

PERCEIVED ENJOYMENT OF MOBILE MATHEMATICAL LEARNING GAMES

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ABSTRACT– Perceived enjoyment is often reckoned as one of the most important factors influencing consumer behavior in educational learning material. Without the educational application providing a positive experience, children are unlikely to interact with it. Previous research on the use of educational applications in mathematics education has focused primarily on the learning potential of these applications and has not adequately addressed the perceived enjoyment. The purpose of this paper is to address this gap and to investigate the perceived enjoyment of mobile mathematical learning games. This study adopted the GameFlow model and Game-Based Learning model as theoretical base. A mixed method research methodology was employed where qualitative and quantitative data was gathered through surveys and semi-structured interviews. Twenty-six children, aged 10 to 13, from selected schools in one of South Africa’s provinces, participated in the study. The results indicate that the interest, fantasy, sensation and goal constructs, as well as the reward systems of mobile mathematical learning games, were most influential in terms of perceived enjoyment. The findings of this study could be used by educators and parents in the evaluation and selection of mobile mathematical learning games.

Keywords: Perceived enjoyment, Mathematical applications, Educational applications, Primary school learners

1. INTRODUCTION

"We are never more fully alive, more completely ourselves, or more deeply engrossed in anything than when we are playing - Charles Schaefer" (Smith, 2014, p.15). This statement points to the generally accepted notion that playing games are expected to be fun and engaging. All commercially successful and popular games for digital devices are fun and entertaining (Boyle, Connolly, Hainey, & Boyle, 2012). The fun appeal can, however, be rapidly reduced when a game is coined as an educational or serious game designed for educational purposes (Wang, Shen & Ritterfeld, 2008). The idea that individuals enjoy and engage in video games has been one of the features that inspired educators to make use of games in education (Prensky, 2001). Therefore, Perceived Enjoyment (PE) is viewed as a very important component in the development of educational software (Giannakos, Chorianopoulos, Jaccheri, & Chrisochoides, 2012; Jabbar & Felicia, 2015; Malone, 1981). Furthermore, if educational software do not provide learners with a positive experience, they are unlikely to interact with it or accept it (Sim, Horton & Danino, 2012). Although the goal of an educational game is to provide a functional benefit rather than to entertain the player, enjoyment is an essential game component, since enjoyable educational games result in an improved functional outcome and higher levels of engagement and motivation (Nagle, Wolf, Riener & Novak, 2014). When turning to the use of digital games in mathematics (math) education, previous research have focused primarily on the learning potential of these games (Bos & Lee, 2013; Pope, Boaler & Mangram, 2015; Riconscente, 2013; Subramanya & Farahani, 2012). To the authors’ best knowledge, little scientific research exists that can shed light on learners’ PE of mobile math learning games (MMLGs). The purpose of this paper is to address this gap by attempting to obtain an answer to the following research question: Which constructs have an influence on the PE of primary school learners towards MMLGs?

2. LITERATURE REVIEW

Before discussing the most recent literature pertaining to MMLGs and PE, it is important to define the terms mobile learning apps (MLAs), mobile math learning apps (MMLAs), MMLGs and PE. Pandey (2016) views MLAs as a delivery format that provides learners with the flexibility to learn anywhere, anytime, and once the app is installed, even without an internet connection. For the purposes of this study the definition that Perrotta, Featherstone, Aston and Houghton (2013) provided for digital game-based learning, namely the use of digital games to support teaching and learning, will be adapted to mobile apps. Therefore, MLAs will be defined as the use of mobile apps to support teaching and learning. In line with the preceding definition, MMLAs will be defined as the use of mobile apps to support the teaching and learning of math concepts. MMLGs will be defined as MML's where game-based features are built into the design in order to engage learners in a fun and exciting way with the presented math learning material (Parsons, Ryu, & Cranshaw, 2007). It is important to note that all MMLGs are MMLAs but not all MMLAs are MMLGs due to the fact that there are many MMLAs that provide video learning content, mobile learning guides, as well as mobile assessments not intended for entertainment purposes (Nima Hunter Inc., 2015). MMLG's will also only refer to commercially available MMLGs that can be played on an Apple or Android mobile device and that can be downloaded from the Google Play Store or from the Apple App Store. Lastly, Davis, Bagozzi and Warshaw (1992) define PE as the degree to which the activity of using technology is perceived to be enjoyable in its own right apart from any performance consequences that may be anticipated.

Prensky (2012) argues that MLAs include some of the most useful learning tools that have ever been available and are preferable to books and laptops as learning tools. More specifically, Subramanya and Farahani (2012) have identified several key benefits of MMLAs, including: self-paced learning; reinforcement of abstract concepts; supplemental learning aids; anytime/anywhere use; enhanced retention; being entertaining and engaging; encourage the use of multiple (rich) media; immersion in interaction; self-assessment; provisions for exploration and experimentation; providing positive feedback; cost-effective; customizable; and time-effective. Another very important potential learning benefit of MMLAs, as identified by Bos and Lee (2013), is the repetitious use of content that will enable weaker learners to use an app repeatedly to learn or practice difficult concepts.

When evaluating specific research that was conducted on MMLGs, several studies now confirm that their use has led to improved academic performance of primary school learners in particular. For example, a study centred on a MMLG, Motion Math, has revealed that fifth graders who regularly played the game for 20 minutes per day over a five-day period increased their math test scores by 15% on average (Riconscente, 2013). Likewise, a Stanford College study revealed that an experimental group of third grade learners that regularly played the MMLG, Wuzzit Trouble, showed a 20.5% increase in numeracy between the pre and post-assessment, compared to the control group who did not play Wuzzit Trouble (Pope, Boaler, & Mangram, 2015). Furthermore, scientists from the Centre for Game Science at the University of Washington found that 80% of third grade learners who played the Dragon Box MMLG for a period of 90 minutes learned basic algebra (Bridges, 2014). Another study on MMLGs focussed specifically on the pedagogical principles applied in 5 MMLGs namely: Wuzzit Trouble, Kickbox, Motion Math Fractions, Refraction and DragonBox Algebra MMLGs (Devlin, 2013). The authors could find no studies pertaining to the PE of MMLGs.

Only two studies could be found that focussed on the PE in a mobile gaming or educational gaming context. The first study identified three key factors that drive PE in casual mobile games, namely design aesthetic, perceived ease of use and novelty. Together these constructs explained 59% of variance for users' PE of casual mobile games (Nguyen, 2015). The second study attempted to develop and verify a scale that assesses user PE of e-learning games. The study concluded that immersion, social interaction, challenge, goal clarity, feedback, concentration, control, and knowledge improvement is a reliable and valid scale for the measurement of PE of e-learning games (Fu, Su, & Yu, 2009).

3. THEORETICAL FRAMEWORK

In order to develop a theoretical framework for this study, the authors have evaluated several theoretical models. This section includes a short description of the theories and constructs included. Flow theory has been used extensively throughout literature to explain an optimal experience of enjoyment when performing an activity (Csikszentmihalyi, 1990). Specifically, the theory of flow identifies interest as a significant aspect towards attaining flow experiences and serves as an enabler for engagement, motivation and learning (Deci & Ryan, 1987). The interest construct is thereby the first construct included in the theoretical model of this study, and was used to portray how interesting or boring learners found mobile educational math games.

The second theoretical model employed in this study was the GameFlow model (Sweetser & Wyeth, 2005). This model was specifically developed to create a framework for player enjoyment in digital games and is based on Flow Theory (Csikszentmihalyi, 1990) combined with criteria from computer game user-experience and usability literature (Sweetser & Wyeth, 2005). The following constructs of the GameFlow model were included in the theoretical model of this study: concentration (how hard learners were concentrating throughout a game), challenge (how challenging a game was), skill (how skilled learners were at playing a game), control (how much learners could choose what they wanted to do in a game, including choosing the difficulty level of the game), goal clarity (how clear the goals of the game were), and feedback (how much feedback learners received when they did things wrong and right in the game) (Sweetser & Wyeth, 2005).

The third theoretical model that was incorporated was the Game-Based Learning (GBL) model (Shi & Shih, 2015). This model was specifically developed to assist designers of educational games to develop entertaining digital game-based learning systems. The fantasy, sensation and mystery constructs of this model were included in the theoretical model of this study. The fantasy construct was used to reveal how much learners liked the fantasy world that was created in a game by making use of virtual characters, stories and environments (Jabbar & Felicia, 2015). In addition, the sensation construct was used to determine how much learners liked the music, animations and the images in the game - in other words the aesthetics of the gaming experience (Schell, 2008). Lastly, the mystery construct was used to depict how curious learners were about what would happen next in the game (Malone, 1980).

In summary, the theoretical model of this study contains the following 10 constructs: interest, concentration, challenge, skill, control, goal clarity, feedback, fantasy, sensation and mystery. Figure 1 portrays this theoretical framework.

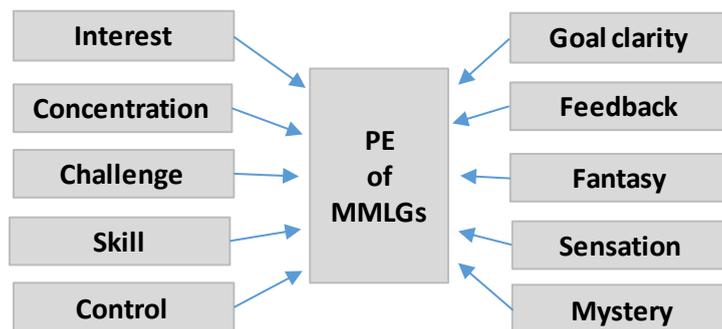


Figure 1: Theoretical Framework

4. RESEARCH METHODOLOGY

4.1. Research paradigm

The interpretivist/constructivist research paradigm was used in this study. This paradigm has the intention to understand the world of human experience and propose that reality is socially constructed (Mackenzie & Knipe, 2006). The constructivist researcher is likely to depend on qualitative data collection methods and analysis, or a combination of both quantitative and qualitative methods (mixed

methods) (Mackenzie & Knipe, 2006). In this study the authors, therefore, made use of a mixed methods methodology.

4.2. Mixed methods methodology

As mentioned, the authors have selected the mixed methods methodology for the study. A mixed methods approach should add understanding and insight that might be missed when only a single method is employed. A broader and more complete range of research questions could also be answered if one is not limited to a single approach or method (Johnson & Ogwenguzie, 2004). In this light, surveys and semi-structured interviews were used to gather data for the study.

4.3. Population and sampling

The population for the study consisted of primary school learners in the Free State province of South Africa (SA). A purposive or purposeful sampling technique was employed due to the fact that it enables the researcher to choose cases that will best answer the research questions and address the research objectives (Saunders, Lewis, & Thornhill, 2007). When using purposive sampling, the researcher must determine the criteria that are essential in choosing who is to be included in the sample. Stake (1994) advises that age, gender, and previous exposure to technology should be used as the characteristics to select a sample from the population. In addition, the amount of time that the researcher will be able to gain access to participants should also be integrated in the sampling strategy. The sampling strategy that was used resulted in the following sample: 26 learners of which 42% were girls and 58% were boys, 51% were 10 years old, 14% were 11 years old, 33% were 12 years old, and 2% were 13 years old. All the learners in the sample were regular mobile technology users, and had access to a mobile device at home.

4.4. Data collection methods

Learners were exposed to 13 MMLGs over a period of 5 weeks. A complete list of the MMLGs that were used in this study, how they were selected, as well as detailed ratings of these games by the learners will be made available by the authors when requested by e-mail. Two 45 minute sessions per week in the afternoon after school were arranged in a classroom at one of the local schools. The games were installed on 7-inch Android tablets. Learners completed a survey for every game they played resulting in a total number of 246 surveys. In order to measure the correlation between each construct and PE of learners towards MMLGs, the authors made use of a 5-point Likert-scale: Not at all (1); a little (2); somewhat (3), pretty much (4); and very much (5). The questions that were asked in the survey, as well as the scales used, were adapted from a questionnaire designed by Shernoff, Hamari and Rowe (2014) for the measuring of engagement in educational games and gamified learning environments, as well as from the GBL model (Shi & Shih, 2015). The feedback from the surveys was coded in SPSS. Semi-structured interviews were conducted with 10 learners and the interviews were recorded, transcribed and analysed with the help of content analysis.

4.5. Reliability and validity

In order to ensure content validity of the survey, the authors made use of items and scales from past literature. The survey questions were also piloted before the data collection for the study began. From the pilot study it was clear that the learners understood the questions and the constructs that were measured by the survey. In order to ensure convergent validity, a principal component analysis (PCA) was conducted on the 10 constructs of the survey. All constructs had high loadings on the extracted factor (between 0.70 and 0.89), indicating good convergent validity (Field, 2009). In order to determine the reliability of the survey used in this study the Cronbach's α was calculated. The resulting value of 0.934 was above the accepted level of 0.8 (Field, 2009) and indicated that the survey was a reliable measuring instrument for PE.

4.6. Ethical considerations

Due to the fact that the participants of this study were young children, special consideration was given to the ethical aspects. A detailed consent form was obtained from the parents of every participant, and every participant completed a consent form as well. The formal ethical clearance procedure of the University of the Free State in SA, from where the research took place, was followed and ethical clearance was obtained for this study in 2015.

5. RESULTS AND DISCUSSIONS

A Pearson correlation analysis and regression analysis were performed in SPSS 19 on the data gathered by the survey in order to answer the research question of the study, namely: Which constructs have an influence on the PE of primary school learners towards MMLGs? The use of parametric statistics in this study is based on extensive research conducted by Norman (2010) who proved that parametric statistics can be used with Likert data, with small sample sizes, with unequal variances, and with non-normal distributions, with no fear of “coming to the wrong conclusion”.

In order to measure the PE of learners, the following question was included in the survey: “How much did you enjoy playing this game?” The correlations reported in Table 1 are between PE and the 10 constructs in the theoretical model. The following guidelines, presented by Evans (1996), were used to interpret the Pearson correlation (r): Very weak (0 - 0.19); weak (0.20 - 0.39); moderate (0.40 - 0.59); strong (0.60 - 0.79); very strong (0.80 - 1.00).

Table 1: Pearson’s correlation coefficients with PE (n = 246)

Construct	r	p	Strength of r (Evans, 1996)
Interest	0.818	0.000	Very Strong
Fantasy	0.672	0.000	Strong
Sensation	0.649	0.000	Strong
Goal Clarity	0.637	0.000	Strong
Concentration	0.635	0.000	Strong
Mystery	0.593	0.000	Moderate
Control	0.566	0.000	Moderate
Skill	0.547	0.000	Moderate
Feedback	0.532	0.000	Moderate
Challenge	0.404	0.000	Moderate

As can be seen from Table 1, all the correlations listed are significant ($p=0.000$). The strongest observed correlation was between PE and interest ($r=0.818$). This finding is consistent with the work of Schell (2008) who argues that the quality of an entertainment experience is strongly correlated with the degree to which an activity is able to hold a player’s interest. The second strongest correlation evident from Table 1 is between PE and Fantasy ($r=0.672$). This finding is in line with various studies that confirm the importance of fantasy in game settings, and report that game fantasy motivates players to participate in a game and is vital for game success (Masters, 2014). Furthermore, a systematic review of literature conducted by Jabbar and Felicia (2015) emphasise the important role that virtual characters and fantasy environments play in providing an entertaining and engaging experience for learners in game-based learning environments. Another strong correlation that can be observed from Table 1 is between PE and the sensation construct ($r=0.649$). The strong correlation found between the sensation construct and PE in this study is confirmed by Schell (2008) who claims that there is a direct relationship between the aesthetics of a game and a player’s experience. Table 1 also reveals strong correlations between PE and the goal clarity ($r=0.637$) and concentration ($r=0.635$) constructs.

In addition to a correlation analysis, the authors wanted to find the proportion of variance in PE that was explained by the various constructs combined in a model. A multiple linear regression was calculated and by using the stepwise method, a significant model emerged ($F_{5,240} = 130.987$, $p < 0.001$). The adjusted R square value is 0.726. Significant variables are shown in Table 2. In terms of the regression model, 72.62% of the variance in PE was explained by the interest, fantasy, skill, sensation

and goal constructs. The interest construct on its own could explain 66.7% of the variance in PE, with fantasy (2.93%), skill (1.75%), sensation (0.76 %) and goal clarity (0.47%) explaining the remaining 5.92 % of variance.

Table 2: Coefficients of significant variables of the regression model (n=246)

Predictor Variable	B	SE B	β	p
Interest	0.500	0.051	0.521	0.000
Fantasy	0.109	0.049	0.116	0.027
Skill	0.161	0.048	0.143	0.001
Sensation	0.124	0.050	0.127	0.014
Goal Clarity	0.110	0.048	0.107	0.024
Dependant variable: PE				

In addition to data gathered by surveys, semi-structured interviews were conducted with 10 learners in order to obtain additional insight as to which determinants have an influence on the PE of primary school learners towards MMLGs

Learners were asked to select games that they enjoyed the most and to provide reasons why they enjoyed the game. It was very clear from the interviews that learners enjoyed games that rewarded them for their efforts. A few responses from learners are included:

“I liked the Math Vs Zombies game the most because you do not only do math, but you get bullets to fight the zombies”;

“The thing I enjoyed about the Squeebles Fractions game is the different flavours that you get to make a cake. You do nice cake sums that make you crave the cake and then you can bake your own cake, and then you have judges who decide how your cake tastes. One get cake rewards to impress people with.”;

“I liked the Squeebles Fractions game because I liked the part where you can bake a cake.”

“I liked the Pet Bingo game the most because if you do something right you get a pet that you can name, and that you can play with.”;

“I also like the Pet Bingo game because you get food for your pets if you do the math correctly.”; and,

“I liked Wuzzit trouble the most because I enjoyed to win keys to unlock the cute little creatures with.”

This finding is consistent with research conducted by Jabbar and Felicia (2015) who showed that reward systems in games increase the enjoyment and satisfaction levels of students, as well as motivate them to explore and complete more missions. From the preceding section the research question of the study can be answered. It can be deduced that the interest, fantasy, sensation and goal clarity constructs, as well as the reward systems of games, had the most important influence on the PE of primary school learners towards MMLGs.

6. CONCLUSION

This study empirically determined that the interest, fantasy, sensation and goal clarity constructs appeared to have the most important influence on the PE of primary school learners towards MMLGs. In addition, interviews revealed that games that were enjoyed the most by learners had various reward systems in place. To the authors’ best knowledge this is one of very few studies (the authors could not find any other) that sheds light on the PE of primary school learners towards mobile games for math education. This insight is very important due to the fact that learners are unlikely to interact with educational math games that do not provide them with a positive experience(Iten & Petko, 2014).

The implication of the findings of this study is that parents and teachers must make use of math games with clear goals, which present math problems in an interesting way making use of fantasy worlds with

abundant aesthetically pleasing audio-visual media and where learners are rewarded for their attempts. A limitation of the study is the small sample size and the controlled environment in which the study took place. The authors are currently in the process of making more parents aware of the study in their province, and are inviting parents to download and test mobile educational math games at home. Currently a total of 64 parents have volunteered to test these games at home. On the basis of the promising findings presented in this paper, research will continue and findings of a larger sample of parents testing these games at home will be presented in future papers. A recommendation for future research could be to test the theoretical model proposed in this study in other game-based learning environments.

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