Computers & Education 80 (2015) 152–161

Contents lists available at ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance

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ARTICLE INFO

Article history:
Received 20 May 2014
Received in revised form
25 August 2014
Accepted 28 August 2014
Available online 15 September 2014

Keywords:
Virtual reality
Improving classroom teaching
Human–computer interface
Interactive learning environments
Teaching strategies

ABSTRACT

Gamification, the application of game elements to non-game settings, continues to grow in popularity as a method to increase student engagement in the classroom. We tested students across two courses, measuring their motivation, social comparison, effort, satisfaction, learner empowerment, and academic performance at four points during a 16-week semester. One course received a gamified curriculum, featuring a leaderboard and badges, whereas the other course received the same curriculum without the gamified elements. Our results found that students in the gamified course showed less motivation, satisfaction, and empowerment over time than those in the non-gamified class. The effect of course type on students' final exam scores was mediated by students' levels of intrinsic motivation, with students in the gamified course showing less motivation and lower final exam scores than the non-gamified class. This suggests that some care should be taken when applying certain gamification mechanics to educational settings.

1. Introduction

Gamification, the use of game elements in a non-game context (Deterding, Sicart, Nacke, O'Hara, & Dixon, 2011), has emerged as a popular trend over the few years, with at least 50% of companies predicted to gamify at least one aspect of their workplace by 2015 (Gartner, 2011). Gamification can take a variety of forms, including the use of narratives to change the context around a typical activity, the creation of social competition, and the incentivizing of behavior through badge and reward systems (an aspect of gamification known as *pointification*). Given the potential to increase engagement and enjoyment, writers and scholars have been touting gamification as a way to transform education as well (e.g., Landers & Callan, 2011; McGonigal, 2011; Muntean, 2011). By applying gamification to the classroom, students could be motivated to learn in new ways or enjoy otherwise tedious tasks.

Teachers commonly employ games in the classroom (Kapp, 2012), but only recently have teachers begun exploring the possibility of making the class itself a game. Modern students are growing up in an age of interactive media and video games, so classroom gamification may be appealing and motivating (Glover, 2013). Recent research, however, suggests that the effects of various gamification elements are mixed. Additionally, of the limited sample of empirical studies done on gamification, many suffer from methodological problems such as a lack of comparison groups, short treatments, singular assessments, and a lack of validated measures (Hamari, Koivisto, & Sarsa, 2014). Although gamification is popular, the effectiveness of various gamification elements have not been sufficiently tested.

Our objective is to create a longitudinal study that addresses the methodological concerns with some previous studies and tests the effectiveness of specific gamification elements. Because the concept of gamification encompasses so many different game mechanics and their application, it is difficult to study every possible facet of gamification. Our study focuses specifically on the effectiveness of a gamified system that gives students tasks to earn badges and features a leaderboard to track progress and increase student engagement. These game mechanics were chosen because they are elements that tend to be used frequently in classroom gamification (e.g., Acedo, 2014; Alvarez, 2014; Gonzalez, 2012; Young, n.d.). Many gamified systems use leaderboards and badge systems as a way to facilitate social engagement

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http://dx.doi.org/10.1016/j.compedu.2014.08.019
0360-1315/

and competition, and our goal was to examine how these mechanics affect motivation, satisfaction, effort, learner empowerment, and class grades. The following will examine previous research on gamification and examine the effectiveness of popular gamification mechanics, such as badges and leaderboards. Then it will examine how research on rewards, motivation, and competition might apply to these mechanics and how to best utilize them for classroom gamification.

2. Background

2.1. Game mechanics and related work on gamification

Using games in education has a variety of benefits, and several game design mechanics demonstrated success in educational environments (de-Marcos, Domínguez, Saenz-de-Navarrete, & Pagés, 2014; Stott & Neustaedter, 2013). Games typically allow the player to restart or play again, making mistakes recoverable. This freedom to fail allows students to experiment without fear and increases student engagement (Lee & Hammer, 2011). Although educational settings provide feedback to students, it is often constrained: In class, teachers can often only evaluate and provide feedback to one student at time, and feedback via grading takes time. Thus, incorporating the immediate and frequent feedback found in game design may be even more beneficial (Kapp, 2012). Additionally, teachers typically present information to their classes in categories that scale by difficulty, a process known as *scaffolded instruction*, but it can be difficult to accommodate each individual student's needs. Games tailor difficulty progression on an individual basis, keeping players at a particular level until they have demonstrated the requisite mastery to move on (Beed, Hawkins, & Roller, 1991). Creating a narrative context around a task has been shown to increase student motivation and engagement (Clark & Rossiter, 2008). In addition, other elements of game design commonly applied to gamification might be helpful: leaderboards encourage engagement through competition, and badges offer a visual display of progress (Camilleri, Busuttil, & Montebello, 2011; Kapp, 2012).

Despite considerable speculation about the benefits of gamification (Brunsell & Horejsi, 2011; Gonzalez & Area, 2013; Hellwege & Robertson, 2012; McGonigal, 2011; Muntean, 2011), empirical research on the effectiveness of gamification is limited. Results from the few empirical studies on various elements of gamification conducted in educational settings are mixed. One study found that students who were given feedback on their course progress in the form of a competitive game enjoyed the experience more, learned more, and had lower rates of failure than previous classes (Charles, Charles, McNeill, Bustard, & Black, 2011). Another reported higher student interest and engagement after gamifying an entrepreneurship course using leaderboards, competition, and serious games to teach course concepts (Bellotti et al., 2013). Dominguez et al. (2013) gamified an e-learning platform by applying competition, trophies, rewards, and leaderboards and found that students in the gamified class scored higher overall and were more motivated, but tended to participate less in class activities and performed worse on writing assignments. de-Marcos et al. (2014) used a gamification system that gave students rewards, encouraged earned trophies, and used a leaderboard to encourage competition. They compared this and a traditional platform with a social networking learning platform where students could comment, blog, and interact with each other. The authors found that students in both gamification and social networking groups outperformed the control group on the skill assignments, though the control group did better on the final written examination designed to assess course knowledge. Additionally, students tended to have very low participation rates with the gamified (24%) and social networking platforms (38%).

These findings are similar to those that study gamification in non-education contexts. One recent study of over 3000 users found that those that viewed their own badges more frequently positively predicted increased page views, comments, trades, and transactions on an e-commerce website. This increased engagement only occurred among users who were actually interested in the badge system, however. In other words, creating a gamified system alone was insufficient to cause an increase in these behavioral measures; rather, it depended on individual users' interest levels (Hamari, 2013). Hamari et al. (2014) conducted a comprehensive review of empirical studies of gamification across different contexts (e.g., education, consumer science), but were only able to identify 24 studies. Of those studies, only two reported entirely positive effects. The majority of studies found some positive aspects of gamification, such as increased engagement and enjoyment, but these outcomes are often dependent on the context of the gamified system (e.g., marketing, educational) and the characteristics of the player. Additional work has shown that the appeal of a gamified system might be due to a novelty effect, and that positive effects such as engagement and interest decrease over time (Koivisto & Hamari, 2014). The authors also noted methodological problems with the studies; of the 24 reviewed, the authors found that few actually compared gamified and nongamified experiences (Hamari et al., 2014). Thus, it is uncertain whether the effects found can be attributed to gamification or other factors. Further, it is possible that the mixed results from studies on gamification come from the different applications of game mechanics in each study. A more focused approach may be required to determine which elements of gamification are most effective to help practitioners make the most of its application.

In addition to these questions regarding the effectiveness of gamification, a long history of research on reward systems in education suggests that elements of gamification, particularly the use of badge and reward systems, might have a negative impact on student motivation and learning (Deci, Koestner, & Ryan, 1999; Deci, Ryan, & Koestner, 2001). Cognitive evaluation theory (Deci & Ryan, 1985) predicts that external events can shape one's intrinsic motivation (i.e., doing it because one wants to, and not due to outside pressures) based on whether individuals process those events as informational or controlling. If a reward provided for a task is seen as an informational, then it will make one feel competent and in control, leading to higher intrinsic motivation. If a reward is seen as controlling, it makes one feel powerless and incompetent, decreasing intrinsic motivation. Studies have shown that giving rewards for a task one already finds interesting ends up harming motivation to do that task (Deci et al., 1999, 2001; Lepper, Greene, & Nisbett, 1973). Thus, although there may be benefits to gamification, it is also important to examine potential drawbacks as it may hamper the motivation educators are trying to cultivate.

2.2. Badge systems, rewards, and intrinsic motivation

Getting students motivated to pay attention and engage with material is a central goal of education. More importantly, educators want students to be *intrinsically* motivated to learn, which occurs when the desire to learn comes from within the student (Deci & Ryan, 2000). Less desired is students being *extrinsically* motivated to perform, wherein their motivation for a behavior is due to some outside force (e.g., parental pressure). Intrinsically motivated students are more engaged, retain information better, and are generally happier (Deci & Ryan,

2000; Ryan & Deci, 2000). Proponents for gamification in the classroom suggest that the elements that make games fun, and the nature of games themselves, are intrinsically motivating (McGonigal, 2011). Thus, applying game mechanics to the classroom should increase students' intrinsic motivation to learn.

Yet a substantial body of research suggests that caution should be taken in how we attempt to increase intrinsic motivation. The rewards, incentives, and competition that drive many gamification efforts have been demonstrated to decrease intrinsic motivation (Deci et al., 2001). This decrease in motivation as a result of being given rewards occurs when an individual is initially interested in a task, is given a tangible reward, and then expects the reward going forward (Tang & Hall, 1995). Essentially, offering tangible, expected rewards to individuals who are already interested in a topic may cause them to shift motivations from intrinsic (i.e., because they wanted to) to extrinsic (i.e., because they want to earn a reward; Lepper et al., 1973). When the reward is present, one may be interested in completing the task, but once the reward is removed one will no longer have a reason to perform a behavior (Lepper et al., 1973).

One example of these extrinsic rewards commonly employed in gamification efforts is the badge system. In these systems, players are given badges for tasks completed and milestones reached. For example, if a student completes a science module, that student will receive the Young Scientist badge. Users have access to their badges and may review previously earned badges as well as the requirements to receive new badges. On their own, using badges as rewards for doing tasks may not be beneficial. Badges meet the requirements that Tang and Hall's (1995) and Deci et al. (2001) meta-analyzes described as necessary for a reward to decrease intrinsic motivation: it must be given for an initially interesting task, be tangible, and be expected. Individuals using a badge system are often initially interested in the task (e.g., reading), receive something tangible in the form of a badge they can view and show others, and are able to see the requirements for receiving a badge and thus are not surprised when they earn one. Cognitive evaluation theory would suggest that giving individuals rewards for something they would already freely choose to do would cause those rewards to be seen as controlling and hinder intrinsic motivation (Deci & Ryan, 1985). Based on this research, using rewards, badges, and other incentives to perform in class may backfire and decrease intrinsic motivation for those already interested in the class.

2.3. Leaderboards and social comparison

By nature, humans make ability judgments about the self and others via comparison, as it is difficult to make a true assessment of one's ability without a reference point (Hoorens & Van Damme, 2012). Social comparison theory predicts that individuals compare themselves to others in order to validate opinions, make judgments, and reduce uncertainty (Festinger, 1954). Ideally, individuals would socially compare with those that are equal on a desired trait, but research shows comparisons often occur with others who are worse (downward comparison) or better (upward comparison) than the one making the comparison (Buunk & Gibbons, 2000). Downward comparisons have been shown to lead to feelings of superiority and positive affect (Major, Testa, & Bylsma, 1991), whereas upward comparisons can evoke negative affect and lower academic self-concept (Dijkstra, Kuyper, van der Werf, Buunk, & van der Zee, 2008).

Gamification often includes the addition of a global leaderboard, where players' scores on given tasks or earned badges are displayed for all players to see. Depending on one's position, a leaderboard can offer opportunities for both upward and downward comparisons on the dimension of class performance (Christy & Fox, 2014). Although individuals high on the leaderboard may feel more positive affect and superiority, they might also feel more pressure and be more likely to choke under that pressure (Wells & Skowronski, 2012). Further, comparisons based on leaderboards may influence students' academic performance (Christy & Fox, 2014). The classroom setting naturally facilitates comparison by providing objective evaluation and constant exposure to peer performance and ability (Wells & Skowronski, 2012), and adding leaderboards ought to further provide students with a visible, objective reminder of their performance relative to others.

Compared to traditional similar methods (e.g., a sticker chart posted in a classroom), digital leaderboards have distinct affordances. Rather than only being accessible in one place, digital leaderboards can be accessed by students outside the classroom as well, further reinforcing their standing. Because digital leaderboards can be accessed outside of the classroom, they also allow anonymous and covert viewing. In physical locations, there are social barriers that prohibit one from spending too much time examining a leaderboard-like chart. Online, students can spend as much time as they like checking out each individual classmate or comparing each of their achievements with others' without anyone else observing or knowing that they are engaging in such deep social comparison. Thus, given their persistence outside of the classroom and the opportunity for unhindered and covert viewing, the impact of digital leaderboards may be considerably more pervasive.

2.4. Social comparison and competition

Social comparison naturally leads to competition, as comparison often makes individuals aware of their lack of skill, status, or position relative to others (Garcia, Tor, & Gonzalez, 2006). When social comparison is made on a mutually relevant dimension (e.g., placement on the leaderboard) and made with another of equal status, competition emerges. Competition is often used as a tool in the classroom to increase motivation but research suggests that competition can have negative effects in the classroom (Reeve & Deci, 1996). Competition can diminish overall performance, cooperation, and problem solving, and also has a positive relationship with cheating (Orosz, Farkas, & Roland-Lévy, 2013).

The negative effects of competition may depend on whether it is *constructive* competition or *destructive* competition. Constructive competition occurs when competition is a fun experience and structured in ways to achieve and grow positive interpersonal relationships where destructive competition is harmful for at least one competitor (Fülöp, 2009). For example, competition decreases intrinsic motivation among children when the children are told to play to “beat the other” students (Vallerand, Gauvin, & Halliwell, 1986). Research also shows that competition is detrimental to feeling connected with other individuals as it is hard to feel personally close or connected with a rival (Tripathi, 1992). Although it is unclear whether leaderboards facilitate constructive or destructive competition, leaderboards typically highlight a single winner. Given the easy ability to view others' progress and socially compare, leaderboard may be a form of destructive competition and may lead to negative outcomes in the classroom.

2.5. Study overview

Despite the calls for gamification and the increasing popularity inside the classroom and industry (Glover, 2013; McGonigal, 2011), there are some potential areas for concern over gamification's benefits for education. The increased social comparison, competition, and reward systems might have detrimental effects over the long term for students' motivation, satisfaction, enjoyment, and engagement with class material. Our goal was to design a study that addressed the limitations of previous empirical research on gamification such as a lack of comparison groups, short treatments, singular assessments, and a lack of validated measures (Hamari et al., 2014). We wanted to test the effects of educational gamification in a real world setting over time. We recruited 80 students in two separate classes of the same course taught by one of the authors and gathered data at four separate times over the course of a 16 week semester. The classes were broken up into a gamified course that required participation, badge completion, and engagement with an online leaderboard, and a non-gamified course. Aside from the gamification elements, both courses featured the same material, assignments, exams, and lectures. We measured motivational and psychological variables as well as behavioral variables.

Our goal was to create a class environment incorporating elements of gamification that theory indicates may be problematic: leaderboards, badges, and incentive systems. We conducted a longitudinal study to assess how these gamification elements affected student satisfaction, motivation, enjoyment, empowerment to learn, and grades over time.

Research on social comparison shows that social comparison as a result of direct competition may have negative effects. We predict that the social comparison required by leaderboards will facilitate competition, and as a result lead to less satisfaction and promote more social comparison over time.

H1. Students in the gamified course will compare more frequently with others over time.

In accordance with research on rewards and motivation (Deci et al., 2001), we predicted that badge systems will have a negative effect on student motivation and satisfaction.

H2. Students in the gamified course will have lower motivation than those in the non-gamified course over time.

H3. Students in the gamified course will be less satisfied than those in the non-gamified course over time.

H4. Students in the gamified course will give less effort than those in the non-gamified course over time.

H5. Students in the gamified course will feel less empowered that they can succeed than those in the non-gamified course over time.

Cognitive evaluation theory (Deci & Ryan, 1985) suggests that rewards affect intrinsic motivation, which may result in poorer performance. We suggest that the effect of a gamified course on a student's final exam score may be mediated by their levels of intrinsic motivation. As such, we hypothesized a mediation model. See Fig. 1.

H6. Intrinsic motivation scores will mediate the relationship between course type and final exam scores.

3. Method

3.1. Sample

Participants (57 males and 23 females) had voluntarily enrolled in two Communication courses at a large Midwestern university. The final sample ($N = 80$) reported their race/ethnicity as: Caucasian/European-American/White ($n = 64$); Asian/Asian-American ($n = 7$); African/African American/Black ($n = 6$); American Indian/Alaskan Native ($n = 1$); Latino/a ($n = 1$); Pacific Islander ($n = 1$). Of the 80 participants, 71 conducted all four surveys. The nine that did not complete all four surveys were not included in longitudinal analyzes. One class was required to complete the badge system as part of the class grade. The other class was not told about the badge system, but was otherwise given the same lectures, assignments, and exams.

3.2. Procedure

Students were asked to give their informed consent, and were given four surveys over the course of a standard 16 week semester. The initial survey (Time 0) was given in the first week of classes and contained an array of trait and personality measurements administered to ensure equivalence of the groups. After the initial survey was administered, the badge system and leaderboard were introduced to the class in the leaderboard condition. The subsequent surveys (Time 1, Time 2, and Time 3) were distributed every four weeks following until the end of the semester.

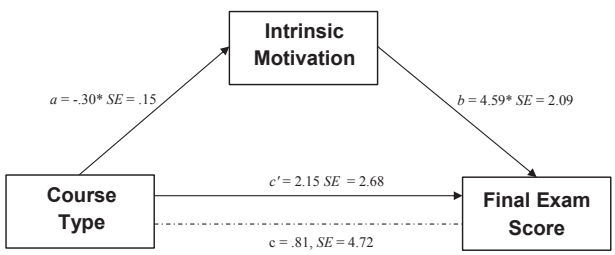

Fig. 1. Path coefficients for simple mediation analysis of course type on final exam score through intrinsic motivation. $ab = -1.38$, 95% CI [−4.25, −.05]. *Note*: Dotted line denotes the effect of course type on final exam score when intrinsic motivation is not included as a mediator. *b,c,* and *c'* are unstandardized logistic regression coefficients, *a* is an unstandardized OLS regression coefficient. * denotes $p < .05$.

3.3. Materials

In the gamified group, 22 badges were created and were designed to engage students in class-related work outside and inside the classroom. The goal was to incentivize engagement with class material. For example, to earn the Critical Hit badge students required to play a video game, write a critical review, and share it with the class. The Twice the Power badge required students to go to the library and study together, whereas students earned the Bookworm badge by exceeding the minimum number of required sources for the class paper. Other badges were given for quality class participation, turning in assignments early, having no formatting or grammar mistakes in a paper, and even coming to class dressed up as a video game character. See Fig. 2 for examples. When students completed all the requirements for a given badge, they submitted a badge completion form for assessment which included the name of the badge and any necessary requirements for completion.

In addition to earning badges, students also had the option to earn “coins” for the class. Coins required less work than badges and were given out for making a meaningful contribution to the class discussion or sharing interesting links or articles pertinent to the class. Although students were required to earn badges, earning coins was entirely optional. Students could spend coins during the class to earn small benefits, such as an extension on a paper.

At the beginning of the semester, students were asked to pick pseudonyms to display and track their progress on the class's badge leaderboard. All students were given access to the badge leaderboard, and could view their progress relative to other students. The leaderboard displayed student pseudonyms, coin totals, and badges earned in the form of the badge pictures next to their names. See Fig. 3. The leaderboard also displayed what place the student was in relative to other students. The top three positions also featured a gold, silver, or bronze star (respectively) that appeared next to the student's name. The badge leaderboard was updated weekly based on completed badge report forms. Placement on the leaderboard was determined by number of badges completed, with coin total as the tiebreaker.

3.4. Measures

3.4.1. Video game habits

Participants completed the 30-item lifetime television exposure scale, with questions adapted for video game use (Riddle, 2010). The scale assessed how often one played video games currently, as an adolescent (secondary school), and as a child (elementary school). Items

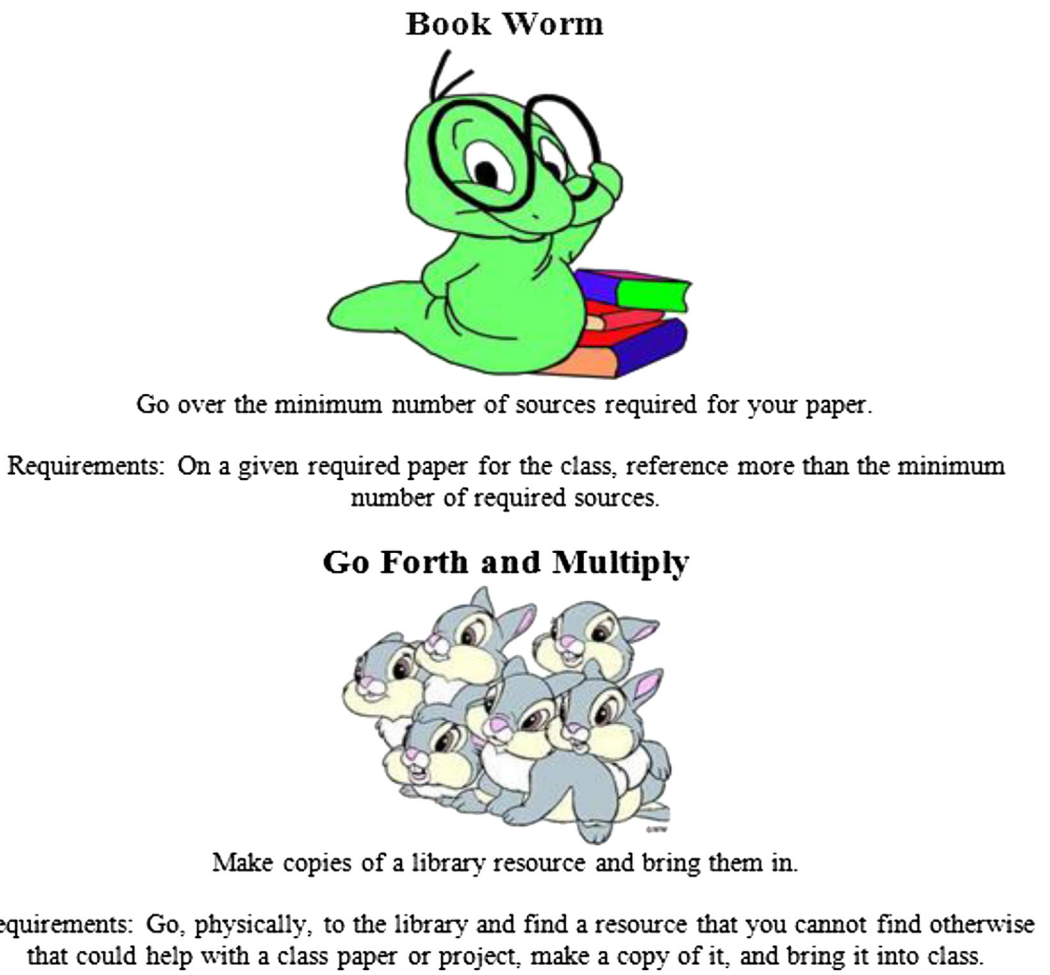

Fig. 2. Sample badge descriptions given to the gamified class. All badges included a name, picture of the badge, description and the badge requirements and were given for a variety of tasks.

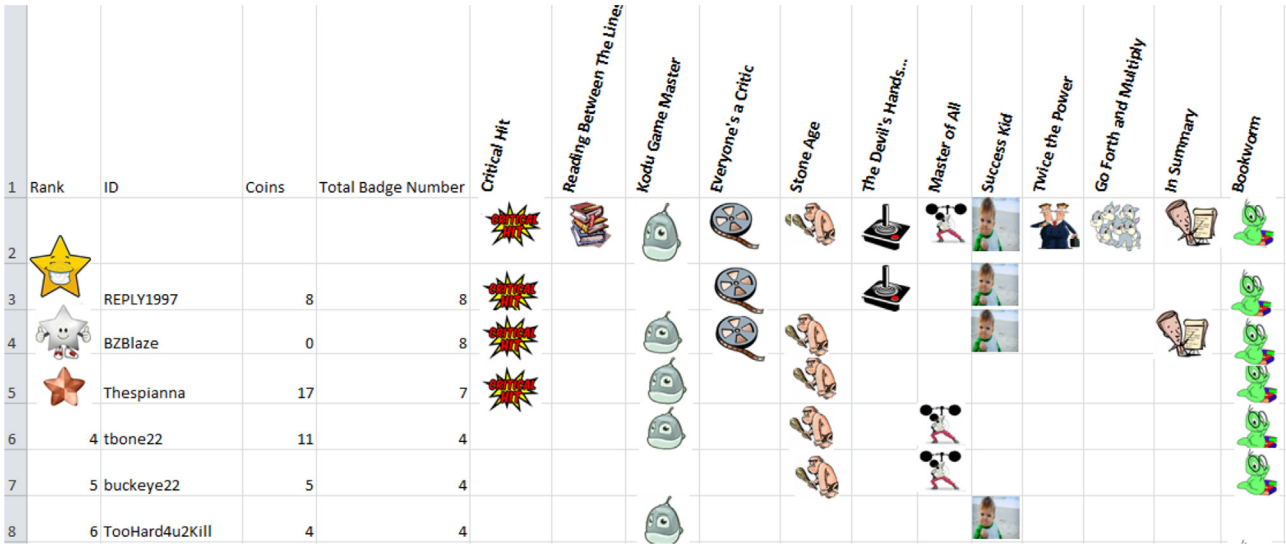

Fig. 3. Screenshot of the badge leaderboard. Ranking was determined by total badge number, with coin count as a tiebreaker. All students could access the leaderboard to see their ranking and badges accumulated in comparison with all other students. Every student was required to create an anonymous name.

were measured on a 7-point scale from 1 (*never*) to 7 (*almost always*) and included "As a child, how often do you play video games when you first wake up in the morning?" and "Currently, how often do you play video games after dinner?" (Cronbach $\alpha = .91$).

3.4.2. Intrinsic motivation

Participants completed the intrinsic motivation inventory (Ryan, Koestner, & Deci, 1991), which contains 22 items such as "I felt like I was doing what I wanted to do while I was working on the task" and "I felt that it was my choice to do the task." Items were measured on a 7-point Likert scale from 1 (*strongly disagree*) to 7 (*strongly agree*; Cronbach $\alpha = .86$).

3.4.3. Class satisfaction

Satisfaction with the course was measured with a 5-item scale (Cronbach $\alpha = .92$). Items included "In the last month, I have enjoyed this class" and "In the last month, I have been happy taking this class" and were measured on a 7-point Likert scale from 1 (*strongly disagree*) to 7 (*strongly agree*).

3.4.4. Class effort

Four items were administered to measure how much effort students gave in the class. Items included "In the last month, I feel I have put forth a lot of effort in this class" and were measured on a 7-point Likert scale from 1 (*strongly disagree*) to 7 (*strongly agree*; Cronbach $\alpha = .70$).

3.4.5. Learner empowerment

Participants completed an 18-item learner empowerment scale (Weber, Martin, & Cayanus, 2005) with statements consisting of "This course will help me achieve my future goals" and "I have the qualifications to succeed in this class." Items were measured on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree;* Cronbach $\alpha = .87$).

3.4.6. Social comparison

Participants completed a 6-item social orientation scale (Gibbons & Buunk, 1999). Students rated how often they compared with other students in the class on statements such as "In the last month, I have looked to others' performance to feel better about my performance," and "In the last month, I have felt envious of someone else's performance." Six items were measured on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*; Cronbach $\alpha = .77$).

3.4.7. Exam scores

Two exams were given over the course of the semester covering course material and readings. The first exam was given midway through the semester, and the second exam was given as the course's final exam.

4. Results

Means and standard deviations for all variables can be found in Table 1. Correlations between variables can be found in Table 2.

4.1. Sample equivalence

Given individual participants were not randomly assigned to conditions and the instructor had no control over who registered for the class, we examined several relevant variables at Time 0 to ensure that there were no existing differences between the samples. Independent samples *t*-tests revealed no significant differences between the leaderboard group and the control group on any variables (hours of video

Table 1
Mean scores of social comparison, motivation, satisfaction, effort, learner empowerment, and grades over times 1, 2, and 3.

	Gamified course			Non-gamified course		
	Time 1	*Time 2*	*Time 3*	*Time 1*	*Time 2*	*Time 3*
Social comparison	3.11 (.77)	3.32 (.72)	3.40 (.65)*	3.05 (.81)	3.16 (.79)	3.08 (.78)*
Motivation	4.74 (.49)	4.57 (.57)***	4.66 (.71)*	4.78 (.56)	4.92 (.53)***	4.95 (.66)*
Satisfaction	4.1 (.61)	3.51 (.84)*	3.57 (.91)*	4.18 (.50)	4.15 (.56)*	4.00 (.82)*
Effort	3.14 (.72)	3.31 (.77)	3.72 (.77)	3.01 (.66)	3.41 (.59)	3.89 (.81)
Empowerment	3.74 (.38)	3.49 (.42)*	3.53 (.47)	3.71 (.53)	3.71 (.52)*	3.64 (.56)

Note. $n = 71$. *denotes $p < .05$, ** denotes $p < .01$, *** denotes $p < .001$.

game play, game play habits, GPA, reward orientation, competitiveness, trait self-esteem, social comparison orientation, or intrinsic motivation), all *ps* > .05. A chi-square analysis also found no differences in distribution by sex,[1] $\chi^2(1, N = 80) = 1.53$, $p = .22$. Although this does not supplant true random assignment, it provides more confidence that these samples were equivalent on related traits and that changes over the course of the class were attributable to the gamification manipulation.

4.2. Hypothesis testing

H1 predicted that over time, students would socially compare more in the gamified course. Video game use was not a significant covariate, $F(2, 65) = .03$, $p = .96$, partial $\eta^2 < .01$. Time, condition, and the interaction effects were not significant over the three time periods on social comparison between classmates. Students in the gamified condition were not significantly different from those in the control group at Time 1 or Time 2, though they scored marginally significantly higher than the control group on social comparison at Time 3, $F(1, 70) = 3.62$, $p = .06$, partial $\eta^2 = .05$. Thus, H1 was partially supported.

H2 predicted that over time, students would have lower intrinsic motivation scores in the gamified course. To address H2, we ran a repeated measures ANOVA with time as the within subjects factor and condition as the between subjects factor. Mauchly's test revealed a violation of sphericity, χ^2 (2) = 8.03, $p = .018$, so the Huynh-Feldt correction was examined ($\varepsilon = .95$). Video game use was a significant covariate, $F(1, 65) = 13.98$, $p < .001$, partial $\eta^2 = .18$. Time was not a significant factor, $F(1.89, 123.04) = .52$, $p = .59$, partial $\eta^2 = .01$. Condition was not a significant factor, $F(1, 65) = 2.00$, $p = .16$, partial $\eta^2 = .03$. The interaction effect was significant, $F(1.89, 123.04) = 5.30$, $p = .007$, partial $\eta^2 = .08$. Although participants did not differ at Time 1, at Time 2 motivation for the control group escalated significantly and was maintained at Time 3. For the leaderboard group, motivation dropped significantly at Time 2. At Time 3, it remained unchanged and was still significantly lower than the control condition. H2 was supported.

H3 predicted that over time, class satisfaction scores would be lower in the gamified course. Mauchly's test revealed a violation of sphericity, $\chi^2(2) = 7.47$, $p = .02$, so the Huynh-Feldt correction was examined ($\varepsilon = .94$). Video game use was not a significant covariate, $F(1, 65) = 2.98$, $p = .09$, partial $\eta^2 = .04$. Time was a significant factor, $F(1.88, 124.07) = 12.60$, $p < .001$, partial $\eta^2 = .16$. Condition was a significant factor, $F(1, 66) = 7.12$, $p = .01$, partial $\eta^2 = .10$. The interaction effect was significant, $F(1.88, 124.07) = 6.74$, $p = .002$, partial $\eta^2 = .09$. Although conditions did not differ at Time 1, at Time 2, the class satisfaction for the control group remained steady while the leaderboard group's satisfaction dropped significantly. The respective groups showed no significant change at Time 3, with the control condition still reporting significantly higher levels of class satisfaction than the leaderboard condition. H3 was supported.

H4 predicted that over time, effort in the gamified course would be lower than the non-gamified course. The Mauchly's test was not significant. Video game use was not a significant covariate. Time was a significant factor, $F(2, 132) = 28.92$, $p < .001$, partial $\eta^2 = .31$. For both conditions, effort increased significantly at each time point. Condition was not a significant factor, $F(1, 66) = .10$, $p = .75$, partial $\eta^2 < .01$. The interaction effect was not significant, $F(2, 132) = 1.36$, $p = .27$, partial $\eta^2 = .02$. H4 was not supported.

H5 predicted that over time, learner empowerment would be lower in the gamified course. Mauchly's test revealed a violation of sphericity $\chi^2(2) = 17.20$, $p < .001$, so the Huynh-Feldt correction was examined ($\varepsilon = .85$). Video game use was not a significant covariate, $F(1, 65) = 2.96$, $p = .09$, partial $\eta^2 = .04$. Time was not a significant factor, $F(1.71, 110.82) = 1.96$, $p = .15$, partial $\eta^2 = .03$. Condition was not a significant factor, $F(1, 65) = .48$, $p = .49$, partial $\eta^2 = .01$. The interaction effect was significant, $F(1.71, 110.82) = 5.60$, $p = .007$, partial $\eta^2 = .08$. Participants did not differ at Time 1, Time 2, or Time 3 in learner empowerment for the control group. For the leaderboard group, learner empowerment dropped significantly at Time 2. At Time 3, it remained unchanged, though was no longer significantly lower than the control condition. H5 was partially supported.

H6 predicted that at the final time period (Time 3), students' levels of intrinsic motivation would mediate the effect of course type on final exam scores. Course type would affect students' final exam scores in such a way that being exposed to the rewards and badge systems would harm their intrinsic motivation, leading to worse exam scores (Fig. 3). To test this prediction, we ran a mediation analysis using the PROCESS macro for the statistical software package SPSS (Hayes, 2012), testing for an indirect effect (the *ab* path) with course type (*gamified* = 1, *non-gamified* = 0) as the predictor variable, intrinsic motivation as the mediator, and final exam grade as the outcome variable. This tests whether the indirect effect is statistically different from zero, by generating 10,000 bootstrap confidence intervals. Video game use was not a significant covariate in the model, and was dropped from the model. The results show that course type directly affects intrinsic motivation (*a* path), where those in the gamified group have lower intrinsic motivation scores, $a = -.30$, 95% CI [−.60, −.01], and that higher intrinsic motivation leads to higher scores on the final exam regardless of condition, $b = 4.59$; 95% CI [.41, 8.77]. However, there is no direct effect for condition on final exam score when holding intrinsic motivation constant, $c = 2.15$; 95% CI [−3.20, 7.50]. Despite a lack of evidence for a direct effect, it is still possible that course type affects final exam scores indirectly via intrinsic motivation. The data are consistent with the

[1] There were no sex differences found over time in the main variables of interest (effort, satisfaction, motivation, learner empowerment, social comparison, or final exam scores), all *ps* > .05.

Table 2
Correlational matrix between all variables.

	1	2	3	4	5	6	7	8	9
1. Course type		−.02	−.06	.01	.06	.23	−.07	−.29*	−.23*
2. Final exam score	−.02		.14	−.07	.04	−.08	.16	.27*	.24*
3. Video game habits	−.09	.14		−.06	−.04	−.04	.33**	.37*	.41**
4. Social comparison (T1)	.01	−.07	−.06		.68**	.61**	.08	.01	−.03
5. Social comparison (T2)	.06	.04	−.04	.68**		.73**	.11	.05	.01
6. Social comparison (T3)	.23	−.08	−.04	.61**	.73**		−.12	−.28*	−.15
7. Intrinsic motivation (T1)	−.07	.16	.33**	.08	.11	−.12		.77**	.70**
8. Intrinsic motivation (T2)	−.29*	.27*	.37**	.01	.05	−.28*	.77**		.84**
9. Intrinsic motivation (T3)	−.23*	.24*	.41**	−.03	.01	−.15	.70**	.84**	
10. Satisfaction (T1)	−.07	.13	.22	−.02	−.06	−.18	.70**	.59**	.58**
11. Satisfaction (T2)	−.42**	.25*	.16	−.13	−.02	−.28*	.46**	.71**	.67**
12. Satisfaction (T3)	−.28*	.20	.17	−.16	−.19	−.32**	.43**	.65**	.75**
13. Effort (T1)	.07	.26*	−.07	−.05	.01	−.11	.02	.15	.11
14. Effort (T2)	−.08	.01	−.27*	−.01	.04	−.11	−.15	.05	.02
15. Effort (T3)	−.11	.13	.05	.13	.03	−.03	−.16	.15	.21
16. Empowerment (T1)	−.03	.18	.20	−.14	−.09	−.31**	.68**	.57**	.55**
17. Empowerment (T2)	−.24*	.20	.13	−.18	−.09	−.39**	.43**	.69**	.60**
18. Empowerment (T3)	−.12	.23	.26*	−.28*	−.19	−.41**	.46**	.68**	.67**

	10	11	12	13	14	15	16	17	18
1. Course type	−.07	−.42**	−.28*	.07	−.08	−.11	−.03	−.24*	−.12
2. Final exam score	.13	.25*	.20	.26*	.01	.13	.18	.20	.23
3. Video game habits	.22	.16	.17	−.07	−.27*	.05	.20	.13	.26*
4. Social comparison (T1)	−.02	−.12	−.16	−.05	−.01	.13	−.14	−.18	−.28*
5. Social comparison (T2)	−.06	−.02	−.19	.01	.04	.03	−.09	−.09	−.19
6. Social comparison (T3)	−.18	−.28*	−.32**	−.11	−.11	−.03	−.31**	−.39**	−.41**
7. Intrinsic motivation (T1)	.70**	.46**	.43**	.02	−.15	.16	.68**	.43**	.46**
8. Intrinsic motivation (T2)	.59**	.71**	.65**	.15	.05	.15	.57**	.69**	.68**
9. Intrinsic Motivation (T3)	.58**	.67**	.75**	.11	.02	.21	.55**	.60**	.67**
10. Satisfaction (T1)		.48**	.47**	.11	−.15	−.04	.69**	.46**	.47**
11. Satisfaction (T2)	.48**		.77**	.03	.03	.06	.48**	.78**	.71**
12. Satisfaction (T3)	.47**	.77**		−.01	.05	.12	.48**	.66**	.73**
13. Effort (T1)	.11	.03	−.01		.45**	.29*	.19	.08	.08
14. Effort (T2)	−.15	.03	.05	.45**		.40**	−.03	.13	.12
15. Effort (T3)	−.04	.06	.12	.29*	.40**		.06	−.03	.11
16. Empowerment (T1)	.69**	.48**	.48**	.19	−.03	.06		.67**	.67**
17. Empowerment (T2)	.46**	.66**	.66**	.08	.13	−.03	.67**		.88**
18. Empowerment (T3)	.47**	.71**	.73**	.08	.12	.11	.67**	.88**	

Note. $n = 71$. * denotes $p < .05$, ** denotes $p < .01$.

claim that course type influences the final exam score indirectly through intrinsic motivation scores, $ab = -1.38$; 95% CI [−4.38, −.05]. Relative to those in the control condition, those in the gamified group were less motivated in the class, which was associated with lower grades on the final exam. This supports H6.

5. Discussion

Holistically, the results suggest that some common mechanics used in classroom gamification (i.e., competitive context, badges, and leaderboards) may harm some educational outcomes. We found that though students from each course started at the same levels of intrinsic motivation, satisfaction, effort, social comparison, and empowerment, over time students in the gamified course tended to decrease in motivation, satisfaction, and empowerment relative to the non-gamified course. Although course type alone did not affect students' grades over time, we found that the effect of course type on students' final exam scores was mediated by their levels of intrinsic motivation. Students in the gamified class tended to be less intrinsically motivated at Time 3, which caused lower final exam scores.

The results suggest that at best, our combination of leaderboards, badges, and competition mechanics do not improve educational outcomes and at worst can harm motivation, satisfaction, and empowerment. Further, in decreasing intrinsic motivation, it can affect students' final exam scores. It should be noted that all of our game mechanics were aligned with learning objectives; the badges were designed to promote additional learning and engagement, and yet students in the gamified classroom were less intrinsically motivated and in turn earned lower exam scores than those in the non-gamified classroom. This suggests that giving rewards in the form of badges and coins, as well as encouraging competition and social comparison via a digital leaderboard, harms motivation. Our findings thus align with existing literature on the negative effects of rewards on motivation (Deci et al., 2001; Lepper et al., 1973; Tang & Hall, 1995) as well as the negative effects of social comparison on motivation and performance in educational settings (Christy & Fox, 2014; Dijkstra et al., 2008).

Cognitive evaluation theory predicts that when a reward is seen as controlling it can cause one to feel less competent and in control, which decreases intrinsic motivation. Students were enrolled in an elective course, presumably of their own free will and because it was somewhat interesting to them beyond other course offerings. When a reward system is imposed on top of a class students already find interesting, it may feel constraining and forced. Our data suggest that these additional rewards are interpreted as controlling, causing students to feel less confident, be less satisfied with the course, and have less motivation to engage with the material.

There is significant evidence that giving rewards for already interesting tasks (i.e., ones where an individual is already intrinsically motivated to do) decreases intrinsic motivation. Some evidence has shown that incentives given for boring tasks might actually increase

intrinsic motivation, however (Cameron, Banko, & Pierce, 2001; Deci et al., 2001). Individuals who receive a reward for a boring task have something to distract them from the boring task, which makes the situation more interesting. In this case, if a student finds the class boring, then rewards and incentives might make the material more engaging. This suggests that gamification in the classroom may be a double-edged sword. For students who are bored and do not wish to be there, rewards and incentives might increase intrinsic motivation. But for students who are innately interested in the material and already motivated to attend, efforts to gamify the classroom might harm their intrinsic motivation.

Still, some suggest that the benefits of gamification are short lived, even for boring tasks (Koivisto & Hamari, 2014; Mollick & Rothbard, 2014). Koivisto and Hamari (2014) found that engagement and interest decreases over time for individuals participating in a gamified system. This may be due to the relative novelty of gamification; in a traditional classroom, introducing some game elements may feel more exciting at first, but over time the novelty expires and excitement decreases. If all of a student's classes were gamified, then this might lose its appeal even faster.

The study contains some limitations. Earning badges was posed as a mandatory activity for those in the gamified class. Being forced to do something can decrease intrinsic motivation (Deci et al., 2001), and gamification may be more effective for individuals who have the option to engage with badges and leaderboards. Individuals tend to be aversive to the idea of "mandatory fun," and Mollick and Rothbard (2014) demonstrated that gamification is more effective when individuals can choose whether or not to participate. In our review of gamified classrooms, however, we found that these systems typically replaced other methods of delivery and were mandatory; thus, our study is externally valid as a practical reflection of how badges and leaderboards are typically executed in the classroom. Although it may be more beneficial to appeal to each student's individual preference, in traditional educational settings it is unlikely that an instructor would have the time and resources to gamify a class for some students but not others as this would require creation, delivery, and evaluation of separate curricula, lessons, and activities. Other options, such as online learning, may make individualized instruction and gamification more feasible. Thus, future researchers may explore how voluntary participation in gamified classrooms influences outcomes.

Additionally, it is important to assess who may benefit the most from gamification. Other factors may predict whether gamification may benefit or harm individual students. For example, students with performance anxiety may be overly pressured by some gamification methods, or they may benefit from the distraction. Students who experience gamification in a content area they are confident in may enjoy the approach, or they may feel it detracts from the learning experience. Future studies should investigate more specifically different conditions under which gamification is effective for individual participants.

6. Conclusion

This is one of the first studies to assess the effectiveness of gamification elements in the classroom longitudinally using motivational, psychological, and behavioral measures. We designed a study to address many of the shortcomings in other empirical gamification studies that have been identified by previous researchers (Hamari et al., 2014), including the use of a comparison group, employing established measures, and examining effects over time. In this study, we chose to focus common game mechanics applied to gamified classrooms: leaderboards, badges, and competition. It is important to note that our findings are thus limited to these mechanics of gamification and are not indicative of all gamification systems. Games have been demonstrated to increase learning (de-Marcos et al., 2014; Gee, 2007), and it is possible that the incorporation of certain game mechanics with clear learning objectives in mind can create an engaging and meaningful experience.

It is important to note that future gamification research should investigate specific elements of gamification rather than as an overarching concept so that the effectiveness of different mechanics can be parsed out. By isolating specific game mechanics and using theory to assess their effectiveness in the classroom we can better understand how to create an ideal gamification system that maintains or promotes intrinsic motivation. Though our study focused primarily on mechanics that are theoretically suggested to have negative effects on the classroom (e.g., badge systems), future research should consider other elements of gamification that may yield more positive effects, such as tactics that emphasize cooperation and interesting narrative contexts. In addition, our study focused on gamification mechanics that can be applied by a traditional teacher in a typical classroom. However, many game mechanics are best applied through use of a computer or virtual world (e.g., immediate feedback, lesson plans tailored to each student). Future research should also consider the unique affordances of interactive technology and create gamified systems that take full advantage of these digital mechanics.

As education continues on a trend of incorporating digital technology into the classroom, it becomes easier to incorporate game elements in the hopes of making the material more engaging. Using certain elements of gamification could be very effective, but our findings indicate that educators should be wary of using rewards, badges, and leaderboards as they may backfire. In general, regardless of any mainstream enthusiasm for a learning technique, it is prudent for educators to evaluate existing empirical evidence behind trends before adopting these approaches in the classroom.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.compedu.2014.08.019.

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