So, H. J. et al. (Eds.) (2020). Proceedings of the 28th International Conference on Computers in Education. Asia-Pacific Society for Computers in Education

Exploring the Effects of Card Game-Based Gamification Instructional Activity on Learners' Flow Experience, Learning Anxiety, and Performance– A Preliminary Study

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Abstract: Game-based learning (GBL) and gamification for learning are trends in education nowadays. While most previous studies focused on the benefits of digital educational games, unplugged games, e.g. board games, have received relatively little attention. In contrast to computer games, unplugged games are more easily in the classroom as they generally cost less and rarely depend on technology. To explore the educational benefits in math of unplugged games, this study designed a card game-based gamification instructional activity to help students review and practice linear equation concepts. 143 seventh grade students from a junior high school in northern Taiwan participated this study. Students were randomly assigned to experimental group (n = 73) and control group (n = 70). This study compared students' learning performance and level of math anxiety in both groups. In addition, students' perceptions toward the game as well as their experience with the game were also collected. The results indicated that students in the gamification instructional activity showed better learning performance. Meanwhile, students' math anxiety level was reduced after the gamification activity. Moreover, students generally reported positive experience with the game, which could be an indicator of students' engagement. Implications of the results and future research are discussed.

Keywords: gamification, board game, math anxiety, linear equation, flow experience

1. Introduction

Game-based learning (GBL) and gamification have been widely discussed in recent years. GBL is known for its effectiveness in improving students' learning motivation, attitude, engagement, and performance (Attali & Arieli-Attali, 2015; Sailer, Hense, Mayr, & Mandl, 2017; Subhash & Cudney, 2018). In general, GBL refers to the idea of using games for the educational purpose, e.g., serious games (for an overview, see Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012). Another common educational practice is the gamification of learning (Seaborn & Fels, 2015), suggesting that teachers apply game elements and game mechanisms into the learning activities, such as points, competition, and leader board. Antonaci et al. (2015) pointed out that applying games in learning could help learners become more active and motivated. The educational benefits of GBL and gamification have been well documented in the literature (Seaborn & Fels, 2015).

Many educational games have been proposed to improve students' learning performance. Most previous educational literature on games generally focused on video or computer games (Coil, Ettinger, & Eisen, 2017; Huang & Levinson, 2012). Computer games provide visually appealing interface, prompt feedback, and dynamic interaction between learners and learning contents. These characteristics can be helpful in drawing learners' attention and promoting their interaction with learning materials, thus leading to the better learning performance. Nonetheless, technology also has limitations in learning. First of all, developing educational computer games requires a lot of time and efforts in coding and artwork. Second, employing educational computer games in the classroom requires multiple digital devices or the internet, and some schools may not have qualified equipments. Third, technology can be a distraction. With a multi-functional digital device in hand, students could be distracted by online contents that are not related to the learning activity.

In contrast to computer games, unplugged games, such as card games or board games, generally cost less and do not need technology. Unplugged games emphasize face-to-face interaction in a real world. In a learning context, the interactions among teachers, students, and learning materials are essential. In this manner, unplugged games might be helpful in facilitating students' learning. For instance, Cheung and McBride (2017) showed that a special board game for math learning gave children multimodal cues to facilitate their number learning. Also, unplugged games have been implemented for supporting varied learning subjects, e.g., creative thinking (Chung, 2013), ecosystem concepts (Lin & Hou, 2016), environmental chemistry (Pippins, Anderson, Poindexter, Sultemeier, and Schultz, 2011), math competency (Skillen, Berner, & Seitz-Stein, 2018), and chemical compounds concepts (Wu, Chen, Wang, & Hou, 2018).

Game was considered an effective tool to promote students' motivation and engagement in learning (da Rocha Seixas, Gomes, & de Melo Filho, 2016). A well-designed gamification instructional activity could create a gaming environment for players to interact with the game and other players. In addition, previous studies also suggested that instructors can use the process-oriented approach with games or activities to reduce negative academic emotions (Brunyé et al., 2013; Harper & Daane, 1998; Kim & Hodges, 2012). Learning new concepts can trigger different emotional arousal. Previous studies showed that academic emotional arousal included positive and negative affect, such as enjoyment, hope, boredom, and anxiety. (Linnenbrink-Garcia, Rogat, & Koskey, 2011; Pekrun, Goetz, Frenzel, Barchfeld, & Perry, 2011).For example, math anxiety could be one of the most well-documented negative academic emotions and it has been a critical issue in teaching math (González, Rodríguez, Faílde, & Carrera, 2016; Hascher, 2010; Steinmayr, Wirthwein, & Schöne, 2014; Zeidner, 2014). Math anxiety could negatively influence students' math performance (Ashcraft, 2002; Wang et al., 2015).

While previous studies have primarily focused on exploring the cognitive benefits of game-based learning, few studies so far have explored gamification instructional activities and the cognitive and affective outcomes. On the other hand, most previous game-based learning literature focused on the effects of computer games. This study, focusing on the potential benefits of unplugged games and gamification of learning, aims to explore the effects of an educational card game on students' game play experience and their cognitive and affective outcomes.

Therefore, this study developed a card game- *Equation Troop* and designed a gamification instructional activity to help students review the concepts and calculation of linear equation. With the card game-based gamification instructional activity, the purpose of this study is to explore the following research questions:

1. Does the card game-based gamification instructional activity improve students' learning performance in math?
2. Does the card game-based gamification instructional activity reduce students' math anxiety?
3. Is there any difference between students' math anxiety levels in the card game-based gamification instructional activity and in the conventional lecture?

2. Research Methods

2.1 The design of the card game-based gamification instructional activity

This study developed a card game called *Equation Troop* to help students review and master concepts and calculation of linear equation. With the gamification of learning, the card game was expected to reduce students' math anxiety. In the card game, players had to correctly solve the linear equation on the cards in order to recruit military forces to their troop. By the end of game, the players who successfully assembled the largest regiment (i.e., had the highest scores) would be the winner. Each card had a question of linear equation with one unknown on it. Each card also represented a troop of different size (i.e., scores). The size of the troop depended on the difficulty level of the questions.

Questions with higher difficulty levels represented larger troop size (i.e., higher scores). When the players correctly solved the equations within the time limit, they could recruit the troop to their regiment. In this game, the size of the troop represented the players' scores in the game. Figure 1 shows the game cards of *Equation Troop*.

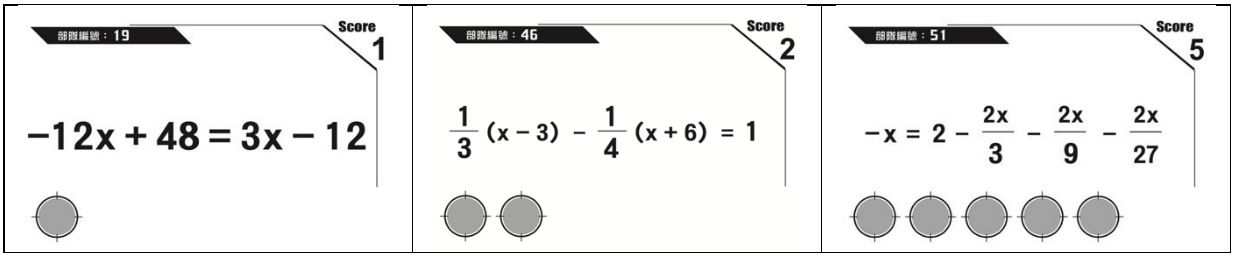

Figure 1: *Game cards of three different difficulty levels.*

There are sixty cards of three difficulty levels, including the basic, the advance, and the master level. Questions of different difficulty levels had different points, i.e. one, two, five points for the three levels. The difficulty levels of the questions depended on the steps required to solve the equation.

Students worked in groups and played the game. The time for game play was 15 minutes. At the beginning, each group received three cards of three different difficulty levels. Students had to solve the linear equation for the correct answer by following the correct steps to earn points. When the players completed the three questions, they could ask the instructor for up to three more cards at a time. Students could ask for cards as many times as they wanted. Nonetheless, two-point penalty would be given for each unsolved equation when the time was up. Students needed to be careful when they asked for more cards and chose the difficulty level. Students in the same group were allowed to discuss on how to solve the equations. This mechanism facilitated social learning as students could learn from each other.

2.2 Participants

Participants in this study were 143 seventh grade students from a junior high school in northern Taiwan. Participants were randomly assigned to the experimental group and the control group. The experimental group consisted of 73 students (35 female) while the control group consisted of 70 students (36 female). In both the experimental and the control groups, students were grouped and five to six students were in the same group. The gamification instructional activity was employed in the experimental group. In contrast, a conventional practice learning activity was employed in the control group. Students in control group were given sixty linear equation questions, which were identical to the questions in the card game instructional activity. Students worked in groups to practice solving linear equations. Both the experimental group and the control group were instructed by the same math teacher. Before the instructional activity, students in both experimental and control groups have received lectures that introduced the concepts of linear equation. The lectures were taught by the same math teacher.

2.3 Measurement

This study adapted Killi (2006)'s flow scale to measure students' attitudes toward the game elements and their gaming experiences in the card game and the gamification instructional activity. The flow scale consisted of twenty-two items from two dimensions, including the flow antecedents and flow experiences. Flow antecedents were the prerequisite characteristics of a task that led to the following flow experience, i.e., challenging, clear goals and feedback, sense of control, and playability. In this study, flow antecedents were used to measure students' perception of the card game- Equation Troop. On the other hand, in the flow experience dimension, the study measured students' gaming experiences, including concentration, time distortion, autotelic experience, and loss of self-consciousness. The scale was measured with five-point likert scale.

To measure students' academic emotion, this study adapted Modified Abbreviated Math Anxiety Scale (mAMAS), which was considered a valid and reliable measurement of math anxiety in children and adolescents (Carey et al, 2017). The mAMAS consisted of nine items to measure respondents' math anxiety based on a five-point Likert scale, from one (low-level anxiety) to five (high-level anxiety). Thus, if the respondent had high scores in the mAMAS, it meant that the respondent had high-level math anxiety. The Cronbach's α of mAMAS was 0.933, suggesting a high reliability of mAMAS.

For student's learning performance, a 15-item test was developed. The 15 items were evenly distributed to the questions of three difficulty levels; The test was firstly developed by an expert in math teaching, who had many years of math teaching experience in high schools. The test was then discussed and refined by the educational researchers of this study.

3. Results

This study conducted a series of tests to examine students' learning performance, math anxiety, students' perceptions of the *Equation Troop* and their gaming experience. The results are presented as follows.

First, Table 1 shows the results of learning performance in the control group and the experimental group. The experimental group, which used the gamification instructional activity, showed significant improvement ($t = 5.09$, $p < 0.001$). In contrast, the control group, which used traditional quiz practice, showed no significant difference between the pre-test and the post-test. Furthermore, this study conducted an ANCOVA test to compare learning performance between the two groups. With the pretest scores as the control variable, the results of ANCOVA showed that learning performance of the experimental group was significantly better than that of the control group ($F(1,140) = 7.25$, $p < 0.01$). These findings suggested that the gamification learning activity in this study promoted the students' learning performance.

Table 1. *Learning performance of the control group and the experimental group.*

	Pre-test		Post-test			
	M	SD	M	SD	*t*	*df*
Control group	5.34	3.68	5.58	4.01	-1.20	72
Experimental group	6.57	3.41	7.51	3.62	-5.09***	69

Second, Table 2 shows the results of students' math anxiety in the two groups before and after the activity. The experimental group showed a marginal decrease in math anxiety after learning with *Equation Troop* ($t = -1.88$, $p = 0.064$), and the control group showed no difference in math anxiety before and after the lecture. The study also conducted an ANCOVA test, with students' math anxiety scores before the activity as the control variable. The results indicated that math anxiety was significantly reduced in the experimental group, but not in the control group ($F(1,140) = 4.48$, $p < 0.05$). These findings indicated that students' math anxiety was reduced after the gamified math learning activity, not after the traditional practice session.

Table 2. *Math anxiety (MA) of the control group and the experimental group.*

	Pre-MA		Post-MA			
	M	SD	M	SD	t	df
Control group	23.56	8.77	23.49	9.30	.090	72
Experimental group	20.43	8.69	18.90	8.73	1.88	69

Third, as for the students' perception of the *Equation Troop* in terms of flow antecedents, students generally perceived the game as challenging (M = 3.94, SD = 1.05), controllable (M = 3.99, SD = 1.02), and playful (M = 3.69, SD = 0.98). They also thought of the game as have a clear goal (M = 4.29, SD = 0.85) and feedback (M = 3.90, SD = 0.93). The average scores in the sub-dimensions of flow antecedents were between 3.69 (playability) to 4.29 (clear goal), and they were all above the mid-point of a five-point Likert scale (i.e., 3). As for flow experience, students generally had a positive flow experience ($M = 4.00$, $SD = 0.82$). The average scores in the sub-dimensions of flow experience were between 3.35 (lost of self-consciousness) and 4.21 (time distortion), and they were all above the mid-point of a five-point Likert scale, including experience of concentration ($M = 4.09$, $SD = 1.00$), time distortion ($M = 4.21$, $SD = 0.90$), autotelic experience ($M= 4.14$, $SD = 0.93$), and loss of self-consciousness ($M = 3.35$, $SD = 1.10$).

Fourth, Flow experience might be beneficial to both cognitive and affective outcomes (Csikszentmihalyi, 2014; Perttula, Kiili, Lindstedt, & Tuomi, 2017). Therefore, this study further explored the relationships among flow experience, learning performance, and math anxiety. As for learning performance, the results showed that students' flow experience and learning performance were positively correlated (Pearson's $r = 0.477$, $p < 0.01$). Moreover, the study explored the correlation between students' flow experience and their math anxiety differences (i.e. the extent of anxiety reduction, pre-MA – post-MA). The results indicated that flow experience and math anxiety differences were positively correlated (Pearson's $r = 0.27$, $p < 0.05$). This finding suggested that students who were more engaging in the gamification instructional activity also showed higher reduced math anxiety. This finding suggested a positive effect of gamification instructional activity on the anxiety reduction.

Lastly, in order to explore the possible gender difference, this study compared perceptions of the game and gaming experience between male and female students. There were no significant differences in both flow antecedents ($t = 1.14$, $p = 0.26$) and flow experience ($t = 0.46$, $p = 0.65$). These findings indicated that the game- *Equation Troop* was not particularly favored by a particular gender.

4. Conclusion and Discussions

The present study developed a board game– *Equation Troop* and designed a gamification instructional activity to help students review the concepts of linear equation and practice solving linear equation questions. Overall, the results showed that the gamification instructional activity significantly improved students' learning performance in math. Previous studies suggested that game-based learning could promote students' engagement in learning, and lead to better learning outcomes (Habgood & Ainsworth, 2011; Kiili & Ketamo, 2018). It seems that students' engagement in the gamification instructional activity leads to their better learning performance.

In the present study, we also found that students who participated in the gamification instructional activity showed marginally reduced math anxiety; in contrast, the level of math anxiety in in the control group remained intact. The math anxiety level between these two groups was significantly different. These results are similar to the results of previous studies that game-based learning help reduce learners' anxiety (Mavridis & Tsiatsos, 2017; Núñez Castellar et al., 2014; Wu, Amin, Barth, Malcarne, & Menon, 2012). One possible explanation is that gamification instructional activity may change students' perception of math learning, thus reducing their anxiety level. Unlike traditional math learning, the elements of games in game-based learning, such as points and competitions, may increase students' motivation in learning and lower their anxiety (Mavridis & Tsiatsos, 2017). And our findings supported the notion that gamification instructional activity could be an effective tool to promote students' learning performance in math and reduce their math anxiety.

This study also adapted Kiili's (2006) flow scale to measure students' perception of the game (flow antecedents) and their gaming experience (flow experience) in the gamification instructional activity. The findings suggested that the students generally reported positive perceptions of *Equation Troop*, and they showed positive flow experience after the game. As Inal and Cagiltay (2007) suggested, boys and girls might have different game preferences. This gender difference might affect their degree of engagement in games and their learning outcomes. Nonetheless, in this study, the results showed that the game– *Equation Troop* was not preferred by any particular gender.

According to our findings, students' flow experience was positively correlated to both their cognitive and affective outcomes. Specifically, the present study found a positive correlation between flow experience and learning performance. This finding suggested that the card game-based learning activity might foster student' engagement and thus contribute to better learning performance (Csikszentmihalyi, 2014; Perttula et al., 2017). In addition to cognitive outcome, flow experience could also contribute to student's math anxiety reduction. Our finding indicated that students' flow experience is positively correlated to the extent of their math anxiety reduction. In other words, students who experienced flow after the game, had lower math anxiety in general. This finding is similar to other previous studies (Hung, Huang, & Hwang, 2014; Isbister, Karlesky, Frye, & Rao, 2012; Mavridis & Tsiatsos, 2017). Mavridis and Tsiatsos (2017) found that game-based assessment could reduce students' test anxiety. They suggested that the game mechanisms might make students feel like they were playing a game, not taking a test. In this study, our game mechanisms may change students' perceptions of math learning. Nevertheless, further research is still needed to clarify what game features and how these features could contribute to math anxiety reduction.

In conclusion, our finding that game-based learning could foster students' engagement and performance is consistent with literature. Moreover, students' math anxiety level can be reduced. Although most students have math anxiety (González et al., 2016; Hascher, 2010; Steinmayr et al., 2014), it does not necessarily mean they have poor math performance. Harper and Daane (1998) proposed several ways to reduce students' math anxiety, such as the process-oriented approach with games and activities and problem-solving group work. This kind of collaborative game play is an essential element of board games. The present study demonstrated a card game-based instruction approach, which could be easily implemented in the classroom. In contrast to computer games, which generally require expensive digital devices and may cause distractions to students (Goundar, 2014), the unplugged game used in this study encourages collaborative work and real-world interaction. It also helps promote students' learning performance.

4.1 Research Limitations and Future Research

As an exploratory study, the present study has several limitations, which should be taken into consideration when interpreting our findings. First, the sample size of this study was limited. Future research could explore the relation between students' engagement and anxiety reduction with a larger sample size. Furthermore, future research could investigate how a gamification instructional activity could lower students' anxiety in different learning subjects, or how it could lower different kinds of learning anxieties, e.g., test anxiety.

Second, this study used self-reports to measure students' flow experience and math anxiety. While self-reports are commonly employed in previous studies, it could be influenced by social desirability bias (Dettmers et al., 2011). Future research could use bio-feedback device to measure students' responses. For instance, Mavridis and Tsiatsos (2017) employed a bio-feedback device and collected learners' physiological signals to interpret their test anxiety level. Similarly, Wouters, van Nimwegen, van Oostendorp, and van der Spek (2013) suggested researchers use objective measures, such as physiological or behavioral indicators, to measure the level of students' engagement in serious games. However, bio-signals might be inaccurate due to device constraints. Therefore, data triangulation by combining subjective measures (e.g., self-reports) and objective measures (e.g., bio-signals) would increase the validity of measurement and help explore students' behaviors and responses in gamification instructional activities.

Third, this study adopted the flow scale developed by Kiili (2006) to measure students' flow experience. Flow was found to be positively correlated with motivation (Chang et al., 2012). Nonetheless, the present study did not specifically measure students' motivation. Game is known for being able to enhance learning motivation (Deterding, 2011), and motivation could subsequently lead to engagement in learning and better learning performance (Chang et al., 2012). Future research can explore the changing motivations of students in games. It can also compare students' behavioral patterns based on different motivation levels or flow experience with sequential analysis (Hou, 2015). These research approaches would help us better understand the relationship between game designs and motivation.

Last, the present study demonstrated positive effects of gamification instructional activity on learners' learning performance and anxiety. Nonetheless, with the rapid development of information technology, novel technology can be applied to improve students' learning outcomes. For example, augmented reality (AR) technology has been widely discussed in recent years. Recent studies also showed the benefits of using AR for education (Akçayır & Akçayır, 2017). For example, Chen (2019) found that learning math with AR could reduce students' math anxiety and promote learning performance. AR augments real-world experiences with virtual objects, such as digital 3D objects, texts, or graphs, thus creating a novel experience for players. Since playing board games is a real-world experience, combining board games with AR technology might bring a more advantageous learning experience and better learning outcomes. Therefore, future research is encouraged to investigate the effects of combining board games and AR in education.

Acknowledgements

This research was supported by the projects from the National Science Council, Republic of China, under contract number MOST- 107-2511-H-011 -003 -MY3, MOST-108-2511-H-011 -003 -MY3 and MOST-109-2511-H-034-002.

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