was originally derived from the term quizzical [14].

Additionally, the dictionary suggests that it may come from the English dialect "quiset", which means "to question". In this case, it may originate as a question and refer to inquisitiveness [15]. Based on the Oxford English Dictionary [16], the term quiz means "to question or interrogate", which may originate from a statement recorded in the year 1843, "She comes back an' quiesed us".

Quiz games have been played ever since the existence of radio shows. In America, the earliest radio quiz show was Information Please, which was aired on NBC from 17th May 1938 to 22nd April 1951. The title of the show originated from the contemporary phrase used to request information from telephone operators. Then, it was called "information", but now, it is called directory assistance. The series was moderated by Clifton Fadiman.

B. Overview of Quiz Games

Mainly, the goal of quiz games is usually to answer all the questions correctly. Nowadays, there are many types of quiz games. Some have the intention to win the game by answering the questions within the time limit, while some are played to beat the opponent's score. These kinds of quiz gameplay have evolved without anyone knowing where and when it all started. Some quizzes offer various kinds of categories, in which players can pick the category of questions they would like to answer, and some are randomly picked questions that usually deal with general knowledge.

Basically, the goal of any quiz game is to make its players win by correctly answering all the questions given. Some gameplays are conducted by counting the participant's highest score mark and considering the event of the participant defeating other players' highest marks. To achieve this, a player has to win by answering a lot of questions correctly. For example, a player begins by registering his/her minor details to the game. Then, the player starts to play by answering beginner's level questions. With every question answered, the rank of the player in the game increases. As the rank increases, the player is then challenged with much more challenging questions than the ones before. As for quiz games that offer prize money, they usually use the single-elimination (SE) tournament system, in which the players must win by answering all the questions correctly within the time limit. If the players answer even one question wrong, they are automatically disqualified from the game.

III. RESEARCH METHODOLOGY

To undertake these challenges, this paper focuses on two parts of quiz games, which are the gameplay of quiz games, and the questioning part of quiz games. For each part, this study attempts to figure out the reasonable game progress model to derive an appropriate measure of game refinement. The data have been collected using a variety of methods. For example, some data were collected through playing the game itself in order to identify the gameplay of quiz games, while some data were obtained from reliable sources on the internet.

This project has implemented a game refinement theory as defined by Sutiono Purwarianti and Iida [17]–the "game progress" is twofold. One is game speed or scoring rate, while the other is the game information progress which focuses on the game outcome. In quiz games, the scoring rate is calculated by two factors: 1) number of questions correctly answered and 2) the time taken to answer the question. Thus, the game speed is given by the average amount of questions divided by the number of total mistakes. In some quiz games, the total score may solely depend on the total number of correctly answered questions instead of depending on the time taken to answer the questions.

Now, considering a model of game information progress, the game information progress itself indicates the certainty of the result of the game in a certain time. Having full information regarding the game information progress, let G be the number of total mistakes and T be the average number of questions. As for game information progress, for example, after the game, the game progress will be given as a linear function of time t with $0 \leq t \leq T$ and $x(t) \leq G$ as shown in Eq. (1) [18].

$$x(t) = \frac{G}{T} t \tag{1}$$

However, the game information progress given by Eq. 1 is usually not known during the in-game period. This is because of the presence of uncertainty during the game until it ends, which is called balanced game or seesaw game. Therefore, the game information progress should not be linear but rather exponential. Hence, a realistic model of game information progress is given in Eq. (2).

$$x(t) = G\left(\frac{t}{T}\right)^n \tag{2}$$

Here, n stands for a constant parameter that is given based on the perspective of the observer in the game. By deriving Eq. (2) twice, the acceleration of game information progress is obtained. Eq. (3) presents the final equation when solving it a t = T.

$$x^n(T) = \frac{Gn(n-1)}{T^n} t^{n-2} = \frac{G}{T^2} n(n-1) \tag{3}$$

In this study, it has been assumed that the game information progress in any type of game occurs in human brains. The physics of information in the brain is not known yet, and it is likely that the acceleration of information progress was related to the forces and laws of physics. Hence, it is reasonably expected that the larger the value of G/T^2, the game becomes more exciting due to the uncertainty of the game outcome. Thus, we have used Eq. (4) as a game refinement measure for the game under consideration. It is called R value in short.

$$R = \frac{\sqrt{G}}{T} \tag{4}$$

Here, the gap between board games and sports games has been considered by deriving a formula to calculate the game information progress of board games. Let *B* be an average

branching factor (number of possible options) and *D* the game length (depth of whole game tree). Table I shows the measurement of game refinement for board games (i.e., Chess, Go, and Mahjong).

A round in board games can be illustrated as a decision tree. At each depth of the game tree, one choses a move, and the game progresses. Fig. 1 illustrates one level of game tree. The distance *d* can be found using a simple Pythagoras Theorem, as shown in Eq. (5).

$$d = \sqrt{\Delta l^2 + 1} \tag{5}$$

Assuming the approximate value of horizontal difference between nodes is B/2, the substitution results in Eq. (6).

$$d = \sqrt{\left(\frac{B}{2}\right)^2 + 1} \tag{6}$$

The game progress for one game is the total level of game tree times *d*. For the meantime, it is not considered because the value *d* is assumed to be much smaller compared to *B*. The game length is normalised by the average game length *D*; then, the game progress $x(t)$ is given by Eq. (7).

$$x(t) = \frac{t}{D} \cdot d = \frac{t}{D}\sqrt{\left(\frac{B}{2}\right)^2} = \frac{Bt}{2D} \tag{7}$$

TABLE I.   MEASURES OF GAME REFINEMENT FOR BOARD GAMES

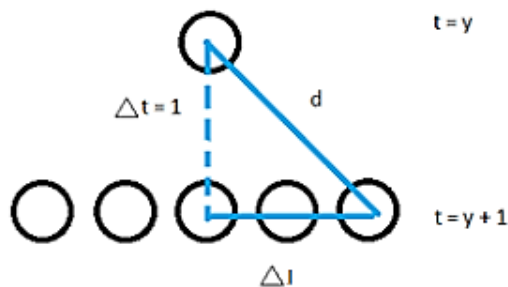| Game	B	D	R
Chess	35	80	0.074
Go	250	208	0.076
Mahjong	10.36	49.36	0.078

Fig. 1.   One Level of Game Tree Illustration.

IV. ANALYSIS OF QUIZ GAMES

A list of questions and answers is the core of a quiz game. To analyse a quiz, it is necessary to focus on this part first. Our first approach was to collect data by searching the information through the game's official website. If the information in the website was deemed not enough, we experimented by playing the game. Moreover, by using this approach, we have collected data from a much more reliable source. Finally, the analysis was conducted to answer our main research purposes.

A. Quiz Gameplay

In this project, five main features were selected to determine quiz attractiveness, which consists of multiple-choice questions (MCQ), time limit scoring system, high-score list, and types of tournament. The details of each feature are as follows:

1) Multiple-Choice Question (MCQ): This consists of several possible answers, from which the correct one must be selected [5]. The multiple-choice format was found to yield more reliability and validity in a shorter amount of test-taking time as compared with short-answer tests [19]. Mainly, quiz games use the MCQ option, where some games offer around 2–4 answer options, from which the players have to pick only one correct answer.

2) Time limit: Many sophisticated board games and popular time limit sports games have a similar value of game refinement [17]. By setting time limit to the game, it introduces challenge into a game in the form of timed response. Players are needed to complete every question within the assigned time limit. Failure to do so may lead to the player losing the game. Time limit is effective for being challenging because it introduces an explicit goal that is not trivial for players to achieve if the game is not properly calibrated [20].

3) Scoring system: One of the most direct methods of motivating players is by assigning points for each and every correct answer during the game. Using points increases players' motivation by providing a clear connection with the effort shown in the game [21]. Furthermore, a score summary following each game provides players with performance feedback as well as facilitates progress assessment on beating the goals of the game.

4) High-Score list: Another method for motivating players to play is by using the high-score list, which shows the names and scores of the players who have achieved the highest scores. The score needed to be beaten by players are shown in order to identify the goal of beating the high score. In a quiz game played by category, the high score is given specifically. By doing this, players become more motivated in answering all of the questions correctly so that they can beat the high score.

5) Types of tournament: There are various ways to run a tournament, but there are about two formats that are popular within the quiz game, which are SE tournament and Round Robin tournament.

B. Data Collection

One possible way to collect the data of quiz games is by experimenting with the games themselves. As most official websites of quiz games do not provide adequate information regarding the games themselves, the only way left is by experimenting with them. Therefore, in this study, two quiz games were simulated by simplifying the factors in the game. The detail of the games is as follows.

1) SongPop 2: SongPop 2 is a music trivia game that was released in July 2015 by FreshPlanet. It is a free-to-play app with in-app purchases. The game is similar to the popular American television game show "Name That Tune", which tests player's knowledge about songs. SongPop 2 features over 100,000 songs and 1,000 curated playlists. Currently, it has more than 5 million downloads in Google Play Store.

Here, players first pick the type of tournament they want. There are three types of mode that players can choose to play: the single-player mode, one-to-one mode, and multiplayers mode. They first pick the music category that they want to play. Then, they listen to the song being played and choose the correct answer from the four options provided in the multiple-choice questions. Some questions ask for the title of a song, and some ask about the singer of a song. The players have only ten seconds to answer each question for a total of 10 questions per round. The faster the players pick the correct answer, the higher their score become. SongPop 2 practices the Round-Robin (RR) elimination tournament, where players can afford to make a number of wrong answers without being eliminated from the game. Table II shows the game mode and game details of SongPop2.

In this version of SongPop 2, players can compete in party mode against hundreds of players in daily multiplayers tournament, where players compete to win badges. Additionally, they can play a single-player mode in which a player competes against the computer. This is the improved version of the game as compared to the earlier version of Songpop 1, where there was only the option of competing with only one opponent. With respect to the SongPop scoring formula, it is awarded based on time and how many consecutive answers players have in their streak, which is completely dependent on the previous questions.

2) HQ trivia: HQ Trivia was released in August 26, 2017 on iOS and later for Android on December 31, 2017. It is developed by Vine creators, Rus Yusupov and Colin Kroll. It is a free-to-play quiz game with in-app purchases that offers prize money to the players who manage to correctly answer a series of questions with increasing difficulty. The app is inspired by a live game show that is aired at 9 pm (the US time). There are around 300,000 players per game in HQ Trivia with 2 million players playing HQ Trivia. Currently, it has more than 5 million downloads in Google Play Store.

Players have ten seconds to answer each multiple-choice question for a total of twelve questions. If there is more than one player who has managed to correctly answer the questions, the prize money is split equally among them. Each question has three possible answers. The players have 10 seconds to answer each question. HQ Trivia game practices SE tournament, in which the players who wrongly answer or do not manage to answer in the limited time are automatically eliminated from the match. Fig. 2 shows the probability of the number of players left with each wrongly answered question.

TABLE II.   GAME DETAILS OF SONGPOP2

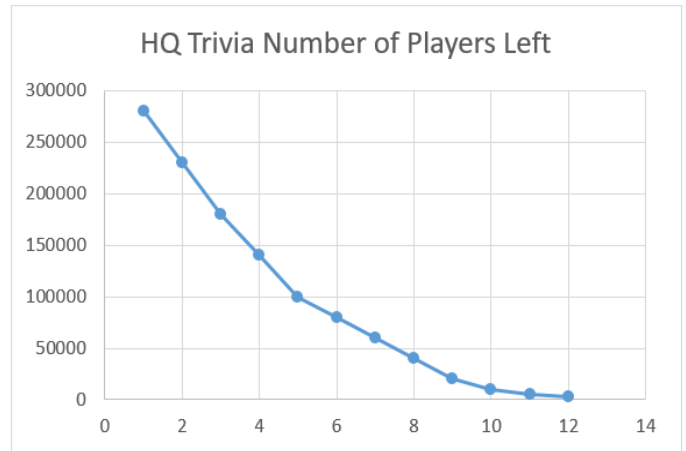| Game Mode	Practice Mode	One-to-one	Multiplayer
Opponent	Computer	1	4
No of Questions	5	5	10
No of Errors	5	5	10

Fig. 2.   Probability of Number of Players Left Per Each Question.

C. Discussion

Throughout the analysis of quiz game apps between HQ Trivia and SongPop 2, two quiz game aspects were found which were round system aspect and tournament style. Fig. 3 shows the quiz game aspects for the measures of game refinement for quiz games. For the round system aspect, a time-limit approach has been used with the game refinement measure variable for Eq. (8).

$$GR = \frac{\sqrt{G}}{T}$$

(8)

The variable G has been identified as the number of error that can be made, and T is identified as the total number of questions per round. The value *n* in the tournament style aspect refers to the number of participants' entry.

Table III shows the comparison between HQ Trivia app and SongPop 2, which identifies each game's refinement measure value. The round system aspect for quiz games uses the time-limit approach. As for HQ Trivia that applies SE tournament type, players answer a total of 12 questions, and they are automatically eliminated if they answer a question wrong even once. The GR-value of 0.08, which is within the game sophistication zone value $0.07 \le GR \le 0.08$ for HQ Trivia indicates that the game is highly competitive and entertaining at the same time. For SongPop 2 that applies the RR tournament type, the GR-value is $0.3 \le GR \le 0.5$, which is higher than the game sophistication value. Therefore, it can be deduced that the game depends heavily on the players' luck.
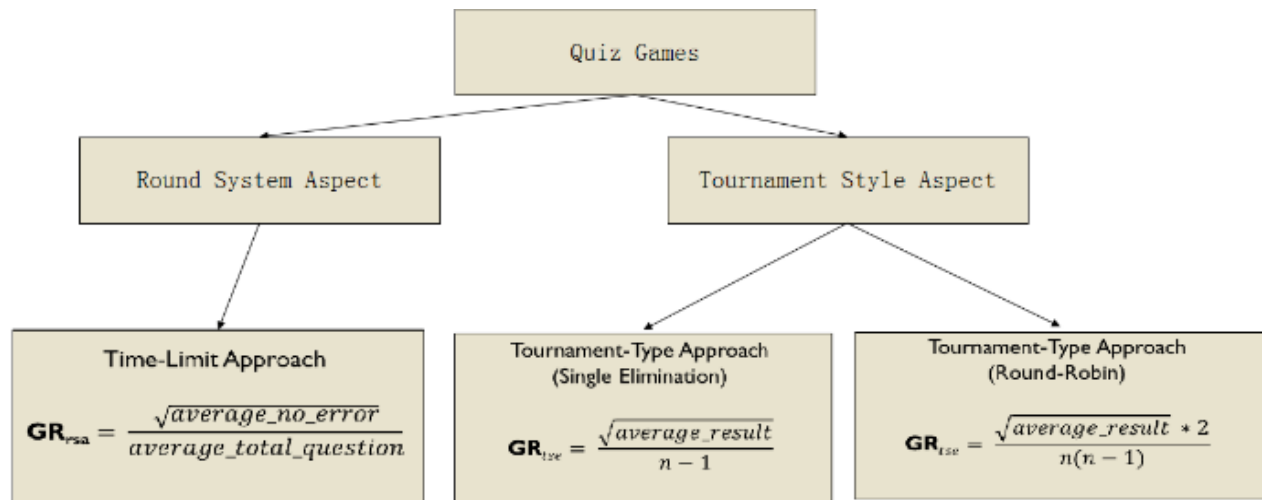
Fig. 3. Quiz Games Aspects.

TABLE III. COMPARISON BETWEEN HQ TRIVIA APP AND SONGPOP2

	HQ TRIVIA	SongPop 2		
Tournament Type	Single Elimination	Round Robin		
		Practice Mode	One-to-One	Multi-player
Total Questions	12	5	5	10
Total Mistakes	1	5	5	10
No. Of Entries	120 000	2	2	5
Possible Results	14	1	1	1
GR_{RSA}	0.083	0.447	0.447	0.316
GR_{TSE}	0.00003	1	1	0.1

As for tournament style aspect, it was divided between the SE type approach and the RR type approach. The SE type quiz eliminates the player once they make an error in answering the question applied in HQ Trivia. The GR-value of the tournament-style aspect for HQ Trivia is lower than the game sophistication zone value, which is 0.00003, in which the minimum value of zone sophistication value is 0.07. Furthermore, HQ Trivia is highly dependable on the player's skills due to the increasing difficulty level of the questions.

As for the RR approach, players have to answer every question without getting eliminated from the game. This kind of approach is applied in SongPop 2. The games with RR approach apply a scoring system to identify the winners. SongPop 2 players are rewarded based on how fast they answer the question and the total bonus marks for consecutive correct answers. The GR-value of the tournament-style aspect for SongPop 2 is quite high, 0.1~1.0. The maximum value of zone sophistication is 0.08. Additionally, SongPop 2 is highly stochastic or unpredictable and depends heavily on players' luck.

For quiz games using the SE tournament setting, its round aspect's GR-value is lower than games that apply the RR tournament setting. A SE tournament quiz such as HQ Trivia has a value of 0.08, which implies that it has both the balance of competitiveness and entertainment. In contrast, SongPop 2 with RR tournament setting recorded a value of 0.3~0.5,

which implies that it was highly stochastic and depends heavily on chances. As for the tournament style aspect, quiz games that use the SE tournament setting have a GR-value was lower than the game sophistication zone value recorded at 0.00003. Furthermore, games that apply the SE tournament setting tend to be highly dependable on the players' skills. Moreover, quiz games that apply the RR tournament setting have a value of 0.1~1.0, which implies that they are highly stochastic and depend heavily on chances. Thus, we have concluded that different types of quiz games that apply different kinds of tournament styles have different game refinement values.

V. CONCLUSION

Quiz games have been popular ever since the radio started broadcasting them; currently, they are being played on television and smartphones. The game refinement measure for quiz games has been calculated for two types of quizzes that has different settings of tournament. This study presents an attractiveness analysis for quiz games that can be used to help refine the development of future quiz games. With deeper knowledge on the refinement value of quiz games, an additional number of quiz games can be used to generalise the game refinement value. Apart from that, an observation can be made to keep track of the game data such as number of the players and number of winners of the game in order to get reliable data.

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