Exploring the Impact of Non-conventional Gamification Elements on Student Motivation and Engagement

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Abstract— **This Full Paper in the Research-to-Practice track builds on research in gamification of instruction. A primary objective of gamifying learning is to encourage and sustain students' engagement in activities by making them more game-like. However, it is still unclear what structures borrowed from games could afford such a "game-like" experience and in what contexts. Embedding classmates' duels in learning settings seems a promising gamification strategy for exploration due to its potential of increasing motivation and engagement through a "game-like" experience. Similar effects are expected from using virtual currency, another design element popular in video games. Accordingly, the goal of this study is to empirically investigate whether the incorporation of dueling leads to increased interest in out-of-class practicing. In addition, we were interested in investigating to what an extent adding virtual currency can boost students' interest in dueling. An introductory class in Python programming served as the experimental environment. Unlike most studies in which the control group works in a non-gamified condition and the experimental group works in a gamified condition, this experiment uses a different approach. We investigated the impact on learners' engagement of adding duels to an ongoing gamified activity. Engagement indicators were measured and logged throughout the semester while student motivation was examined through surveys. The opportunity to challenge classmates appeared after the first exam (around one-third of the semester) and continued for the remaining two thirds of the class time. Thus, the same students in the new condition served as the experimental group. After the third exam, we added virtual currency. Students were able to earn virtual currency by issuing and responding to duel requests as well as by doing extra practice. This had a noticeable effect on the use of dueling. The empirical results of the study show that overall, for this group of students, adding duels alone had no positive effect on students' engagement with the gamified practicing system. However, evidence from the survey suggests that the studied combination of gamification elements (points, badges, leaderboard, avatars, duels, and virtual currency) did increase student intrinsic motivation.**

Keywords—engagement, motivation, gamification, case study

I. INTRODUCTION

Gamification in learning uses elements drawn from game design to make learning activities more motivating and engaging and to improve learning outcomes [1, 2]. Despite the wide application of game elements in a variety of learning domains, the underlying mechanisms by which these elements work are not yet understood well [3, 4]. In particular, it still remains unclear as to what kind of gamification features may affect which specific motivation and behavior and of which learners. This gap is partially a consequence of the fact that the majority of the studies focus on a small subset of game elements, such as points, badges, and leaderboards (the so called points, badges and leaderboards triad) [1, 5], although Tondello et al [6] identified 49 different game design elements in their study. As a result, the effect of game elements beyond this triad on learning experiences were left underexplored. This gap was confirmed by a recent meta-analysis [7] concluding that there is much more potential in gamification beyond the prevalent points, badges and leaderboards found in most applications.

Gamification builds on an individual's instinct to play, with the idea to promote desired behaviors and to change attitudes. Specifically, a common intent in gamifying learning is to encourage and sustain students' engagement in activities by making them more gameful, i.e., by enhancing their intrinsic value. In this aspect, the concept of gamefulness refers to an individual's experience typical for games that is experienced outside of games [8]. However, it is still not clear whether such gameful experience is transferable into learning environments

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by transferring relevant game structures, nor what game structures afford "game-like" experiences. In this context, embedding *duels* in learning settings seems a promising gamification strategy for exploration and specifically for its potential to increase motivation and engagement of learners through "game-like" experience. In the context of a gamified learning environment where students can take practice quizzes (referred to as challenges), duels can take a form of competition between students to solve a particular challenge correctly. Notably, little research has been done on how dueling impacts learning through gameful experiences. Therefore, the main goal of this study, which is part of a sequence of empirical studies on the effect of gamifying learning activities, is to empirically investigate whether the incorporation of dueling leads to the emergence of intrinsic interest in practicing with the course gamification platform OneUp [9] and if this interest may be further enhanced.

Virtual currency (VC) is another game element that has not been frequently used in educational gamification [10]. VC can serve as a continuous and immediate feedback for students' participation in a course, as well as a reward that can be spent to purchase certain items or benefits. VC has not been in the center of empirical research, but very recent studies on its impact in gamified learning that we conducted showed that virtual currency alone did increase student engagement, although there was not sufficient evidence for increased intrinsic motivation [10, 11]. Therefore, it is an interesting question to study the effect of VC when combined with other game elements. In addition, we were interested to investigate to what an extent VC can boost students' interest in dueling.

The present study responds to these gaps and questions by investigating the relationships between five gamification elements (points, badges, leaderboard, avatars, classmates' challenging/dueling, and virtual currency) and the two types of learners' motivation (intrinsic and extrinsic) and relate the results to learners' OneUp usage and course engagement.

The majority of gamification studies deploy a dichotomous design (i.e. gamified versus non-gamified). In this paper, we present a study exploring the influence of adding new game elements to an ongoing gamified activity on motivation and engagement. The effects of points, badges, and leaderboards has been studied in a variety of learning contexts [12]. The points, badges and leaderboards triad dominates the landscape of gamification since they can be more easily added as an additional layer to an existing learning system compared to other more complex game elements. Still there are many more game elements available with potential to motivate and engage learners [6, 12]. Using OneUp [9], which conveniently allows increasing the number of game elements used, the starting point of our study was a course gamified with points, badges, leaderboard, and avatars. Avatars were added to points, badges and leaderboards to provide virtual representations of participating learners and give sense of personal meaning for the gamification, as well as anonymity. In this context, an interesting research question is how much incremental (psychological/behavioral) value can a new game element add on top of points, badges, leaderboards, and avatars and, more generally, on top of an ongoing gamified activity. To empirically address this question, a Programming For All course, more specifically, its out-of-class practicing, was gamified using points, badges, leaderboard, and avatars in the first third of the Fall 2020 semester. In the second third of the semester, duels were added on top of the existing gamification. In the last part of the semester virtual currency was added. Engagement indicators were measured and logged throughout the semester. The intention with deliberately incrementing points, badges, leaderboard, and avatars in a learning setting with new game features was to gain an insight into an unexplored practical challenge: does adding duels and virtual currency to a course gamified with a somewhat "standard" set of game elements results in enhanced motivation and engagement for the involved learners. Thus, we addressed in the study the following unexplored by now research questions:

RQ1: Does challenging classmates (duels) improve student engagement in out-of-class practicing?

RQ2: Does combining of duels with virtual currency lead to increased number of performed duels?

RQ3: Does the studied combination of gamification elements (points, badges, leaderboard, avatars, duels, and virtual currency) improve student intrinsic motivation (compared to a condition with no gamification elements)?

It is important to stress that these questions were explored in the context of using the studied game elements in a voluntary, out-of-class learning activity, which is not graded and where sustaining engagement is challenging. The results may be very different in another context.

II. Related Works

Education is an increasingly common application area for gamification [13, 14]. This approach employs elements that are typically seen in games in educational contexts [1, 8]. It has been driven by the potential for gamification to address challenges around student motivation and to improve learning [15, 16]. Koivisto and Hamari [12] examined 514 research papers on gamification and found that most of the research was conducted in educational contexts. In computing education, specifically, the use of gamification is also growing [17]. As a result, gamification has been used in various activities with the intention to promote positive student behaviors [18,19,20,21, 22,23,24]. Many game elements have been identified to be relevant to gamification [6, 12]. The combination of points, badges, and leaderboards tends to be the most commonly used subset of game elements [1,25,26]. In addition to the ease of their implementation, a possible explanation for the popularity of this triad of game elements is that they parallel in gamification terms the classroom assessment model [1].

However, along with the many studies reporting increased student motivation and engagement [19,20,21,22], there are some which indicate that implementing the points, badges and leaderboards triad may not lead to increased motivation or behavioral changes in every condition. For example, Hanus and Fox [27] compared the satisfaction and performance of students in a gamified course, featuring leaderboards and badges, with students in an equivalent non-gamified course. Students in the gamified course reported lower levels of satisfaction and exhibited lower motivation and course performance. Similarly, the results of Fitz-Walter et al. [28] show that even though their gamified application was perceived as motivating and enjoyable

by the participants, it did not have any significant effects on individuals' behavior, compared to the non-gamified application.

The theoretically based gamification research typically refers to Self-Determination Theory [40] with a focus on motivational affordances promoting autonomy, competence and relatedness. However, learners are not always intrinsically motivated to learn. Their view of gamified learning activities is colored by the perceived value (usefulness and interestingness) experience while learning [4]. Accordingly, in this experiment we are exploring whether enhancing the gamefulness of the learning activity (by incorporating duels and avatars) and by increasing the perceived usefulness (by incorporating VC) will strengthen the learners engagement.

Avatars are frequently employed as a user interface element for improving user experience [29]. In gamification, avatars are commonly used visual representations of users within the gamification environment [30]. In addition to introducing some level of personalization, they offer playful anonymity.

Duels are featured in a number of video games [31]. Competition with other players or with the game itself is one of the basic elements of videogames, but the fine balance between increased mental effort and potential motivational benefits is not well understood [32]. Computing education is the area where dueling games were most studied. More recently, duels (where a learner can challenge other learners to answer a round of 5 questions) were studied as part of a learning game incorporating a number of game elements. The goal was to investigate how two different types of students (learners and gamers) utilize the different game elements incorporated in the game [33]. The authors conclude that the learners ignore duels while they were appreciated by gamers. To the best of our knowledge duels have not been studied as a game element for gamifying voluntary, out-of-class learning activities. This gap motivated the study reported here. Being one of the most exploited features in games, it is expected that duels can afford gameful experience that can increase the intrinsic interest to the gamified activity.

Virtual currency has been used as a gamification element in several gamified learning environments with the purpose of improving learners' engagement. These include gamified courses in statistics [34], second language [35], discrete mathematics [10], and high school practicing [36], with the majority of reported gamified learning activities being in computing disciplines, such as computer games development [37], introductory computer science [38], software testing [39], data structures [21], and computer networking [11]. While empirical research assumes examining empirical data with statistical methods, most of the above studies [34,35,37,38,39] report evidence based on observed results with subjective assessments and without adequate empirical evaluations. As a sign of an emerging trend, four empirical studies [10,11,21,36] examined the effect of virtual currency on learning-related outcomes based on validated and established methods. Two of the experiments studied the effects of VC in gamified discrete mathematics [10] and computer networking [11] courses isolated from other game elements. These works provide empirical support on the potentials of VC-based gamification to increase student motivation [10] and engagement [11] in out-of-class activities. Differing from previous works, the objective of the present study is to shed more light on how much impact VC exerts when added to duels on top of points, badges, leaderboard, and avatars.

III. Case Study

A. Study Description

In the Fall 2020 semester, we incorporated OneUp elements into an introductory course in Python programming at Villanova University. The course is not a requirement for any students. Two options are available for students wishing to learn programming, both of which have grown in popularity in recent years. This course is titled *Programming for All* and is intended to be a comfortable introduction to programming for students who do not wish to take the Java-based course taken by the Computer Science majors. The required textbook is the online book *Rephactor Python*[1]. The book, written by John Lewis and Tom Way, is interactive and provides practice exercises as well as content material. We obtained permission from the authors to use the exercises in OneUp. The students had access to the interactive exercises in the book, and would have found some programming practice elements useful. The content checks in the book were replaced by activity in OneUp. The course topics are typical of an introductory programming course. In order, the material covered includes these: Overview of the python language, comments and style, error types, the standard library, algorithms, variables and constants, print and input, flow of control (if, for, while), range, data types, numeric expressions, import (math, random), Boolean expressions and operators, conditional expressions, membership and identity, comprehensions, a bit of history, hardware, number systems and conversions, a brief introduction to operating systems and networks, break-pass-continue statements, try-except, formatting, strings and lists, functions, classes and objects, inheritance, tuples, dictionaries, data from the web, a little bit of encryption, basic data structures.

The study was conducted in one of the course sections. The 27 students enrolled in the class include 12 women and 15 men; 24 of the students were from the School of Business, 2 from Arts majors, and one from the Sciences. Although the course is an introduction to programming, 10 of the students were sophomores, 15 were juniors and 2 were seniors. Most of the students (25 of the 27) agreed to participate in this research study. The majority had no prior programming experience though a few had some exposure in high school.

The course naturally progressed in complexity during the semester. However, for students with no programming experience, the initial exposure to programming is as daunting as later material. The later material is more advanced, but the students have gotten past their initial difficulties with syntax and with using the programming environment, executing and debugging code. Thus, the level of difficulty was fairly consistent throughout the semester. This is illustrated by the consistency of exam scores. The mean score on exam 1 was 90.2 and on exam 2 was 91. The average score dropped a bit to 87.26

[1] https://rephactor.com/#!/

on the final exam, which covered the full semester's material. The maximum score on all exams was 100.

Following the goals of the study, the experiment included three conditions, in which the students used progressively the following game elements:

Condition 1: points, badges, leaderboard, and avatars.
Condition 2: classmate challenges (added to Condition 1).
Condition 3: virtual currency (added to Condition 2 with the primary purpose to make duels more attractive).

The duration period of each of the three conditions was about the same, approximately 30 days (one third of the semester): Condition 1 started in the beginning of the semester; Condition 2 started after Test 1; and Condition 3 started after Test 2 and continued to the Final exam.

As new features of OneUp became available to the students, class time was used to illustrate the resource and how it is used. In addition, a video posted for the class showed a step-by-step process for using the game elements.

B. Course Gamification

The course was gamified by using the OneUp course gamification platform [9]. OneUp supports two types of automatically graded *challenges*: warm-up challenges (for student practice and self-assessment) and serious challenges (graded course quizzes and tests). Each challenge consists of a number of questions. The supported question types include: multiple-choice questions, multiple answer questions, true/false questions, fill-in-the-blank questions, matching questions, Parsons' problems and dynamic problems. Parson's problems ask students to rearrange blocks of scrambled code to construct a program. Dynamic problems are short computer programs, which use a random seed to generate a unique instance of a particular programming or calculating problem and then grade the correctness of the answer submitted for that problem. The platform is course independent, so the instructor is responsible for entering the challenges.

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. The instructor selects and specifies the desired gamification elements in the OneUp Gamification Configuration panel which provides a convenient user interface. The subset chosen for this experiment conforms to the particular research questions of the study.

The gamification of the course consisted of creating warm-up challenges for students practicing and configuring the gamification features in the OneUp platform. A total of 123 practice quizzes, called warm-up challenges in OneUp, were created, including 935 questions of the following formats: true/false (240), Parson's problems (290), multiple choice (323), numerous answers (13), dynamic (2), and matching (67).

With regard to the gamification, we created badges and rules for awarding them. Table I shows some examples. For Condition 2, we enabled the features for challenging classmates that OneUp provides. There are two ways for a student to challenge their classmates in OneUp: duels and call-outs.

TABLE I. EXAMPLE BADGES USED IN THE COURSE

Badge	Earning Rule
	You will get this badge after completing at least 2 warm-up challenge with scores of 90 or higher in one topic.
	You will get this badge after spending at least 10 minutes on warm-up challenges for a topic.
	You will get this badge after spending at least 30 minutes on warm-up challenges for a topic.

In the case of a duel, a student sends a duel invitation to a classmate and OneUp randomly selects a warm-up challenge not previously completed by either of the two students (the duel sender and the duel receiver). Both students solve the challenge and the winner is the student who gets a higher score. In the case of a call-out, when a student completes a warm-up with a high score, they can challenge the whole class or a particular student to "beat" their record. So, OneUp will send the specific problem solved by the challenger to the class (or a specific student) for them to solve. Whoever gets the highest score is the winner.

For Condition 3, we added the possibility for students to earn virtual currency for participating in and winning duels and call-outs. This was done through the gamification configuration settings, as well as by creating VC earning rules. We set the following in the Challenge Classmates' configuration options:

- VC amount rewarded to duel winners: 10 bucks
- VC amount rewarded to duel and call-out participants: 5 course bucks
- Maximum amount of VC allowed for betting: 3 bucks.

In addition to rewarding participation in the classmate challenges, we created VC Earning Rules to award the initiators of duels (10 course bucks) and of call-outs (10 bucks). The students can spend their earned virtual currency in the Course shop, which provides the students with course-related 'goods' specified by the instructor. Table II shows some VC spending opportunities.

TABLE II. COURSE SHOP

Item	VC	Limit
Homework deadline extension	10	2
Add points to quiz	20	1
Drop lowest quiz	10	1
Drop of the lowest homework score	10	1
Add 5 points to final exam	20	1

OneUp has a game engine which supports the awarding of badges and call-outs. When a rule is satisfied, it automatically assigns the corresponding award to the student. The rules are entirely under the control of the instructor. The students see their awarded points, badges, virtual currency, and taken duels

and call-outs, as well as the recently awarded class badges and the class leaderboard on the OneUp entry page for the course (see Fig. 1).

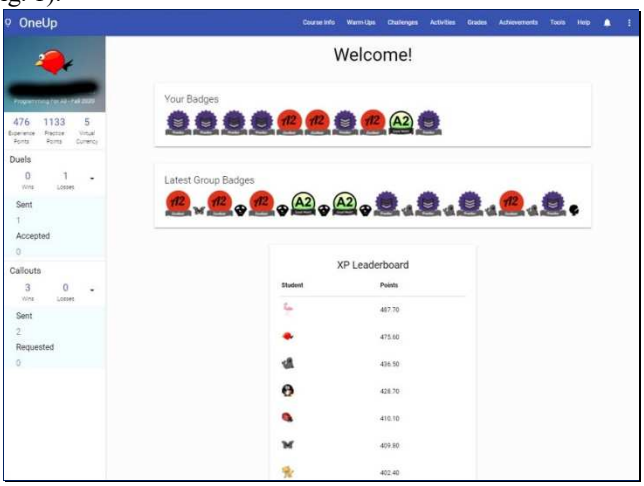

Fig. 1. OneUp course entry page

C. Research Methods

In this study we considered the students in Condition 1 as the control group, while those in Conditions 2 and 3 - the experimental group. This division reflected our goal of investigating what would be the impact of adding the social game elements duels and call-outs to the traditional points, badges, and leaderboard, with the flavor of VC added towards the end. So, the same students comprised the control and the experimental group taught by the same instructor and using OneUp in the same way – for out-of-class learning and practicing. Only the added gamification was different. All participating students signed an Informed Consent Form to participate in the study.

To answer the research questions we extracted data from the OneUp system log and conducted a pre-test and post-test motivational survey. The OneUp log provided data for students' communication with the system, including taken warm-up challenges, duels and call-outs, awarded badges, and earned and spent VC. The motivational survey, derived from Self-Determination Theory (SDT) [40]. Self-Determination Theory posits that three domains of psychological need (i.e., autonomy, competence, and relatedness) are critical for supporting human motivation, self-regulated learning, academic performance, psychological health, and well-being. The current study used a slightly modified version of the 21-item Basic Psychological Needs Satisfaction Scale – Work Domain [41] to assess participants basic needs satisfaction. For this study, we slightly modified the scale 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".

IV. Results

A. Exploration of the System Logs

In this section we report statistics on the use of the game elements badges, classmate challenges, and virtual currency, as well as the use of OneUp for practicing.

1) Use of badges

During the semester, a total of 602 badges were awarded. Each student received at least two badges with the 2 highest achievers receiving 46 and 48 badges, and 71.4% of the students gaining at least 15 badges. Fig. 2 shows the number of badges completed for each category, with "Good start to warm-ups" and "Excellent work!" leading, followed by "Progress with warm-ups", which is given for spending at least 20 minutes practicing for a topic. The badge for sending 10 or more call-outs to the class was given to only one student.

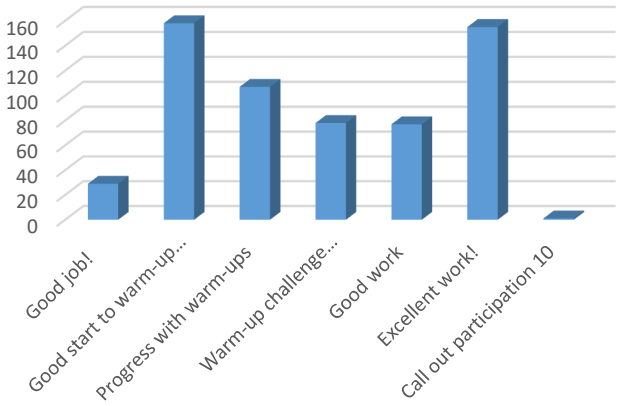

Fig. 2. Earned badges by category.

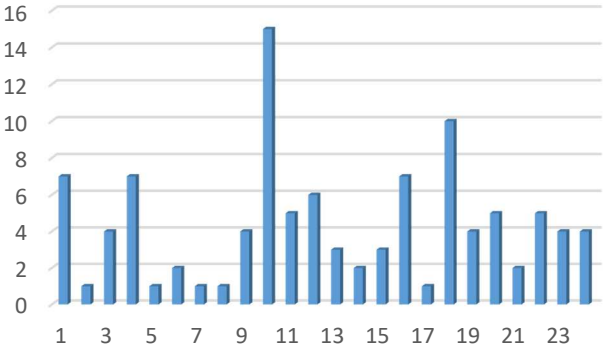

Fig. 3. VC earning transactions by student.

2) Duels and call-outs

Duels and call-outs were enabled for the experimental group, which used OneUp in Condition 2 and Condition 3. In Condition 2, when duels and call-outs were introduced, not even one duel was sent. After introducing virtual currency in Condition 3, 5 duels were sent, 2 of which were accepted and completed. In Condition 3, the duels were changed to give 10 course bucks to the initiators of duels, 5 course bucks to the participating students and 10 course bucks to the winners. The maximum amount allowed for betting in duels was 3 bucks, but none of the students used betting.

Similarly to the duels, no call-outs were issued in Condition 2. However, after the introducing of virtual currency in Condition 3, 19 call-outs were sent by 9 students. Of them, 3 students sent 1 call-out each, 4 students sent 2 call-outs each, and 2 students sent 3 and 5 call-outs correspondingly. Of the

total call-outs sent, 5 were to the whole class and 14 were to individual students. Ten course bucks were set to be awarded to the initiators of call-outs and five to the participants.

Thus, in our experiment, the interest of the students to engage in voluntary duels and call-outs with classmates only appeared after giving them the opportunity to receive virtual currency for participating in and winning these challenges. This was a bit of surprise, since duels offer one truly gameful experience as part of gamified practicing.

The results answer positively Research question RQ2: combining duels with virtual currency did lead to increased number of performed duels and call-outs. This outcome demonstrates that learners had to be incentivized to involve themselves in duels. A possible explanation is that the practicing environment is perceived differently from game environments and practicing challenges do not engender the same experience as the game challenges. In addition, practicing is an individual activity while duels assume interactions involving competition between learners. Thus, it did not result in a collective enthusiasm for a dueling experience.

The answers of the research questions RQ1 and RQ2 contribute new knowledge to what is already known about educational gamification, since the use of voluntary duels/challenging classmates in a gamified practicing environment has not been explored before.

3) Use of virtual currency

Virtual currency was used only in the last third of the semester (Condition 3), aiming to boost student motivation to get engaged in duels and call-outs. For this reason, VC was given mainly for initiating and winning duels and callouts. The instructor set the following configuration options: duel winners get 10 course bucks; duel participants get 5 course bucks, call-out participants get 5 course bucks; the maximum amount of VC allowed for betting is 3 course bucks. In addition, two VC earning rules were created: issuing at least one duel challenge per topic is awarded 10 course bucks and issuing at least one call-out challenge per topic brings 10 course bucks. During this period, 104 earning transactions for initiating or winning callouts were recorded for a total of 640 course bucks.

Fig. 3 shows the distribution of the earning transactions by student. 41% of the students have made between 1 and 3 transactions, 38% of the students had between 4 and 6 transactions, and 21% had more than 6 transactions. As to the transaction categories, 31% of the transactions were from sending callouts and 64% were from performing the same as or better than the sender in the call-out; only 5% were from sending duels.

Considering the spending of the earned virtual currency, students made 87 purchases in the Course Shop (see Table II). Fig. 4 shows the distribution of VC spending transactions by category. It shows that students' favorite was buying 5 extra credit points to be added to the final exam score. The next is dropping the lowest quiz score, followed by dropping the lowest homework score and adding 5 extra credit points to a quiz score.

In order to track the reasons for spending virtual currency, we used a feature in OneUp asking the students why they are buying a particular item in the Course Shop at the time of completing their purchases.

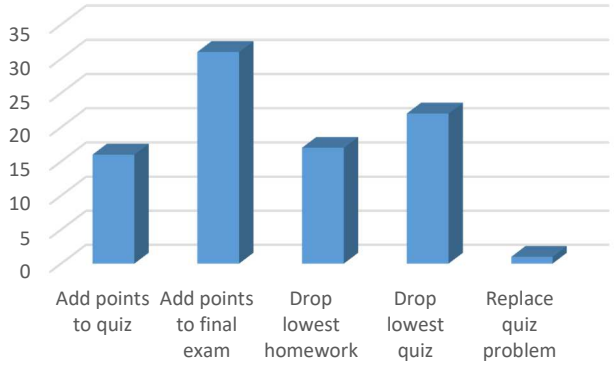

Fig. 4. Spent VC by Category.

The data shows that 29% of the students selected that they did it because they worried about their performance in this course, 52% - because they had a good quantity of VC and wanted to spend some, 3% - because they were busy and could benefit from some extra time, and 16% preferred not to share the reason.

The results showing the effect of adding virtual currency confirmed that the use of VC in this particular context increases student engagement, which is in line with the findings from previous studies.

4) Taking warm-up challenges

During the study, the students took 1,323 unique warm-up challenges with a total of 2,562 attempts. It is worth noting that the warm-up challenges completed between the last day of instruction and the final exam in the course were about 74% of all challenges taken between Test 2 and the final exam.

The distribution of the attempts between the control group (Condition 1) and experimental group (Conditions 2 and 3) is as follows: 1,018 attempts were made by the students in the control group, while 1,544 were made by the students in the experimental group. Note that the numbers of attempts for the experimental group are normalized, since it spanned a twice longer period of time (60 vs. 30 days)

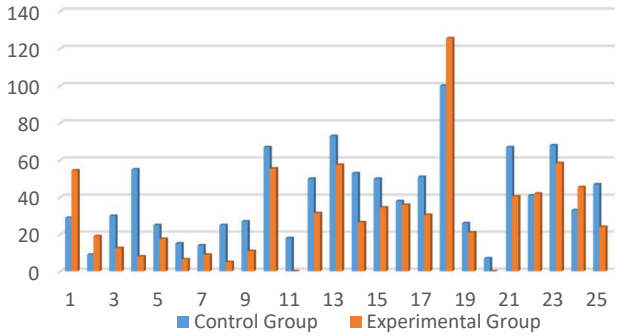

Fig. 5. Warm-up challenges taken by student.

Fig. 5 shows the taken warm-ups by student over the entire course. For each student, the blue bar shows the warm-up attempts made under Condition 1, when only points, badges, and leaderboard were used, and the orange – those made under Conditions 2 and 3, when classmate challenges and virtual currency were added.

The results of the comparison show that the warm-up challenges taken by the experimental group are actually fewer than the warm-up challenges taken by the control group: the average number of taken warm-ups for the control group is ~34 per day, while for the experimental group it is ~25 per day. Thus, the result rejects our hypothesis that challenging classmates (with duels and call-outs) will improve student engagement in out-of-class practicing (RQ1).

This is another unexpected result in the current study. In our previous studies [10,23,53], the results consistently showed a higher rate of practicing in OneUp in the experimental condition (i.e., in the gamified course). An explanation of this could be that in those studies the control group used OneUp as a practicing system without any gamification elements enabled. In this study, the control group used points, badges, leaderboard, and avatars, and those may explain the active taking of warm-ups from the beginning of the course (Condition 1). There could be different reasons why this did not persist under Conditions 2 and 3. One of the reasons might be the novelty syndrome, which typically brings higher interest in the beginning of usage of new tools, but with the time, the interest fades away. Another reason might be that after getting more experienced (in the second part of the course), the students have preferred to practice solving coding problems provided in the interactive textbook, since such problems were not offered in OneUp. In any case, these results prompt to a following investigation with a cleaner design of the experiment.

B. Survey Results

A paired-samples t-test was conducted to assess the impact of gamification on pre- to post-test differences between the current study's participants' scores on autonomy, competence, and relatedness. Participants demonstrated significant pre- (M = 3.66, SD = .63) to post-test (M = 4.44, SD = .49) effects for Autonomy, t(18) = -3.83, p = .00, significant pre- (M = 3.76, SD = .60) to post-test (M = 4.32, SD = .67) effects for Competence, t(18) = -2.43, p = .02, and significant pre- (M = 3.67, SD = .98) to post-test (M = 4.50, SD = .83) effects for Relatedness, t(18) = -2.56, p = .02 (See Table 3 for participants' sociodemographic information). Thus, in response to Research Question 3 (RQ3), the current study found that the combination of game elements points, badges, leaderboard, avatars, classmate challenges, and virtual currency do improve student intrinsic motivation overall.

Because the literature suggests that women and men respond differently to gaming environments, with women showing less interest in computer games that men, the paired-samples t-tests were ran again after splitting the dataset by gender to assess the impact of gamification of learning on pre- to post-test differences for men and for women. For men, the analyses only uncovered significant pre- (M = 3.94, SD = .56) to post-test (M = 4.69, SD = .39) effects for Autonomy, t(6) = -2.52, p = .05, whereas for women, the analyses uncovered significant pre- (M = 3.48, SD = .62) to post-test (M = 4.29, SD = .50) effects for Autonomy, t(10) = -2.80, p = .02, significant pre- (M = 3.60, SD = .55) to post-test (M = 4.20, SD = ..43) effects for Competence, t(10) = -2.57, p = .03, and significant pre- (M = 3.42, SD = .85) to post-test (M = 4.42 , SD = .1.00) effects for Relatedness, t(10) = -2.45, p = .03.

TABLE III. *SOCIODEMOGRAPHIC INFORMATION OF PARTICIPANTS*

Baseline Characteristic	**Full Dataset (Pre-Test)**		**Matched Pairs**	
	n	***%***	***n***	***%***
Age				
18-25	23	100	18	100
26-35	0	0	0	0
36-45	0	0	0	0
46 or older	0	0	0	0
Race				
Af-Am/Black	2	8.70	0	0
Euro/White	19	82.60	17	94.44
Mex-Am/Hisp	0	0		
Asian-Am	2	8.70	1	5.56
Other	0	0	0	0
Class				
Freshman	0	0	0	0
Sophomore	8	34.78	7	38.89
Junior	13	56.52	9	50.00
Senior	2	8.70	2	11.11
Major				
ComSci	0	0	0	0
Mathematics	1	4.35	1	5.56
Other	22	95.65	17	94.44
Sex				
Male	11	47.83	7	38.89
Female	12	52.17	11	61.11
Non-binary	0	0	0	0

[a.] Note: Five participants who had no post-test data were removed to form matched pairs for the analyses.

When broken down by gender, these analyses do not necessarily lend credence to the notion that women are differentially impacted by gamification, as the women in our study improved their Autonomy, Competence, and Relatedness scores from pre- to post-test because of gamification of the learning environment. If anything, men's improvement in only Autonomy scores might indicate that they are less positively impacted by gamification of the learning environment, which one could argue stems from their increased exposure to games and gamification relative to women.

The overall results show an intriguing finding, suggesting that although a specific combination of game elements can provoke increase in learners' motivation, this does not necessarily imply boosting the desired learning behavior. Considering this result within the context of our particular study, we theorize that the more selective student population may not have been appropriately challenged by the practice materials presented. Thus, for a number of students the perceived value of practicing was decreasing.

All these results contribute to the knowledge base of the impact of educational gamification on student intrinsic motivation, which contains rather contradicting reports.

V. CONCLUSION

In this paper we investigated how adding duels to points, badges, leaderboard, and avatars influences the practicing behavior of students and whether adding VC reinforces duels usage. Our study is the first to evaluate the use of duels for gamifying out-of-class practicing in a computing education context. We analyzed student behavior recorded in the system log and collected student perception data using a motivational survey. The results from the student survey suggest that the gamification increased students' intrinsic motivation towards the gamified practicing activity. However, the behavior analysis shows that adding duels had no positive impact on students' practicing, although adding VC increased the initially very low interest in duels. A potential explanation of the reported effect is that the students may be less receptive to duels in learning context. However, further research is needed to confirm these findings in a broader range of contexts.

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