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Do points, badges and leaderboard increase learning and activity: A quasi-experiment on the effects of gamification

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Abstract: Gamification is the integration of game-like design elements into non-game context to engage people, motivate action, and solve problems. In tertiary education, researchers and practitioners have been seeking for effective ways to improve student engagement and promote learning. In this study, we conducted a quasi-experiment at the University of Hong Kong to examine the effects of gamification on student learning and engagement. Quantitative data from control group and treatment group, such as pre-test and post-test scores, participation rate, extra-assignment scores, were collected and analyzed. Results suggest that gamification strategies, aligned with instructional objectives and user context, are effective in improving student participation and encouraging extracurricular learning. Future research directions, on the effective use of gamification strategies, are discussed and suggested in the conclusion part.

Keywords: Gamification, effectiveness, learning, participation, engagement

1. Introduction

Gamification is the integration of game-like design elements (e.g. badges, leaderboard, levels) into non-game context to engage people, motivate action, and solve problems (Deterding, Dixon, Khaled, & Nacke, 2011; Kapp, 2012; Zichermann & Cunninghma, 2011). In recent years, researchers (e.g. Barata, Gama, Jorge, & Gonçalves, 2013; Domínguez, Saenz-de-Navarrete, De-Marcos, Fernández-Sanz, Pagés, & Martínez-Herráiz, 2013; Ibanez, Di-Serio, & Delgado-Kloos, 2014) have drawn growing attention on the implementation of gamification strategies for engaging learners and promoting student learning purpose. However, concerns on the effectiveness of integrating gamification in educational context have been raised.

Several studies reported that gamification has positive effects on student engagement (e.g. Barata et al., 2013), while some studies reported that gamification can hamper student engagement (e.g. Domínguez et al., 2013). In a literature review on the effectiveness of using badges (i.e. a common game mechanic) for computer science education, Falkner and Falkner (2014) concluded that there was not enough evidence to conclude that the use of badge could improve student engagement or learning effectiveness. They also urged that the research context (e.g. course goals, user context) should be clearly reported, so that other researchers can compare the contexts and adjust their gamification designs. Hamari et al. (2014) conducted a literature review on the empirical studies of gamification across nine industries (e.g. commerce, health, education). They criticized that present studies on gamification were strongly dispersed, and there was a lack of coherent evidence (e.g. controls and effect size) on the effectiveness of gamification.

In this research, a quasi-experiment has been designed to investigate the effects of gamification in a higher-education setting. Our specific research questions are: 1) Do points, badges and leaderboard increase students' behavior engagement? 2) Do points, badges and leaderboard increase students' cognitive engagement?

2. Literature Review

2.1 Gamification and game mechanics

Gamification is different from a full-fledged game (Deterding et al., 2011). Game is "a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome" (Salen & Zimmerman, p.80), and it addresses the deployment of a complex narrative and provision of exquisite visual settings (Ibanez et al., 2014). Gamification, on the other hand, "uses elements and dynamics of games with no ambition to deploy complex narratives or visual settings" (Ibanez et al., 2014, p. 292).

The most commonly used game mechanics are points, badges, and leaderboards (Dicheva, Dichev, Agre, & Angelova, 2015; Hamari et al., 2014). Points refer to tokens that can be collected by users, which can be used as status indicators, or to spend on virtual goods or gifting (Bunchball, 2010; Educause, 2011). Badges refer to trophies that appear as icons or logos on a webpage that signify a user's accomplishments of a particular activity such as completion of a project (Bunchball, 2010; Educause, 2011). Leaderboards refer to high-score tables that indicate an individual's performance compared with other users (Bunchball, 2010; Educause, 2011).

2.2 Related work

Current empirical research on gamification spans from K12 to tertiary education, which mainly covers 3 ranges of topics. The first range of topics examined the effects a single game mechanic or multiple game mechanics have on student learning performance (e.g. Barata et al., 2013). The second range of topics examined the effects game mechanics have on different types of learners (e.g. Abramovich, Schunn, & Higashi, 2013). The third range of topics examined the effects game mechanics have on changing behavior or habit, such as dietary habit (e.g. Jones, Madden, Wengreen, Aguilar, Desjardins, 2014).

Barata et al. (2013) carried out a 5 year study to examine whether gamification would improve participation and learning in a Multimedia Content Production course. They compared the course attendance, forum participation logs, and grades of the first 3 years (non-gamified years) with the later 2 years (gamified years). The researchers found no consistent increase in course attendance, but significant growth of forum posts. They also reported that students' mean final score in the gamified years was higher than the non-gamified years. However, Barata et al. (2013) also acknowledged that the internal validity of this study might be affected by some uncontrolled factors, such as the use of different support materials, different tests and different instructors.

Dominguez et al. (2013) conducted a two group experiment to assess the effectiveness of gamification on student performance. The result showed that students in the experiment group scored lower than the control group in the final examination. Moreover, the participation score of the treatment group is much lower than the control group. These negative results indicate that gamification can be motivating or demotivating. To ensure the effectiveness of gamification, the design and implementation of gamification should be meaningful to users.

2.3 Motivation theories

Nicholson posits that in order to make a gamification design meaningful, practitioners should integrate user-centered elements into non-game contexts (Nicholson, 2012). He defines this as "meaningful gamification". The theoretical base of meaningful gamification is self-determination theory (Deci & Ryan, 2000). It postulates that autonomy, competence, and relatedness are the three essential elements that could make an activity meaningful to participants (Deci & Ryan, 2000).

Based on the self-determination theory, we postulate that meaningful gamification design should have three basic properties: First, it makes the learning tasks meaningful to the user by giving him or her a sense of autonomy to choose one's learning goals and activities (Deci & Ryan, 2000; Nicholson, 2012). Second, it helps learners feel that the difficulty level of task matches their abilities, and helps them feel their competences are growing when participating in learning activities (Csikszentmihalyi, 1978). Third, it allows learners to compare their performance with their peers and makes learners feel they are connected to their peers (Deci & Ryan, 2000; Festinger, 1954).

3 Methods

3.1 Research Context

The participants were recruited from two master classes (year 1) at The University of Hong Kong. Students from class 1 (N=21) were assigned into the treatment group, and students from class 2 (N=19) were assigned into the control group.

The SPSS (i.e. quantitative data analysis) module of the Research Methods and Inquiry course was selected as the testing course. The rationale for selecting it as the testing course was that: 1) The difficulty level of the SPSS module was relatively higher than other modules. Previous students usually reported that they had difficulties in operating SPSS software independently. 2) There was too much content to be conveyed in this module, such as basic concepts about independent and paired sample t-tests, processes for conducting these t-tests, and differences of t-tests, Mann-Whitney U test and Wilcoxon Signed Rank test. 3) The SPSS skills were important and fundamental skills that master students should acquire. In other words, the difficulty level, importance, and large information stream of SPSS module stimulated us to choose it as a testing course. We attempted to test if gamification could help solve problems and increase engagement in this conceptually and technically challenging course.

3.1 Gamifying SPSS Module

The gamified SPSS module was launched on the learning management system Moodle. Moodle is one of the most widely used open source learning management system (Machado &Tao, 2007), and it self-contains some gamification features, like badges, and unlock-levels. By installing plug-ins, Moodle can also support some other features, e.g. leaderboard, point system.

The development of this gamified course underwent 3 stages. The first stage was to analyze the instructional objectives of a course. Falkner & Falkner (2014) states game mechanics (e.g. badges) should not be decoupled from course objectives. The second stage involved the analysis of the target audience. Considering the course participants (i.e. master students) are usually active enough when taking in-class activities, but might procrastinate over or neglect pre-course and post-course activities, the gamification strategies would mainly be used in pre-course and post-course phase. The third stage involved the implementation of the game mechanics. Early bird badges were used to encourage early participation and task completion. Points and leveled up tasks (i.e. task of different difficulty levels) were used to guide learners in setting up approachable goals and developing competences in a stepwise manner. Leaderboard was integrated to provide learners an access for comparing progress with peers, as well as developing their sense of relatedness. Meanwhile, learners were provided the autonomy in deciding which post-course activities to participate. Because individuals with a greater sense of autonomy are more likely to show higher levels of engagement and enjoyment (Skinner et al., 2008).

3.2 Implementation of the Gamified Module

This research adopted a quasi-experiment. In this research, the treatment group, class 1 (N=21), had access to the gamified SPSS course on Moodle. The control group, class 2 (N=19), had access to the same content and activities but without the gamification features. To minimize the potential interferences brought by covariates (e.g. different teaching style or procedures), both treatment group and control group were taught by the same instructor. The topic was introduced in the same procedures. The learning contents were the same. The assignments were scheduled almost at the same time. Email invitations for doing pre-course activities were both sent 3 days before the class begins. The in-class learning period both lasted 3 hours. Both groups completed a pre-course quiz before the class started. Both groups then completed a post-course quiz by the end of the in-class learning period. Both groups were assigned 2 weeks to do the post-course activities. Meanwhile, both groups were informed of their autonomy in choosing to or not to do the post-course activities.

4 Results

4.1 Behavioral Engagement

Viewing of Course Resources. In treatment group, all participants (N= 21) viewed the gamified SPSS course site. In control group, all participants (N=19) viewed the non-gamified SPSS course site. But the view rates differed distinctively between the two groups. An independent sample t-test was conducted to compare the differences on view rates. There was significant differences in view rates for participants under gamified SPSS course (M=86.86, SD= 43.79) and non-gamified SPSS course (M=13.05, SD= 9.05); t (38) = -7.20, p< .05. The results suggested that students were motivated to view more in a gamified setting than non-gamified setting. See Table 1 for tabulated information.

Posting of course forum. In the treatment group (N=21), 20 students posted on course forum, and only 1 student did not. In the control group (N=19), 5 students posted on the course forum, and 14 students did not. An independent sample t-test was conducted to evaluate the difference on post rates. There was significant differences in post rates for participants under gamified SPSS course (M=6.43, SD=4.64) and non-gamified SPSS course (M=0.42, SD=0.84); t (38) = -5.55, p< .05. The results suggested that students were motivated to post more in a gamified setting than non-gamified setting. See Table 1.

4.2 Cognitive Engagement

Scores of Pre-course Quiz and Post-course Quiz. A pre-course quiz was conducted at the beginning of the in-class learning session, and a post-course quiz was conducted by the end of the in-class learning session. The difficulty levels of both quizzes were the same. In treatment group, 19 students took the pre-course quiz, and 21 students took the post-course quiz. In control group, 16 students took the pre-course quiz, and 18 students took the post-course quiz. To make the data consistent, those who did not take any of the quizzes were excluded from data analysis. Therefore, the quiz participants for treatment group is N=19 and for control group is N=16. See Table 1.

To evaluate if the treatment group's quiz score improved after taking the in-class learning activities, a paired sample t-test was conducted. The results indicated that the mean quiz score (M=4.69, SD=1.86) was significantly improved after the in-class learning activities (M=10.87, SD=2.68); t (18) = -9.56, p<0.05. To evaluate if the control group's quiz score improved after taking the in-class learning activities, a paired sample t-test was conducted. The results indicated that the mean quiz score (M=5, SD=1.26) was significantly improved after the in-class learning activities (M=10.94, SD=2.10); t (15) = -11.08, p<0.05. To evaluate if there was difference in two groups' in-class gains, an independent sample t-test was conducted. There was no significant differences in gains for participants under gamified SPSS course (M=6.18, SD=2.82) and non-gamified SPSS course (M=5.94, SD=2.14); t (33) = -0.29, p>0.05. The results suggested that students from two groups did not have significant differences in their in-class gains.

Table 1: Views and Posts, Pre and Post Course Quiz, and Gains of Treatment and Control Group

Behavior engagement	Treatment group(n=21) Mean (SD)	Control group(n=19) Mean (SD)
Views	86.86 (43.79)	13.05 (9.05)
Posts	6.43(4.64)	0.42(0.84)
Cognitive engagement	Treatment group(n=19) Mean (SD)	Control group(n=16) Mean (SD)
Pre-course quiz	4.69 (1.86)	5 (1.26)
Post-course quiz	10.87 (2.68)	10.94(2.10)
Gains	6.18(2.82)	5.94(2.14)

Attempts of pre-course activities. For the pre-course activity, "*Enter Data into SPSS"*, there were obvious differences between the two groups. In the control group (N=19), 3 participants (15.79%) completed this task before due time, 2 participants (10.53%) completed after due time, and 14 participants (66.67%) did not complete the task. In the treatment group (N=21), 11participants (52.38%) did it before due time, 4 participants (19.05%) did it after due time, and 6 participants (28.57%) did not complete it. See Figure 1 for pre-course activity data.

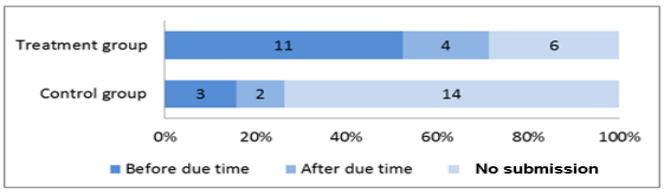

Figure 1. Pre-course Activity Data

Attempts of Post-course Activities. After the in-class sessions, students of both groups were provided access to some post-course activities, which could help them reinforce their skills and extend their knowledge. The gamified group was told that they have freedom in choosing to do it or not do it, but if they do it they would be able to earn points, which would contribute to at most 5 scores of their term score; the non-gamified group was told that they have freedom in choosing to do it or not do it.

The performance differences between these two groups were huge. In the control group (N=19), none of the 19 participants opted to complete the tasks. In the treatment group (N=21), 20 participants (95.24%) completed level 1, 2 and 5 tasks, 15 participants (71.43%) finished level 3 task, and 16 participants (76.19%) completed level 4 task. The post-course activities of treatment group were assessed by an independent viewer. In the skill reinforcement tasks (i.e. level 1-4), 5 participants (23.81%) scored the full score 10, and 8 participants (38.10%) scored between 9.8 - 8.8. The average score for skill reinforcement tasks was 7.33. In the extracurricular learning task (i.e. level 5), 8 participants scored 4 or more than 4, which were close to full score 5. See Figure 2 for scores of post-course activities.

These data showed that the efforts students made differed greatly between two groups. The gamified group (95.24%) was motivated to do more practices. Furthermore, most of the gamified group (95.24%) conducted extracurricular learning, with 38.10% achieved high extracurricular learning outcome (score≥4).

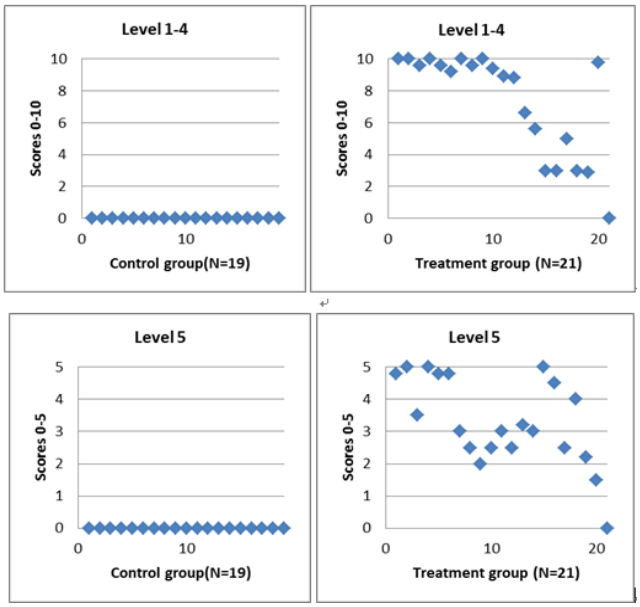

Figure 2. Scores of Post-course Activities

5 Conclusion and Future Research

This paper reports the results of a quasi-experiment launched at The University of Hong Kong, which examined the effects of gamification on students' engagement and learning. Result indicated that the gamification strategies adopted in this case was effective in motivating students to view and post more. Result also showed that gamification was helpful in cognitively engaging learners. Learners in gamified environment were motivated to invest more efforts on learning, especially pre-course and post-course

learning. Badges and leaderboard motivated most learners (71.43%) in the treatment group to participate in pre-course activity, whereas only a few learners (26.32%) in the control group participated in it. Points stimulated learners (95.24%) in treatment group to take more challenging tasks and do extracurricular learning, whereas learners in control group did not attempt any challenges. This suggests that, in tertiary education, educators and practitioners may consider using gamification strategies, at least in the short term, to scaffold out-of-class learning.

However, as this study tested only students' engagement differences for one cohort, further researches are in demand to evaluate the long-term effects of gamification. More reports on how gamification are contextualized in their research would be helpful in informing wise adoption of gamification strategies.

It is also noticed that though most students were motivated by gamification strategies, some individuals were not motivated. In our future research, we may probe into why different learners were motivated at different degrees, and seek to adjust our gamification strategies to better support learners of different styles.

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