Exploring the Effect of Virtual Currency on Learners Engagement

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***Abstract*—There has been an increasing effort to make activities that are not inherently interesting for all learners more attractive through gamification. Although the research on the effectiveness of educational gamification has been growing, the effects of some gamification elements on learners' motivation and engagement are not well understood. In response to this gap, in this paper we describe an experience of gamifying out-of-class practicing with Virtual Currency (VC) in a Computer Networking course. The results of our study show that the VC-based gamification (without interactions with any other gamification elements) had a positive impact on student engagement compared to non-gamified online practicing. The learners' VC earning and spending behaviors indicate also that Virtual Currency brings additional objectives for students to strive for, besides grades.**

***Keywords*— active learning, gamification, virtual currency, intrinsic motivation**

I. Introduction

Lack of engagement is a recurring problem in education [1]. Student engagement refers to the active participation of students in various activities that lead to quality learning [2]. Gamification is an approach to engage learners which is gaining popularity and evolving. A boost for this trend was provided by early studies showing that gamification was effective in promoting students' engagement in some educational contexts [3].

According to Ortega-Arranz et al [4], there are three types of engagement: cognitive, emotional and behavioral. In this paper, we focus on behavioral engagement by way of the observable behaviors that represent learners' progress and learning through practicing. Practicing, although a critical learning activity, has been mostly outside of the focus of educational gamification research. Learning STEM topics is typically an incremental process in which the introduction of a new concept should be accompanied by exercises to assimilate information [5]. The use of practicing tools enables learners to have immediate feedback outside the classroom, and thus promotes self-learning through practice anytime and anywhere. However, providing students with such tools does not solve the common lack of interest in practicing [5], since typically only highly motivated learners will take the initiative to practice. Therefore, this is one area that needs motivational support to increase learners' engagement.

While a number of studies have empirically tested the positive effects of reward strategies on behavioral engagement in different educational environments (e.g. [6]), there is a relative dearth of empirical evidence on the effectiveness of Virtual Currency (VC). This raises the question, "Can VC positively impact student engagement in practicing?" Although there have been several efforts to analyze the effects of VC on learning, the research so far has reported anecdotal or inconclusive results and needs to be complemented with new empirical studies. In this regard, analyzing learners' behavior and perceptions toward VC, and their relation to student engagement is important as it may help understand the effects and consequences of using VC in practicing environments. Attending to this gap, we are conducting a longitudinal study focused on learners' behaviors toward using VC and exploring the relation of such behaviors with learner engagement in the online gamified practicing platform OneUp [7]. In Spring 2020 we studied the effect of Virtual Currency on practicing in a Discrete Math course from a motivational perspective [8]. The present paper investigates the use of VC in a Computer Networking course. It focuses on student engagement with OneUp over the duration of the course and relates the observable practicing behavior to learners' engagement. The engagement effect of VC is manifested in both earning-related and spending-related actions. To address our study objectives from both perspectives, we examined learners' behaviors toward earning VC, spending VC and their relationship with their behavioral engagement. Our first research question (RQ1) tests the hypothesis that gamifying online practicing with VC would have a positive effect on learners' engagement. An additional goal (RQ2) was to confirm the results of the previous study, which concluded that VC actually did not change the intrinsic motivation of the students to practice.

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II. RELATED WORK

A common objective of using gamification in an educational context is to benefit learning by increasing engagement in learning activities [9]. Several past studies indicate that incorporating game elements in learning activities can be effective for increasing user engagement, but they also caution that different game elements may have different impacts [10]. Compared to points, badges, leaderboards and levels, virtual currency (VC) has been examined less often, especially in gamified academic courses [3].

O'Donovan and colleagues are among the first to use VC, together with a storyline, badges and a leaderboard, in a university-level gamified course [11]. They reported that the in-game currency was very well received by the students, but its effect was not statistically confirmed. In [12] Lopes reports using VC (BitPoints) together with levels and stars in a gamified Computer Science course. Students earn BitPoints for overcoming obstacles associated with completing practical exercises and can spend them for purchasing tools or information for use in solving other tasks. Explicit evaluation of the VC impact on student learning has not been performed. Virtual coins have been used in gamifying a Software Testing course, but the results of the study were inconclusive [13]. VC (eCoins), was used in a Statistics course [14] in combination with levels, progress feedback, time pressure and pathways. The awarded eCoins depended on the experience points and the task difficulty and could be used for removing parts of a question or an entire question from a test set. Munday [15] describes an application of Duolingo [16] in a college-level second language courses, where the Duolingo VC (lingots) were used together with points, streaks and crowns. Lingots were awarded for learning skills, going up levels, and long streaks and could be used to unlock bonus skills, a timed-practice option, a progress quiz or power-ups.

A major limitation of the works above is that they report either preliminary studies with inconclusive results or informal observations without an explicit evaluation of the VC impact on student learning.

Among the formal empirical studies, Snow et al [17] studied how VC impacts in-system performance and learning outcomes in the context of an intelligent tutoring system (ITS). Students earn iBucks through their interactions with the ITS and use them to unlock game-based features. The study revealed that students who were more interested in spending their earned currency did not perform well and also had lower scores on the learned skills. However, gamifying an ITS is very different from gamifying an academic course. Another formal study on the effect of VC (used together with badges, leaderboard, and progress feedback) on learners' engagement, performance and attitude was conducted in a gamified Data Structures course [18]. Students earned VC based on the amount, level of difficulty, and correctness of completed practice quizzes and spent it on purchasing deadline extensions, homework resubmission, and other course-related 'benefits.' The study results confirmed that the targeted engagement effect of the gamification used was achieved but without isolating the impact of VC.

To address the lack of formal empirical studies assessing the specific impact of VC on student learning, we are conducting a longitudinal study, including studies in various academic courses with different student populations. Previously, we conducted a study on VC in a gamified Discrete Mathematics course, with a focus on its motivational effects [8]. This paper presents a study in a different context (subject and student population) with a focus on learners' engagement as a measurable motivational outcome of gamifying a specific learning activity with virtual currency.

III. CASE STUDY

A. Course Description

The study was conducted in a junior level Computer Networking course, which includes both theory and hands-on practice. The course covers various computer networking concepts, such as TCP/IP and OSI layering models, topologies, protocols and addressing schemes. For the hands-on practices, students use both a simulator via Cisco Packet Tracer and actual networking equipment via Netlab. For the study, the students used the gamification platform OneUp for out-of-class practicing. A total of 66 practice quizzes (warm-up challenges) were set up, including 122 multiple-choice questions, 54 true-false questions, and 30 dynamic problems. Dynamic problems are computer-generated, based on random seeds, so each invocation of a problem generates new values for the input parameters. In this course they were primarily used for number conversion and IP address calculations.

B. Course Gamification

The OneUp platform, used to gamify the course, provides instructors with a flexible VC implementation. Instructors decide what activity earns VC and what options students have to spend it. The platform provides many built-in automatic rules and instructors also have the option of defining manual rules for activities that cannot be tracked by the system (e.g. a student showing up for a review session). Similarly, the instructor has complete control over the ways in which a student can redeem VC. Popular examples include allowing an extension on a due date, dropping the lowest quiz or homework score, etc. To gamify the course, we created rules for earning and spending VC (course bucks). When a student satisfies an earning rule, the corresponding number of course bucks is credited to the student. The categories of the created VC earning rules are shown in Table 1 and those of the spending rules – in Table 2.

TABLE I. VIRTUAL CURRENCY EARNING RULE CATEGORIES

VC	Earning Rules Categories
2	Taking the very first warm-up challenge
1	Taking a new warm-up challenge with a score>=80%
1	Completing the first N^a distinct warm-up challenges
1	Taking N^b distinct warm-ups for a topic scoring >=90%
5	Class event participation

[a] N = 10, 25, 35, 45, 60 [b] N = 4, 6, 8, 12, 13, 14

TABLE II. VIRTUAL CURRENCY SPENDING RULE CATEGORIES

VC	Spending Rules Categories
5	Get a 3-day extension of an assignment
10	Drop the lowest lab assignment score

25	Drop the lowest quiz score
6/4	Skip one initial post/peer response in a class discussion

C. *Research Methods*

The study was conducted in two consecutive 8-week online classes in fall 2020: a control group (28 students) and an experimental group (21 students). The students signed up for one of the two classes based on their own schedule. In the experimental group, 86% of the students were males and 14% were females. Participant demographics showed that over half of the participants were European American/White (i.e., 61.1%), whereas 11.1% were African American/Black, 11.1% were Mexican/Hispanic/Latin American, 5.6% were Asian American, and 11.1% indicated "other" race. Age demographics showed that 16.7% of participants fell into the 18 – 25 age range, 38.9% into the 26 – 35 age range, 27.8% into the 36 – 45 age range, and 16.7% of participants were 46 years of age or older.

Though taught by different instructors, both groups had the exact same course content, assignments and tests. In both groups students were encouraged to practice in OneUp, but the gamification (i.e. VC) was turned off for the control group, while it was made available for the experimental group.

To answer the research questions, we used data from various sources: the OneUp system log (for tracking student interaction with the system), final course grades of the control and experimental groups and two surveys with the experimental group, a student satisfaction survey and a motivational survey. The motivational survey was a modified version of the Basic Psychological Needs Satisfaction Scale – Work Domain [19], which was slightly modified to represent work being done in the classroom as opposed to the career setting.

IV. RESULTS

A. *Student Engagement*

To evaluate students' engagement in the gamified practicing activity, we extracted data from OneUp's system logs reflecting student interactions with the system.

1) *Using Virtual Currency*

In OneUp, VC earning transactions happen when a VC earning rule defined by the instructor is satisfied for a student. As a result, the student receives the course bucks specified in the rule. During this course, 693 earning transactions were recorded with a total of 806 course bucks earned. The distribution of the transactions by students is shown on Fig. 1. About 30% of the students had between 1 and 10 transactions. These were either for participating in class activities or for taking 2-3 warm-up challenges in the very beginning, apparently out of curiosity to try OneUp. We can see that from the real users of the system, the biggest group (37%) had more than 50 earning transactions each. Fig. 2 shows the distribution of the VC earning transactions by category, i.e., by the defined VC rules. It shows that most of the earning transactions were a result of completing a new warm-up challenge (240) or completing 4 or 5 challenges with 90% or more correct (275). Note that the fact that the most virtual currency was received for achieving a max score of 90% or greater on a warm-up challenge indicates that students keep re-taking some warm-up challenges until they get them correct.

The students could spend their earned virtual currency in the Course Shop. Surprisingly, from the earned 806 course bucks in total, they only spent 405 bucks, which left in student accounts balances totaling to 401 course bucks. Among the reasons for this might be that some students missed opportunities to purchase time-sensitive items in the Course Shop and also the students were told that unspent bucks would be credited to their lowest performed Packet Tracer project. Of all students, 37% did not make any purchase. Most of the remaining students (31%) spent between 21 and 40 course bucks. Fig. 3 shows the distribution of the students' spending transactions by category. It shows that students favored purchasing "Dropping the lowest lab assignment score" (43%), followed by "Dropping the lowest quiz score" (30%), and "Skipping the initial post or a peer response in a discussion" (20%).

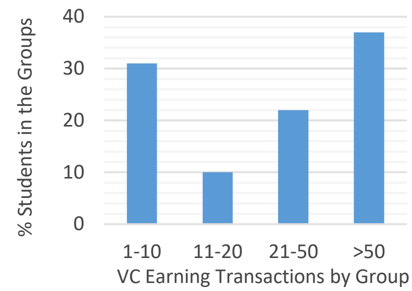

Fig. 1. Completed VC Earning Transactions by Students.

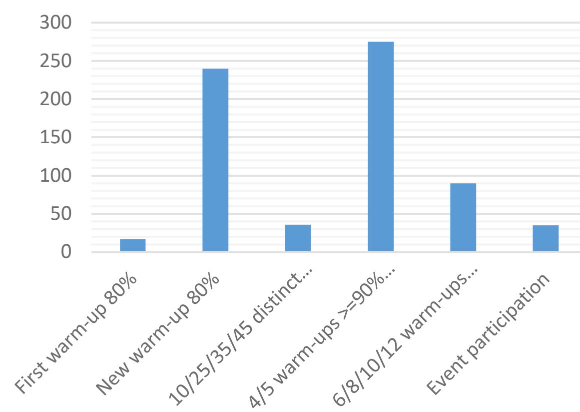

Fig. 2. Completed VC Earning Transactions by Category.

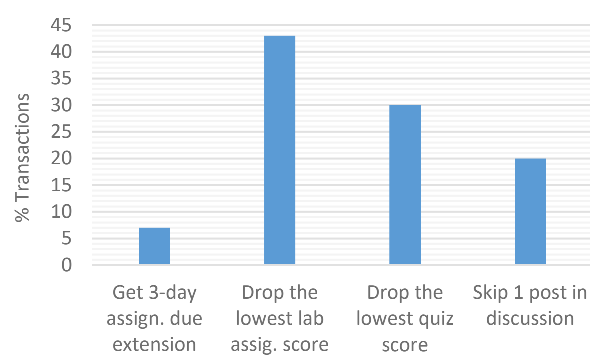

Fig. 3. Percent Spent Transactions by Category.

We also collected the reasons for the spending transactions. We did this automatically: after each purchase in OneUp, the system asked the student to select the reason for it. The results show that the most purchases were done because students worried about their performance in the course (~60%), followed by "I have much VC and would like to spend it" (18%), "I was busy and could benefit from extra time" (5%), and 18% of the students did not answer or selected "Prefer not to say".

2) Taking Warm-up Challenges

Perhaps the best indicator for the student engagement in the out-of-class work is how often and how persistently the students practice, i.e. take warm-up challenges in OneUp. The data we extracted shows that the control group (28 students) took 198 distinct warm-up challenges with a total of 369 attempts, while the experimental group (21 students) took 544 unique warm-up challenges with a total of 1,108 attempts. Fig. 4 shows the percent of students who have taken 1-10, 11-20, 21-30, or over 31 warm-up challenges for both groups.

As can be seen, the number of students who haven't taken any warm-up challenges in the control group (68%) were three and a half times more than in the experimental group (19%). From those in the control group who have practiced in OneUp, 11% took from 1 to 10, 11% from 11 to 20, none from 21 to 30, and only 10% took more than 30 unique challenges. In contrast, 19% of the students in the experimental group took between 21 and 30, and 33% took more than 30 unique warm-up challenges. The latter is 23% more than for the control group.

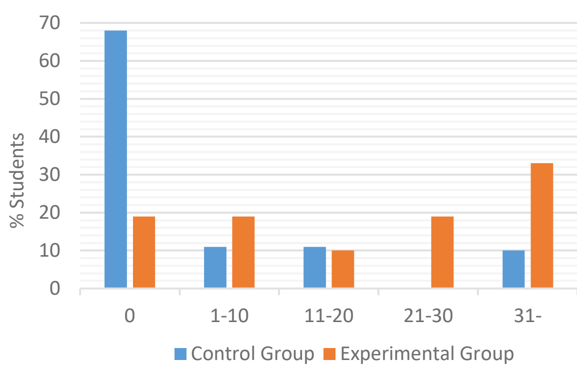

Fig. 4. Distinct warm-up challenges taken.

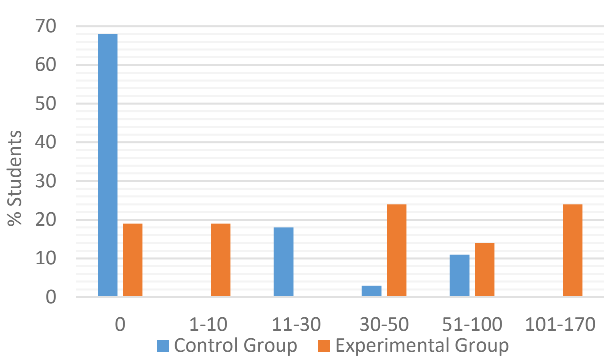

Fig. 5. Warm-up challenges attempts.

The difference in the numbers of warm-up attempts is even more pronounced (see Fig. 5): the majority of the students from the control group who have taken warm-ups have between 11 and 30 attempts and none of them have taken more than 92, while 62% of the experimental group students have taken between 30 and 170, with 24% more than 100 warm-ups. The average number of warm-up challenge attempts for the control group was 11.9032, while the average number of challenges for the experimental group was 46.1666. The Welch Two Sample t-test ($t = -3.0212$, $df = 31.77$, p-value $= 0.004941$) shows that the difference is statistically significant. These results answer RQ1 by confirming our hypothesis that after the gamification intervention, students' practicing has intensified significantly.

3) Student Feedback

At the end of the semester, we conducted a survey to gather feedback about students' perception of usefulness of the system. The students had to answer the questions "How did you like OneUp? Did it help you learn the class material?". Eighteen students completed the survey with 3 answering that they didn't use OneUp. All others stated that they liked the system, with 7 saying they liked it a lot. The answers included "It was nice knowing I was able to do extra credit. Took stress off from the class and helped.", "This was a great incentive to help students practice questions. I learned a lot from taking these as well. Liked it a lot.", "I enjoyed earning and spending VCs.", "It gave me a chance to make up for a lot of failures.", etc.

B. Student Performance

To see if virtual currency had any effect on student performance, we compared the final grades obtained by the students in both control and experimental groups.

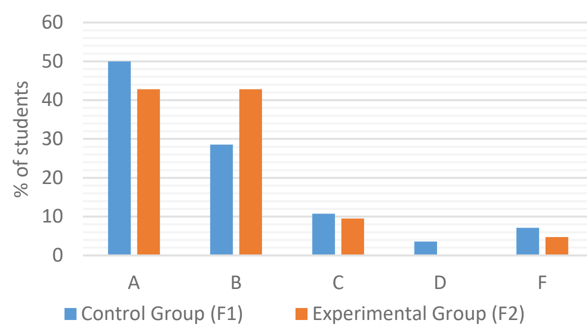

Fig. 6. Final Grades of the Control Group and the Experimental Group

Fig. 6 depicts the final grades of students in the control group and the experimental group. Specifically, it shows two improvements that the experimental group has over the control group. First, the total percentages for the students who obtained A and B combined is 86% in the experimental group vs. 79% in the control group. Second, the total percentages for the students who obtained D and F combined is 5% in the experimental group vs. 11% in the control group. That is, a higher percentage of students obtained A and B, and there was no Ds and fewer Fs in the experimental group than in the control group. The latter is important since our main concern is reducing course failure.

C. Motivational Survey

One of the goals of this study (RQ2) was to test a previous finding that using VC did not change the intrinsic motivation of the students to practice. To address this, we used paired-samples t-tests and a stepwise regression. Self-Determination Theory [20] posits that satisfaction in all three domains of psychological need (i.e., autonomy, competence, and relatedness) is related to increased intrinsic motivation. So, the first set of analyses centered on exploring pre- to post-test differences between the three factors, autonomy, competence, and relatedness, as measured by the Basic Psychological Needs scale [19].

Eighteen pairs of pre- to post-test data were matched for the current analyses. A paired-samples t-test was conducted to determine if there were any significant pre- to post-test differences in participants' autonomy, competence, or relatedness. Participants demonstrated no significant pre- ($M = 4.6$, $SD = .79$) to post-test ($M = 4.85$, $SD = .87$) effect for Autonomy, $t(17) = -1.67$, $p = .11$), no significant pre- ($M = 4.99$, $SD = .77$) to post-test ($M = 5.14$, $SD = 1.19$) effect for Competence, $t(17) = 1.25$, $p = .48$), and no significant pre- ($M = 4.22$, $SD = .72$) to post-test ($M = 4.3$, $SD = 1.20$) effect for Relatedness, $t(17) = -.36$, $p = .72$. This confirms our previous finding that using VC did not have significant effects on the intrinsic motivation of the students.

We also explored relationships between participants' final course grades and intrinsic motivation as measured by three factors of the Intrinsic Motivation Inventory - Value/Usefulness, Interest/Enjoyment, and Perceived Choice [20]. We did an exploratory stepwise regression analysis to determine which of these factors most strongly predicted participants' final course grades. The predictor variables for this regression model were Value/Usefulness, Interest/Enjoyment, and Perceived Choice and the outcome variable was the participant's final grade. The results showed that the zero-order correlation with Grade of Value/Usefulness was 0.53, of Interest/Enjoyment was 0.54, and of Perceived Choice was 0.33. Since no significant associations between students' final grades and the three predictor variables were found, the proposed regression model was non-significant.

V. CONCLUSION

In this paper we have taken a subsequent step in a longitudinal study aimed at characterizing the game element virtual currency as a motivational mechanism in out-of-class practicing. The paper provides empirical support on the potentials of VC-based gamification to increase student engagement in out-of-class activities. The results show that VC had a measurable impact on learners' engagement. The study also examined whether there were any significant pre- to post-test differences in learners' autonomy, competence, or relatedness. It revealed that gamified practicing did not increase students' intrinsic motivation and thus confirmed the results published in [8]. We believe that VC-based gamification has a motivational role in out-of-class practicing that has to be further explored and evaluated. In the next iterations with virtual currency we are planning to extend the diversification of metrics to further assess the performance and motivational drives of the learners.

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