Using Gamification for Supporting an Introductory Programming Course. The Case of ClassCraft in a Secondary Education Classroom

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Abstract. Old teaching methods mechanisms are no longer beneficial to the students. In traditional instructional methodology, where the lecture classes are perceived to be tedious by students, the gamification technology has a great advantage to solve the problem as it can improve learning motivation of students. Various studies have shown that gamification under appropriate conditions may create an environment conducive to learning and lead to large increases in students' interest in programming. ClassCraft is a game that it can be used in the classroom to help students to have fun, promote teamwork, and become better learners. In this paper, we present a pilot teaching intervention. The results showed that the general students' performance has not been affected positively. On the other hand, their engagement has been affected positively.

Keywords: ClassCraft · Gamification · Introductory programming courses
Secondary education

1 Introduction

A recent report (August 2017), highlights the fact that "regardless of race/ethnicity or gender, 80% of students who have learned Computer Science (CS) claimed that they learned CS in a class at school, about twice the rate of any other means of learning, including on their own, through afterschool clubs, online, or in any other program outside of school" (p. 26) [30]. As Wang states, this data strongly suggests that formal education remains the best way to ensure widespread and equitable access to CS learning [30].

At the same time, various other reports highlighted the fact that in CS classes the dropout rate seems much higher compared to other classes and indeed, many CS classes face a "lack of interest" from the general school population [2, 23, 31, 32]. There are concerns among researchers and education professionals that students in our classrooms are bored, unmotivated and disengaged from school [4, 26]. One of the reasons is that old teaching methods are no longer beneficial to the students. On the other hand, game-based learning can improve learning motivation of students [1, 14, 15, 21]. Compared with traditional lectures, digital game-based approaches can indeed

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produce better learning effects, which underscore the need to develop appropriate instructional materials [1, 26].

ClassCraft is a role-playing game which aims to transform any classroom into a role-playing platform that fosters stronger student collaboration and encourages better behavior [5, 28]. Gamification systems such as ClassCraft add an adventure game layer on top of the existing course infrastructure. Students create a character, play as part of a team, and gain experience points and rewards based on class-related behaviors [1].

The rest of paper is organized as follows. Section 2 describes the use of computer games in education, and Sect. 3 describes the role-playing video game ClassCraft. Section 4 describes the comparative study of different teaching methods. Finally, Sects. 5 and 6 present the results and conclusion of the teaching intervention.

2 Gamification

Digital games are an important part of most adolescent's leisure lives nowadays and are expected to become the predominant form of popular culture interaction in our society. Studies show that even young children under the age of 8 are frequent users of digital games and applications [10, 21, 24]. Many educators see digital games as powerfully motivating digital environments [23, 27] because of their potential to enhance student engagement and motivation in learning, [13] as well as an effective way to create socially interactive and constructivist learning environments [6]. According to [11], "Video games engage players in powerful forms of learning, forms that we could spread in various guises, into schools, workplaces, and communities where we wish to engage people with "education" (p. 216)".

There are a lot of studies that demonstrate the advantages of digital games in learning, not only for transversal skills like communication, collaboration, fine motor skill, to name but a few but also for specific skills in particular knowledge domains [18, 21]. Through gamification of education, the intention has been to incorporate the aspects of games that produce flow into the school setting, increasing thus student school engagement [4].

Gamification is defined as the application of game elements to non-game contexts [4]. In education overall, the conversation about gamification posits that this approach when used in the classroom could be an effective tool for increasing student learning and engagement, compared to the traditional lecture format [4, 11, 21]. The reason is that through gamification, we can not only create a mindset that encourages students to try new things and not be afraid of failing, but also enable students to engage in enjoyable experiences for the purpose of learning [1]. Another key advantage of gamification is the low cost of development and the possibility of making learning content more appealing or interesting using game elements [1].

Gamification will not on its own ensure the engagement of students in class, but it can provide another means of promoting students' active participation and investment into something beyond the academic expectations of a lesson. Gamification should be used as an adjunct to other well-supported engagement strategies [4].

3 ClassCraft

Inspired by role-playing video games, ClassCraft (https://game.ClassCraft.com/home) was created by a high school science teacher Shawn Young to help engage his students [29]. The first public version of ClassCraft was made available in February 2014 as a beta version. The official global launch of the game was in August 2014 [28].

ClassCraft is a game that students and teacher play together to transform how both members experience class every day. It can be considered to metaphorize the functioning of a classroom as a battlefield combining collaboration and competition [5, 28]. The service requires no installation (other than mobile apps, if one decides to use them). The game operates on a real-time web engine, so events in the game are pushed in real time to other users' devices, much like in a normal online video game [28]. ClassCraft is not related to a specific school subject, and the duration of the game depends on the teacher's expectations (from a few class hours to the entire year). The students play the game during school hours and outside of class [28].

Game rules are quite simple. A student by demonstrating positive behavior in class can earn "Experience Points (XP)" that will allow him/her to level up and learn new powers. If a student "breaks" the class rules, he/she will lose "Health Points (HP)"—his/her life energy in the game—and eventually, he/she will fall in battle. For instance, if a student earns XP points, these powers have real benefits for the student and for his/her team (see Fig. 1). Accordingly, if a student loses HP points the rest of his/her team will take damage, too. In any case, students need to work together to succeed. In ClassCraft, students are placed in teams of four to six members and play as Mages, Warriors, or Healers [28]. Each group has unique properties and powers and is designed for different types of students [12]. Each team has at least one Warrior, one Mage, and one Healer so they can help each other succeed in class tasks [8].

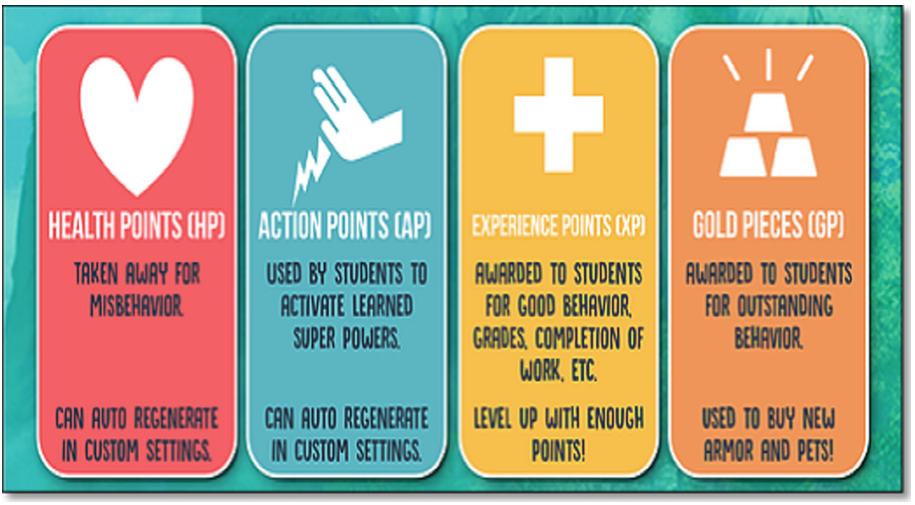

Fig. 1. ClassCraft point system (Reproduced from Dylan Peters EDU. Source: https://goo.gl/btWWf9).

The teacher played the game with his students in the school computer lab. He used the video projector in order for the students to watch the game during the whole teaching hour. At the beginning of the teaching hour, the teacher used the game class announcement tool to send messages to students, to reward or punish them for their performance, e.g., arriving in class late. Also during the teaching hour, the students were rewarded, or punished, for good or bad behavior of for their contribution in class, accordingly.

4 The Study

To determine the effectiveness of gamification compared to traditional approaches, the implementation of an experimental intervention was chosen. Class consisted of students attending the 1st grade of Senior High School (Lyceum), in the region of Crete, Greece. An experiment has been conducted to evaluate the effectiveness of the proposed approach via investigating the following research questions:

H1: The implementation of ClassCraft will have a positive impact on students' attitudes toward the programming course.
H2: The implementation of ClassCraft, will have a positive impact (improvement) in the overall grades of students in the programming course.

4.1 The Research Procedure

According to the working hypothesis of this work, the study followed an independent-subjects design. A random representative sample of subjects is selected and then the subjects are randomly assigned to either an experimental group or a control group. This procedure ensured that there was no systematic relationship between features of the subjects and to the group in which they were designated. One group, the experimental group, receives a treatment designed to produce some effect (the teaching intervention using ClassCraft). The other group, the control group, is left alone or given a fake treatment. Data is gathered; the dependent variables are measured. Results from the two groups are compared and analyzed to see if the experimental treatment made any difference [4, 9].

The sample consisted of 30 students enrolled in a public high school in Heraklion, (M age = 15.72 years, SD age = 1.22 years). At the beginning of the school year 2016–2017 the students were voluntarily enrolled in a lesson entitled "IT Applications". Students were distributed at random in two groups. Both groups of students were taught the same teaching material, in the same school computer lab but at different days and/or hours. All the lessons were taught by the same Computer Science teacher.

The intervention was applied in a special section of the lesson entitled "Programming environments for creating applications" (teaching duration of 16 h). The

researcher randomly decided that the students of the first group would be used as a control group. The second group of students was assigned to the experimental group that would be taught the basic programming principles. The teacher implemented ClassCraft in the classroom to examine if this game can create an environment conducive to learning, leading to an increasing student interest in programming. Among the students, 51% were boys and 49% were girls. The two groups had an equal number of students and were similar with respect to age and gender. App Inventor for Android (AIA) for various pedagogical and practical reasons [19, 20, 22, 24, 25, 27] was qualified for the overall experimental design and implementation of the intervention.

In order to take results comparable with other studies the teacher followed the procedure given by [28] in the experimental group: Once students were introduced to the game, the students were asked whether they wanted to play or not. After the students of both genders, voluntarily agreed to play, they were asked to choose their five teammates following the teacher's instructions: Each team should contain different kinds of students, slow achievers and good learners, with or without behavioral difficulties. Prior the intervention, a pre-test evaluation focused on student's knowledge in the basic programming skills and attitudes toward programming showed that the two groups were statistically equivalent. The teacher used the computer lab video projector to show students the various messages during the course (announcements, penalties, rewards, assignments etc.).

As far as the ClassCraft implementation in the experimental group is concerned, the teacher did not use the game just as a simple badge system, but instead he tried to make lesson adjustments directly. For instance, if a student was a warrior and his/her teammate arrived late in class (which meant HP loss) the student could act and save his/her friend. If players lose all their HP, they receive a sentence and their teammates also lose HP [28]. In other cases, a student could use his/her power to bring a homework late, etc. Consequently, the students knew that their behavior in class affected the overall outcome. Concerning the learning content, the teacher regularly introduced personalized questions in the game and rewarded the students with in-game bounties. The students also earned XP points when they helped other students, collaborated during school activities, and got good grades. In general, the teacher used ClassCraft as an alternative way to empower students to take control of their learning process by reinforcing teamwork and collaboration rather than competition among students. Although students' parents had been informed, they did not show much interest for the intervention. Some parents disagreed with the idea of playing a game in the school. For that reason, the teacher did not use the parent mode of the game. Unlike similar studies [28] the teacher did not face any technical problems. Even the game's internationalization didn't pose a problem, although the Greek language was not supported by the game. Figure 2 shows the experimental design of this study.

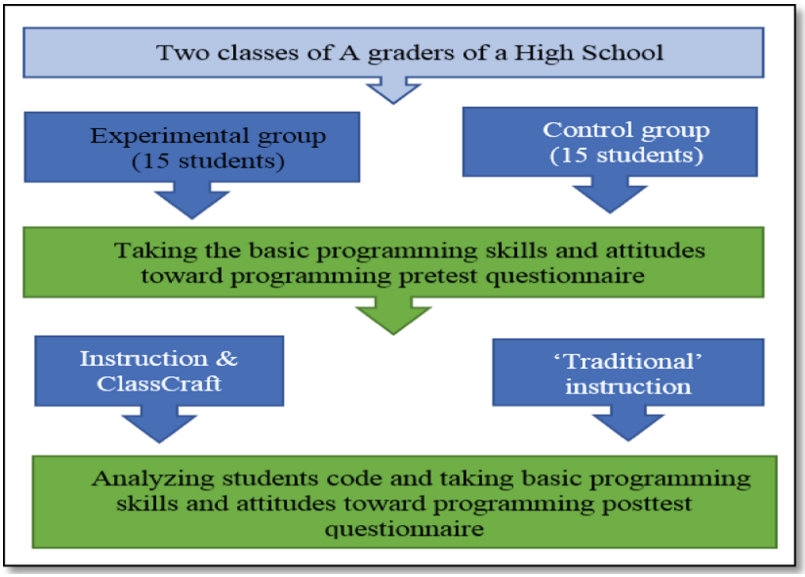

Fig. 2. Experimental design for the learning activities.

4.2 Evaluation

The teacher used a variety of data collection methods. First, the teacher collected and analyzed the correctness and complexity of the code created by students in various projects in both experimental conditions. Then, the teacher used the data from the students' final knowledge evaluation using an online questionnaire. The study of Kleinschmager and Hanenberg was used as a basis for creating the questionnaire [16]. The third tool was an appropriately designed questionnaire which was created by the teacher and composed of measures taken directly or adapted from previous studies. All aspects were measured with the use of four-point Likert scales (Not at all true to Very true). The questionnaire contained questions about students' attitudes towards programming. The questionnaire was developed on the basis of the Computer Attitude Scale (CAS) [17].

The adaptation of both the pre-test and the post-test were made by two experienced teachers who had taught the science course for many years [24, 27]. This is a common approach for developing achievement tests [20, 25]. All questionnaires were pilot tested prior to the main study to establish reliability, validity, and feasibility. They were distributed to 20 students who did not participate in the study to minimize potential problems related to the students' understanding of the questionnaires, the translation from English into Greek, the process of conducting the investigation etc. No problems were encountered during the pilot study. The Cronbach's alpha value of both the pre-test and the post-test questionnaire were .82 and .84 respectively, showing good reliability in internal consistency.

4.3 Statistical Analysis

The whole data was analyzed in the Statistical Package for the Social Sciences SPSS application (ver. 21). Prior to teaching intervention, statistical analyses of differences between the experimental and the control groups were performed. The results after applying suitable statistical tests showed that both groups did not differ significantly in their characteristics, such as gender ($X^2(2) = 0.54$, $p > .05$), behavioral approach ($F(1, 28) = .51$, $p > .05$) and knowledge in programming ($F(1, 28) = .82$, $p > .05$). In summary, the results show that both groups are equivalent in term of factors that are thought to underlie behavioral and programming knowledge differences [3, 7].

At the end of the teaching intervention, the equivalence of the two groups was checked using the independent samples *t* test. As it is a parametric test prior to its use, the application of standard statistical analysis techniques assumed that data met the necessary assumptions for parametric analyses such as the homogeneity of variances and that the dependent variable normally distributed for each group of the independent variable.

The analysis of students' projects (code complexity etc.) showed that although students in the experimental group ($M = 66.60$, $SD = 8.84$) recorded the highest score compared with their peers in the control group ($M = 64.87$, $SD = 9.96$), those results were not statistically significant ($t = -.29$, $df = 28$, $p > .05$).

Similarly, the analysis of the results of the online test at the end of the teaching session showed that there was not a clear progression in learning and understanding of basic programming concepts and problem-solving ability in the experimental group. Again, although the experimental group ($M = 74.60$, $SD = 7.21$) had slightly better performance than the control group ($M = 73.47$, $SD = 8.11$), the difference in performance between the two groups was not statistically significant ($t = -.41$, $df = 28$, $p > .05$).

The teacher, therefore, wanted to verify whether the attitudes of students toward programming varied in relation to the group to which they belonged. The results showed that the difference in performance between the two groups was statistically significant ($t = -7.78$, $df = 28$, $p < .001$), indicating that the method brought about a crucial difference between the two groups. Further analysis showed that the experimental group ($M = 92.27$, $SD = 2.09$) had significantly better performance than the control group ($M = 72.87$, $SD = 9.43$).

5 Discussion of Results - Intervention

Regarding the research hypotheses, the results of the present analysis are somewhat ambiguous. The first hypothesis seems to be confirmed by the findings as they showed that the use of ClassCraft in the classroom contributed positively to the growth of students' interest and attitudes for programming. It also seems that students involved with the game gave a more playful and pleasant feel to the learning process compared the 'traditional' approach. Regarding the acquisition of knowledge and skills, the results indicate that students in the experimental group did not significantly outperform their counterparts in the control group in terms of their understanding of the basic

programming concepts, skills concepts, and problem-solving ability. From this first part of our study, we can conclude that the second hypothesis was not confirmed statistically in this small sample.

These markings are also consistent with those noted in other studies, which show that the use of ClassCraft in the classroom helps increase motivation, improves classroom behavior, and forms meaningful collaboration [28]. In the same study [28] note that ClassCraft helps to make appropriate and non-appropriate behavior clearer to students through a system of rewards and penalties, depending on the school rules. Overall, students feel they have had a more engaging and enjoyable experience. We can consider that the implementation of ClassCraft in the classroom/computer lab is appealing to students because it brings the language and culture of digital games which are part of their daily life to the school environment, [4]. In general, students in the experimental group, reported positive feelings towards the system and increased motivation to participate in similar courses in the future.

On the other hand, this game in no way affects the curriculum or in class assessments. The main drawback is that it does not provide integration with the course curriculums in a direct and simple way [29]. As [5] note, making effective use of commercial games in the classroom requires careful thought and explicit direction in the extraction of this unintended pedagogical value. However, the role of the teacher and his/her own appropriation of the game are key [28]. Finally, one of the more encouraging elements of this intervention is that both genders appeared to equally be involved in the game and it is compliant with the results of [28].

6 Conclusion

There are a lot of studies that demonstrate the advantages of digital games in learning, not only for transversal skills such as communication, collaboration, fine motor skill, etc., but also for specific skills in particular knowledge domains [18]. Through gamification of education, the intention has been to incorporate the aspects of games that produce flow into the school setting and to increase student school engagement [4].

Though this study has a number of limitations (small sample, short duration etc.) similarly to other studies, it provides implications that gamification can ensure the engagement of students in the class, in means of promoting students' active participation [4].

However, the proper application of an innovative method requires a thorough understanding of its various subsets and careful attention to exclude potential pitfalls, a thorough preparation on the part of the teacher and proper training of students [20, 25]. Prior to the implementation of gamification in the classroom teachers need to determine the needs and interests of them and their students, as well as what they wish to achieve through the implementation of a gamification system [4]. One of such barriers is the lack of methodologies and tools that would allow teachers to embrace their approach in an appropriate manner [18]. Undoubtedly, to generalize the use of games in formal education settings, educators need additional support [5].

Thus, further research into this area is required as it will provide valuable understanding of the potential of gamification as a tool for increasing student engagement.

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