

Do Badges Increase Student Engagement and Motivation?

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ABSTRACT

Gamification – using game mechanics for affording gameful experiences in non-game contexts – is getting increased attention in the educational field. However, its motivational mechanisms, intended to enhance student learning, are still not sufficiently understood. In this paper, we present an empirical study on the use of one of the most popular gamification elements, badges. The goal is to shed some light on their impact on student engagement and motivation. The study results suggest that while the badges improve student engagement and academic performance, they do not affect the student's intrinsic motivation. However, we speculate that they foster internalization of the learning-related extrinsic motivators' values, which results in increased engagement in the learning activities.

CCS CONCEPTS

• Human-centered computing ~ User studies

KEYWORDS

Active learning, gamification, badges, intrinsic motivation

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1 Introduction

There are many challenges in teaching programming-related subjects: the abstract and time-consuming nature of programming, the diversity in students' ability and disposition, and especially the difficulty in motivating students to persists in mastering new programming concepts. Like many skills, programming is best learned through practice [1]. Persistent practice, needed in

programming-related courses, requires efforts, and effort is directly associated with motivation. Thus, student motivation needs to be maintained for students to achieve success [2]. However, motivating students to practice programming is a challenging task. There has been an increasing effort to make learning activities that may not be inherently interesting for all learners, such as practicing programming skills, more game-like through gamification in order to sustain engagement with them. Gamifying learning has emerged as an approach that attempts to transfer games' motivational qualities to learning activities [3]. As a potential solution, gamified learning has gathered growing attention from the education sector. Badges are one of the most popular forms of gamification [4]. They are a form of feedback typically used to recognize achievements and accomplishments that can also serve as progress indicators.

As a common game mechanics, the potential effects of badges have been studied in various educational contexts [3]. These include the effect of badges on student engagement, participation, performance, and competition ([5], [6], [7], [8]), the impact of badges on course completion [9], and their effect on students behavior in computer science courses [10]. While the findings are generally positive, several studies report contradicting results [11]. Moreover, it is not only important to know whether gamification as a design approach has demonstrated the potential to produce the intended changes in learner's behavior, performance or learning outcomes, but also to know the motivations driving these changes. The empirical work that has been done on the impacts of badges on learners' motivation had also produced conflicting results [12]. Notably, studies on the effects of gamification on learners' motivation demonstrated positive, neutral, and negative results ([13], [14], [15]). Such conflicting results suggest that several contextual factors can play a role in influencing motivational mechanisms. These contextual factors need to be taken into account to understand the motivational effects of badges better.

According to Self-Determination Theory (SDT) [16], the goal-directed behavior is triggered by two types of motivation: intrinsic motivation (making volitional choices while meeting one's needs of autonomy, competence, and relatedness) and extrinsic motivation (doing something for separable outcomes). In an educational context, intrinsic motivation is considered as one of the hallmarks of successful education. However, from a gamification perspective, whether a given game element is perceived as extrinsically or intrinsically motivating depends on individual and contextual factors [17]. For example, some learners may view badges as game elements that demonstrate competence and convey

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relatedness that leads to intrinsic motivation. Others may perceive them as external rewards driving learners to perform specific activities to receive the badges, which results in extrinsically motivated behavior.

Furthermore, the motivational impact resulting from the badges might differ based on the dynamics that are programmed into the gamification rules (such as when and what type of badges one gets and their psychological value). Although several studies have examined the motivational impact of badges, no empirical research has been undertaken to analyze the motivational effect of badges on learners from both intrinsic and extrinsic perspectives. It is still difficult to form a clear picture of the types of motivation badges invoke and their effect on learning activities and learners' performance. To contribute to the knowledge about the effectiveness of using badges in education and, in particular, on the motivational effect of badges, we conducted a study in a gamified Computer Software Systems course. The study was focused on the impact of badges on out-of-class practicing and addressed the following research questions:

RQ1: Do badges encourage more active engagement in out-of-class practicing?

RQ2: Does receiving badges improve students' course performance (grades)?

RQ3: Does gamified practicing using badges improve student intrinsic motivation?

In the next section, we review the related work. The study's design, the research methods, and the data collection process are described in Section 3. The results of the experiment related to student engagement, student academic performance, and student motivation are reported in Section 4. Section 5 concludes the paper.

2 Related Work

While the benefits of gamification applied to education have been explored in a number of studies, the attention given to activities gamified solely with badges, which are considered as one of the prototypical examples of gamification, has been disproportionate. The disproportionate impact applies to the effects of badges on behavioral and learning outcomes and, to a greater extent, to the impact of badges on student intrinsic motivation. In this section, we review the studies addressing these impacts.

The studies on educational gamification vary in the targeted learning contexts and subject domains. In particular, Hakulinen et al. ([10], [13]) evaluated the use of badges in an online learning environment where students completed automatically assessed exercises in a Data Structures and Algorithms course. Denny [18] explored the use of badges in the social learning system PeerWise, where students could ask and answer questions in the context of a Population Health course. Morris et al. [8] studied the effect of badges on set learning goals in an Educational Psychology course. Abramovich et al. [5] studied the effect of merit and achievement badges, used in an intelligent tutor for teaching mathematics to middle-school students. In contrast, Imran [7] used badges for gamifying a learning environment, helping students prepare for entrance exams to higher education institutions. Kyewski and

Krämer [14] studied the impact of badges awarded for performance of specific activities within a graduate-level e-learning seminar on Computer-mediated Communication. Zainuddin [11] and Huang and Hew [19] used badges to gamify flipped-class instruction in a Science class and graduate Statistics and Library Sciences courses, correspondingly.

Most of the published empirical studies focused on investigating whether badges improve the students' engagement in the gamified activities and/or their academic achievements and as already pointed with contradicting results. Most of the authors, e.g., Hakulinen et al. [13], Denny [20], Huang and Hew [19], Zainuddin [11], Imran [7], and Anderson et al. [21] have found a positive effect of badges on student actions and on students' engagement with the gamified activities (practicing, question answering, online participation, out-of-class work). Concerning the student performance (course grades), some reported that the use of badges led to better student performance on the tests [11], to a reduced failing rate [13], or encouraged students to produce higher quality work [19]. Yet, others concluded that badges did not have a significant effect on course grades and learning ([8], [10]), did not make a difference in how often students answered correctly to their peers' questions [18], or in general, have less impact on motivation and performance than commonly assumed [14]. Several studies reported that the results vary with regard to the students and the types of badges used. For example, different types of badges concerning the various effects on students' behavior and different students respond differently to the intervention effects [10], [13]). Furthermore, [22] reported that the attitudes towards the badges varied between the groups of students with different achievement goal orientation profiles. All papers have in common the suggestion that more empirical studies are needed to understand better the impact of badges on student engagement and learning.

From a motivational perspective, we found few studies on the impact of badges on students' intrinsic motivation for engaging in learning activities, again with contradicting results. Zainuddin [11] used Self-Determination Theory to evaluate student motivation and found a positive outcome with regard to perceived competence, autonomy, and relatedness. Kyewski and Krämer [14] found that badges do not influence intrinsic motivation (neither increasing nor decreasing it). In contrast, according to Reid et al. [23], learners with high expectancy toward their course domain had higher intrinsic motivation to earn the course badges, but that was not valid for low-expectancy students. More recently, Facey-Shaw et al. [15] reported a 3-year study on the effects of badges on students' intrinsic motivation in an Introductory programming course. Intrinsic Motivation Inventory (IMI) was employed to assess participants' subjective experiences while conducting an activity. The authors confirmed the negative impact of badges on intrinsic motivation. However, they pointed out that due to several study constraints, it cannot be claimed that the badges generally reduced intrinsic motivation.

The conflicting results indicate that the motivational mechanisms of badges in learning contexts are not fully understood. In this context, our study attempts to advance the understanding of how badges motivate learners.

3 Case Study

3.1 Study Description

This study aimed to determine the effect of using badges in a sophomore-level computer science course to enhance students' motivation and engagement in order to improve their academic performance. For gamifying the course, we used OneUp, a course gamification platform [24] designed to allow an instructor to create assignments, quizzes, practice problems, and connect game elements to them. This semester-long study was implemented with 14 undergraduate students self-enrolled in an Introduction to Computer Software Systems course at an HBCU in the southeastern United State during the Spring semester 2020. The participants all fell into the 18-25 age category, and 90% were African American. There were 12 males and 2 females. The course covered java programming review, an overview of assemblers, linkers, loaders, operating systems, and elementary assembly language programming. It included lectures and labs, and the students were evaluated through quizzes, 2 semester tests, and a comprehensive final exam. Course lecture notes and other materials were posted on the Canvas Course Management system. Students were recommended to use the OneUp platform for self-study and practicing to prepare for the course quizzes and the tests. The use of OneUp was voluntary. The students enrolled in the course formed a comparison group in the first one-third of the semester and an experimental group in the next two-thirds of the semester. Both groups used OneUp for practicing and self-assessment, but the comparison group used it without game features, while gamification was added for the experimental group. At the beginning of the semester, students were given detailed instructions on the purpose of the research study. Informed consent was obtained from every participant.

3.2 Course Gamification

The OneUp gamification platform was used for gamifying the course. OneUp is highly configurable and supports a range of gamification features, including experience points (XP), skill points, progress bar, avatars, leaderboard, skill board, badges, virtual currency, content unlocking, activity streaks, goal setting, challenge duels, callouts, learning dashboard, and chat. However, as suggested recently in several studies (e.g. [20]), empirical studies should focus on the effect of single elements and clarify their role in a gamified system. Thus, we chose to study only the impact of badges on student engagement and motivation.

The gamification of the course consisted of creating warm-up challenges for students practicing and configuring the gamification features in the OneUp platform. The formats of the questions in the practice quizzes, called warm-up challenges in OneUp, were true/false (88), multiple choice (143), numerous answers (4), dynamic (5), and matching (1). Thirty-six warm-up challenges were created and grouped in the following topics: Review (12), Essential Background Information (6), Ethical Computing Issues (3), MIPS Computer Organization (4), and MIPS Assembly Programming Language (11). As to the gamification, we created badges and rules for awarding them in OneUp (see Table 1).

Table 1. Badges used in gamifying the course

	You will get this badge after collecting 8 badges.
	You will get this badge after collecting 5 badges.
	You will get this badge after completing 25 distinct warm-up challenges.
	You will get this badge after completing 10 distinct warm-up challenges.
	You will get this badge after completing your first warm-up challenge with a score $\geq 60\%$.
	If you take the most warm-up unique challenges for two weeks (with a passing score of 70%).
	You will get this badge if you take 5+ unique warm-ups with a 75% score in one week.

When a rule is satisfied, OneUp automatically assigns the corresponding badge to the student. The students see their badges and the recently awarded class badges on the OneUp entry page for the course (see Fig. 2).

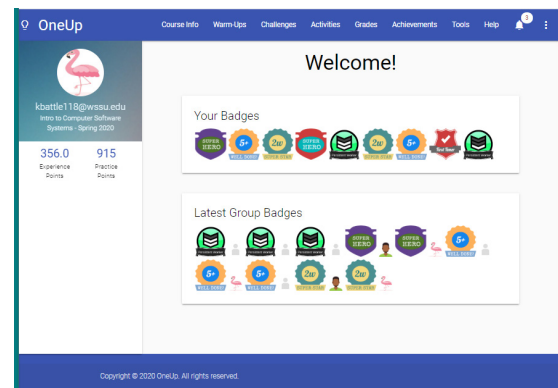


Figure 1: OneUp course entry page

3.3 Research Methods

To answer the research questions, we used different methods and sources of data. For the first research question (R1), we used the OneUp system log to extract data of students' completing practice quizzes. As stated earlier, to assess the impact of badges on student out-of-class practice, we used the class as a control group in the first month of the semester, and the same students comprised the experimental group in the next two months of the semester. Both groups used OneUp for practicing, but the gamification was added only for the experimental group. To evaluate the impact of gamifying the course on students' academic performance (research question R2), we compared the grades of one quiz, the final exam, and the final course grades of the experimental group (Spring 2020) with the corresponding grades of the students in this class in the

previous semester (Fall 2019). Both classes were taught by the same instructor, using the same instructional materials, teaching methodology, and assessment, however for the experimental group in Spring 2020, the course was gamified. To answer the third research question (R3), we conducted a motivational survey with the experimental group. The survey was a modified version of the Basic Psychological Needs Satisfaction Scale – Work Domain [25]. This 21-item scale was chosen because there is considerable research linking elements of Self-Determination Theory to basic psychological needs, i.e., Autonomy, Competence, and Relatedness ([25], [26], [27]). For the current study, we hypothesized that these basic psychological needs applied to work completed in the classroom domain, so the Likert-type scale items ranging from 1 (not at all true) to 7 (very true) were slightly modified to represent work being done in the classroom as opposed to the career setting, e.g., “I feel like I can make a lot of inputs regarding how my classwork gets done” vs. “I feel like I can make a lot of inputs regarding how my job gets done” (see Table 3 in Section 4.3).

4 Results

4.1 Student Engagement

One of the objectives of this study was to evaluate whether the gamification feature of awarding badges encouraged more active engagement in the course beyond the classwork. The data for assessing student engagement were extracted from the OneUp system log. We were particularly interested in finding out whether the use of badges intensified the taking of practice quizzes. In this section, we report statistics on the badges earned by the students in the experimental group and also compare the use of OneUp as a platform for out-of-class practicing by the students in both the control and the experimental group.

4.1.1 Use of badges. During the experimental period, a total of 52 badges were awarded. Each student received at least one badge with the 2 highest achievers receiving nine badges and 86% of the students gaining at least 3 badges. Figure 2 shows the number of badges completed for each category, with “First Timer” and “5+ Warm-ups in 1 Week” leading, followed by “Persistent Worker” and “Most Warm-Ups in 2 Weeks”. Notably, the “Persistent Worker” badge was awarded to over 70% of the students. The data also showed that during the spring break period, the experimental group continued to practice (take warm-up challenges). After the last day of instruction, additional warm-up challenges were completed before the final examination for the course.

4.1.2 Taking Practice quizzes. The amount and frequency of taking practice quizzes (warm-up challenges) measure most reliably the level of engagement of students within the gamified course since this activity is not required and doesn’t count towards the course grade. We extracted from the OneUp system logs the number of taken warm-up challenges for both the control and the experimental group by students and by dates. The warm-up challenges taken by the control group (for 34 days) were 64, while those taken from the experimental group (for 53 days) were 448. Since we wanted to

compare these numbers of taken challenges, we needed to modify the data appropriately to accommodate the difference in the periods of usage of the OneUp system for the two groups. Thus, we multiplied the number of taken challenges for the control group by 1.56, and after processing the data, we found that the average number of warm-up challenges for the control group was 7.1071, while the average number of challenges for the experimental group was 37.3333. The Welch Two Sample t-test ($t = -3.364$, $p\text{-value} = 0.005505$) shows that the difference is statistically significant. This signals that after the gamification intervention, students’ practicing has intensified significantly.

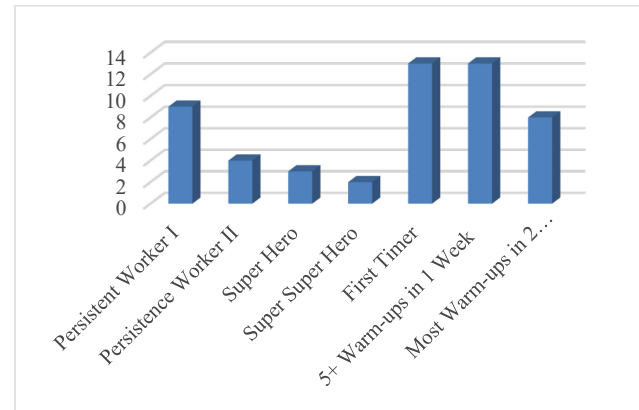


Figure 2: Badges earned by category

The results in this section positively confirm that badges encourage more active engagement in out-of-class practicing (RQ1).

4.2 Student Performance

To investigate the potential of badges for improving students’ academic performance, we compared the current semester scores on the number conversion quiz, the final exam scores, and final course grades to the prior semester. The final examination for the course is comprehensive. The reason for choosing the quiz on Number Base Conversions was that the students scored poorly on it during the previous semesters. Thus, we compared the number base conversion quiz scores and the final examination scores from this study to the Fall 2019 semester.

Table 2. Student Academic Performance (Means)

Semester	Number of Participants	Number Base Conv. Quiz	Final Exam	Final Grade
Fall 2019	11	61.82	80.64	3.09
Spring 2020	13	85.00	86.38	3.77

Considering the demographics characteristics of the two groups, the students in the control group were 75% males and 25% females; 58% African-American, 25% Hispanics, and 17% Whites. The experimental group students were 85% males and 15% females,

90% African-American, and 10% Whites. As Table 2 shows, all mean scores - on the number base conversion quiz, final examination, and final grade are higher for the experimental group than the historical data, with a substantial difference in the score on the number base conversion quiz. An independent-samples t-test was also conducted to compare the data for the number base conversion quiz, the final exam, and the final grade for the experimental and comparison groups. The results of the t-test yielded no significant difference in the final exam and final grade. However, there was a considerable difference in the number base conversion quiz scores for Fall 2019 ($M=61.82$, $SD=9.42$) and Spring 2020 ($M=85.00$, $SD=5.31$) based on $t(22)=3.327$, $p=0.036$.

The results mentioned above show that there is a significant difference between the students' academic performance of those who used the gamification platform and those in the previous semester. This confirms that gamifying voluntary online practicing with badges improves student academic performance (RQ2).

4.3 Motivational Survey

The motivational survey was given at the beginning of the semester (around the 3rd week) and again at the end of the semester. The survey questions are given in Table 3.

Table 3. Basic Psychological Needs Satisfaction Scale

Scale	Items
Autonomy	- I feel that I can make a lot of inputs to deciding how my classwork gets done. - * I feel pressured in this class. - I am free to express my ideas and opinions in this class. - *When I am in this class, I have to do what I am told. - My feelings are taken into consideration in this class. - I feel like I can pretty much be myself in this class. - *There is not much opportunity for me to decide for myself how to go about my work in this class.
Competence	- *I do not feel very competent when I am in this class. - People in this class tell me I am good at what I do. - I have been able to learn interesting new skills in this class. - Most days I feel a sense of accomplishment in this class. - *In this class I do not get much of a chance to show how capable I am. - *When I am in this class I often do not feel very capable.
Relatedness	- I really like the people I'm in this class with. - I get along with people in this class. - *I pretty much keep to myself when I am in this class. - I consider the people in this class to be my friends. - People in this class care about me. - *There aren't many people in this class that I am close to. - *The people in this class do not seem to like me much. - People in this class are pretty friendly towards me.

* = Reverse coded item

A paired-samples t-test was conducted to answer research question RQ3 and to explore other potential pre- to post-test differences in participants' intrinsic motivation. The original pre-

test dataset included 14 participants, and the original post-test dataset included 12 participants. Because pairs must be matched for the paired samples t-test, participants who completed the pre-test during the first third of the course but not the post-test and 2 participants who completed the post-test during the final third of the course but not the pre-test were removed before running the analyses. Analyses were ran on the remaining matched pairs. The overwhelming majority of students were men (i.e., 90%). Participants demonstrated no significant pre- ($M = 4.6$, $SD = .70$) to post-test ($M = 4.58$, $SD = .90$) effect for Autonomy, $t(9) = .051$, $p = .96$, no significant pre- ($M = 4.45$, $SD = .81$) to post-test ($M = 4.58$, $SD = .45$) effect for Competence, $t(9) = -.44$, $p = .67$, and no significant pre- ($M = 4.45$, $SD = .81$) to post-test ($M = 4.58$, $SD = .45$) effect for Relatedness, $t(9) = .46$, $p = .65$.

Although there were no significant pre- to post-test effects for the variables related to intrinsic motivation, the significant differences between quiz scores for the comparison group ($M = 61.82$, $SD = 31.25$) and the experimental group ($M = 85.00$, $SD = 19.15$) suggests that students are significantly engaged in the process of working toward increasing their quiz performance $t(22) = -2.23$, $p = .04$. This is a particularly exciting finding. Previous research suggests that certain forms of extrinsic motivation become intrinsic motivation depending upon factors like students' expectancy values (e.g., the value they place on the task at hand). Based on Expectancy-value theory [28], expectancies for success, the subjective value placed on the task at hand, and other achievement factors work in tandem to impact motivation. If a student expects to perform well on a task and also highly values that task, then the student will be more motivated to complete the task at hand successfully. If a student expects to perform well but holds a low value for the task at hand, then the student will not be motivated.

Conversely, if a student has low expectations for a task but values the task highly, they will be less motivated. Both values and expectations need to line up for students' motivation to be positively impacted. Understandably, a student's value for improved quiz performance is clear, and their increased pre- to post-test performance in that domain lends credence to the notion that tasks with increased subjective value will result in more intrinsically motivated performance gains.

These results indicate no significant pre- to post-test differences in intrinsic motivation as measured by a modified Basic Psychological Needs Satisfaction for work scale; however, internalization of motivation was apparent as referenced by a significant increase in engagement for improving quiz performance between our comparison and experimental groups (RQ3).

5 Conclusion

The goal of this experimental study was to find out the effect of awarding badges on learning activities, beyond the scheduled class meetings, on student engagement and motivation. We used the OneUp gamification platform to gamify with badges an Introduction to Computer Software Systems course. The study's results substantiated our hypothesis that awarding badges would increase student interaction with online course activities. This

gamification feature stimulated more student engagement with course out-of-class work. The use of the OneUp gamification platform for online practice also resulted in improved academic performance in the course. The early adoption of badges was often based on the assumption that they are ‘fun’ and intrinsically motivating. However, we could not positively confirm an increase of student intrinsic motivation as an outcome of this study. This led us to conclude that extrinsic motivation led students to complete online activities to gain badges. While these results increase the body of literature on the effects of badges on student learning, we are unable to generalize them to the student population of interest as the study is limited by the small sample sizes of the comparison groups.

Overall, the results from the study support the usefulness of using badges to gamify online activities. They suggest that while badges do not impact intrinsic motivation they can boost students engagement and performance. They also highlight a need for future studies that parse out the direct effects of internal motivation on performance and achievement and illuminate a need for empirical research exploring how external tools of engagement (e.g., badges and leaderboards) might promote internalization of motivation and lasting impact.

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