Gamification of Game Programming Education: A Case Study in a Croatian High School

Markus Schatten
Artificial Intelligence Laboratory
Faculty of Organization and Informatics
Pavlinska 2, 42000 Varaždin, Croatia
markus.schatten@foi.hr

Marinela Schatten
Dugo Selo High School
Ul. S. Ferenčaka 25, 10370, Dugo Selo, Croatia
marinela.schatten@skole.hr

Abstract. *An initial case study on gamification of a game programming education lectures for computer science high-school students is presented and analyzed. For the sake of this study the gamification platform ClassCraft has been used on two separate classes each of which was divided into two groups - a group that used the gamified platform and a group that used a traditional e-learning platform. Results show that students using the gamified platform were more motivated and had better results.*

Keywords. gamicifation, classcraft, e-learning, mixed learning, computer games

1 Introduction

Gamfication, defined as "*the use of game design elements in nongame contexts*" (Deterding et al., 2014; Huotari and Hamari, 2012) has raised major interest from both academia and industry as a successful method of motivating people (and especially students) to support user engagement and enhance various positive patterns in service use including but not limited to increasing activity, social interaction, quality and productivity (Hamari et al., 2014).

Especially in education the process of gamification has been showing promising results (Dicheva et al., 2015; de Sousa Borges et al., 2014; Huang and Soman, 2013; Kapp, 2012). Computer science educators were one of the first to adopt these techniques to teach various types of computer science related courses including programming education (see Akpolat and Slany, 2014; Khaleel et al., 2015; Panagiotis et al., 2016 for examples), which is a topic that this study would like to contribute to.

Herein we would like to take an initial step further and introduce gamification to a very particular type of programming education - computer game development. Videogame development is a specific type of software engineering for which various programming techniques and methods have to be adapted to suite the problem at hand (Ampatzoglou and Stamelos, 2010). While there are numerous programming related gamification platforms around, see for example (Combefis et al., 2016; Swacha and Baszuro, 2013) for an ovetview, we have chosen to use the ClassCraftfootnoteAvailable at https://www.classcraft.com platform in a high school environment for a mixed on-line/off-line computer programming course.

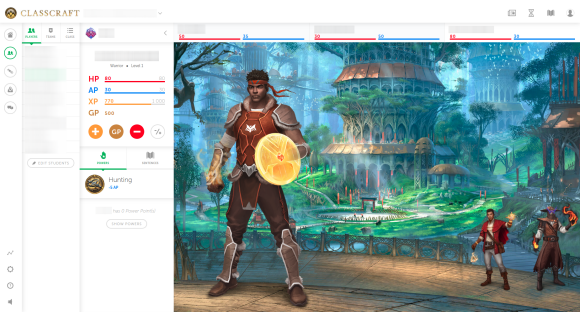

Figure 1: Main Dashboard

ClassCraft is an interesting gamification platform that allows one to "*create self-paced, personalized learning adventures for students out of existing lessons*" (Classcraft Studios Inc., 2018). It allows students to play virtual characters which level up and acquire powers. These powers have real-life benefit, for example, a power might allow a student to switch places in class or ask the teacher to check if he/she has answered a quiz question correctly.

These avatars collect experience, hit and action points by solving quests (lessons) or doing some work during face-to-face lectures like answering a question or solving a task. Figure 1 shows the main dashboard of a class we have used in our study.

We have chosen to create a simple experiment in which two high school classes of second grade computer technician students have been divided in two groups each during their algorithms and programming course. Each class had one group working with the gamified platform and one group working without. All groups had the same assignments: (1) a presentation on computer game development had to be examined, (2) a short on-line test had to be taken, (3) a simple example of a game programming code had to be examined, (4)

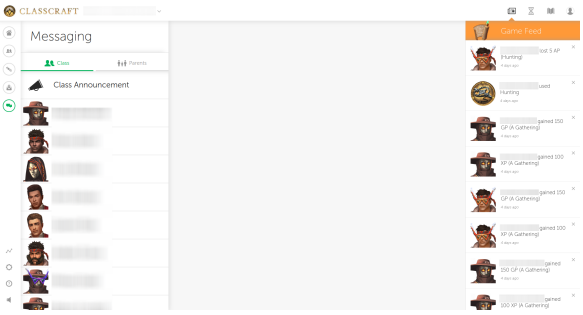

Figure 2: Messaging and Gamefeed

an exercise in programming had to be solved and in the end (5) a short survey had to be taken. All groups had two school hours (45 minutes each) to complete their task. In this paper we present the results of their results on the test, the exercise as well as survey on their opinion on this particular lecture.

The rest of this paper is organized as follows: firstly in 2 we provide an overview of related work. Then in 3 we show the gamification process of the selected lecture and survey design. Then in 4 we provide a discussion on obtained results. Finally, in 5 we give a conclusion and provide guidelines for future research.

2 Related Work

There have been numerous empirical studies which applied various methods of gamification to programming education. For example (Panagiotis et al., 2016) "*used a combination of instructor feedback, real time sequence of scored quizzes, and live coding to deliver a fully interactive learning experience*" for an introductory university-level Python programming course. In particular these authors have used the Kahoot! classroom response system, a classroom version of the TV game show "Who Wants To Be A Millionaire?" as well as Codecademy's interactive platform. They have found that attendance, downloading of course material, final grades and motivation were positively influenced by the gamification process.

A very similar study to the one at hand was performed by (Papadakis and Kalogiannakis, 2017). The authors have used the same gamification platform (ClassCraft) in a similar setting: 1st grade high school students in a programming course on a sample of 30 students. Likewise, they have split the class into two groups, one using the platform and one not. Their findings, however are a bit different to the results we have obtained. For example, they have found that there is no significant influence of the gamification process on the actual performance of students, i.e. the students which used the gamified platform did not outperform their peers not using the platform significantly. Additionally, they have used gamification to teach computer programming, while our study was focused on game programming and we have in addition to comparing study outcomes performed a survey that gives additional insight into students' opinions.

3 Gamification and Lecture Design

In our study we have used the mentioned ClassCraft platform on two classes of second grade high school students (10th year of study) enrolled in a computer technician school. Both classes (we will denote them with A and B) have already at least two years of experience with programming courses in the C programming language. Both A ($n = 21$) and B ($n = 17$) were divided into two groups (A_G, A_N and B_G, B_N) where groups with index G were using the gamified platform for the lecture, and groups with index N were not. Group A_G was composed of 11 students, group A_N of 10 students, group B_G of 9 students, and group B_N of 8 students. There were no significant differences between groups related to age, sex, ethnicity or academic performance.

ClassCraft allows teachers to overview students progress and activities as well as social activities by introducing a game like environment. Figure 2 shows a main gamefeed of a class as well as messaging capabilities.

While there are a mutitude of game-related functionalities in ClassCraft we have chosen to evaluate the use of quests as a means of self-learning by students and testing their accomplishments. Quests are a series of tasks that have to be solved to gain additional points which can later be used either to get a grade or for example to use some power. Each task of a quest usually has two parts: (1) a story part which is part of the game (e.g. a situation in the game story), and (2) an assignment part (e.g. a quiz, exercise or other educational related activity) which has to be solved by the student in order to advance to the next task.

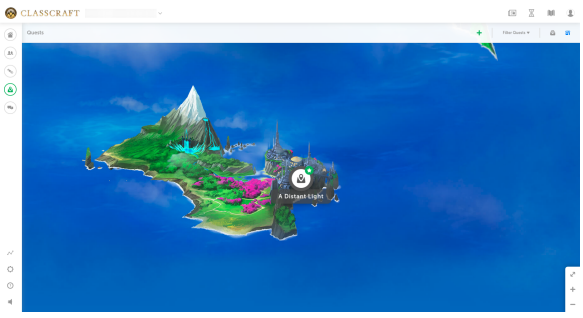

Figure 3: Quest Dashboard

ClassCraft provides us with a marketplace of already finished game related quests which can be used as templates to develop own unique quests for students. Figure 3 shows the main dashboard for quests which shows a map and a quest we have developed for the study.[1]

[1]The quest template we have used for our quest is A Distant Light

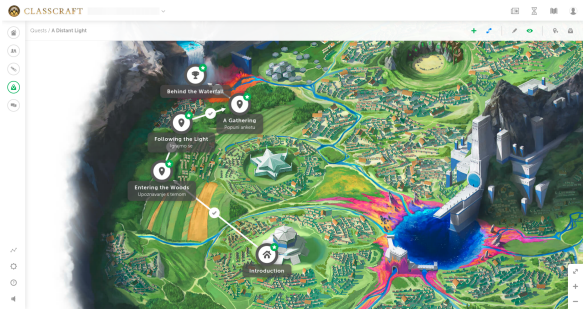

Figure 4: Quest Map

As stated previously, all groups of students were given the same series of tasks: groups with index G were using a ClassCraft quest to solve their tasks, whilst groups with index N were using a not gamified approach (in our case we have used the platform Edmodo, which student were using on a daily basis, to distribute the various documents and tasks to students and let them upload their results).

Their first task was to download a presentation and study its content. The presentation had a total of 16 slides with an introduction into game development. It included a typical structure of a game program in C similar to the following listing:

```
int main()
{
    int status = 1;
    initialize();
    while( status )
    {
        process_inputs();
        update_state();
        status = show_outputs();
    }
    end();
    return 0;
}
```

The second task was to take a simple quiz with questions related to the content of the presentation. We used SurveyMonkey to implement the quiz to automate collection of responses. It consisted of 5 multiple-choice questions each asking for some facts from the presentation.

The third task was to study an implementation of a simple game in C that was developed around the structure given in the above listing. It was the implementation of the "Guess which number I thought of" game with random generated numbers from 1 to 10.

The fourth task was to extend the code from task 3 so that after a game the program asks the user if he/she wants to play again (the initial implementation was intentionally developed for one use only). The task included printing out an additional question, collecting an answer from the user and depending on the answer either finish the game or restart it by resetting all game variables (i.e. generating a new number, resetting the round counter etc.). After finishing the task, the student were asket to upload their solution, either to ClassCraft or to Edmodo depending on the platform they used.

For the fifth task we have designed a short survey to get the opinions of the students about the work they just did, the lecture and their overall motivation and interest in the subject. The survey consisted of eight questions:

1. What was your overall impression of this lecture?
2. What was your initial interest into the subject of videogame development?
3. How would you rate the used course materials?
4. How would you rate the time you had available for solving the tasks?
5. How would you rate the way in which this lecture was performed?
6. How motivated are you to study the field of game development now after this lecture?
7. What did you like the most about this lecture?
8. What didn't you like about this lecture?

The first six questions were rated on a scale from 1 to 5, and the last two were open ended questions. Again we have used SurveyMonkey to collect the responses.

4 Results & Discussion

The lecture was held during the last regular classes of the summer semester, there were no additional incentives for participating in the tasks except for mandatory attendance (the tasks were not graded), so it would be expected that a usual motivation for performing well would be low. Nevertheless, all students in all groups did finish all tasks except for one student which didn't answer the last two questions of the survey.

As already mentioned each individual group had two school hours (a total of 1 hour and 30 minutes) to finish their tasks. As opposed to the results of (Papadakis and Kalogiannakis, 2017) in our case the students using ClassCraft have outperformed their peers using Edmodo in both the quiz and the programming exercise.

Table 1 provides an overview of the students' performance results. The scores are average scores for each group and the t-test is the p-value of a two-tailed heteroscedastic t-test. As one can see from the results the student using the ClassCraft gamified platform have outperformed their peers significantly both in quiz and programming exercise results.

Table 2 provides an overview of the survey results. We have provided means, medians, standard deviations and t-test p-values for each of the questions for the two

by Benjamin Weaver available at https://marketplace.classcraft.com/en/quests/LZ4JNQy8pEvr6qzgz/a-distant-light

Table 1: Statistical analysis of performance

	A_G	A_N	B_G	B_N	G	N	t-test
Quiz	96.97%	85.33%	92.59%	83.33%	94.78%	84.33%	0.0479
Exercise	81.82%	48.00%	84.44%	62.50%	83.00%	54.44%	0.0010

groups (G is for groups A_G and B_G, and N is for groups A_N and B_N). These results are further visualized in figure 5 (a comparison of mean values) and figure 6 (a comparison of median values). As one can see from table 2 the opinions of students which have used the gamified platform were better on all six scale questions than the opinions of students which haven't used it. Moreover, these results are all statistically significant except for the question on initial interest in the subject which would be expected.

An interesting observation is that students which didn't use the gamified platform have rated the time available to solve the tasks quite low (mean value 3.28) as opposed to the students which have used the platform (mean value 4.40). Given that the time to solve the tasks was self-paced and more than enough (1 and a half hours) it can in a way confirm the old saying that "*time flies when you're having fun*".

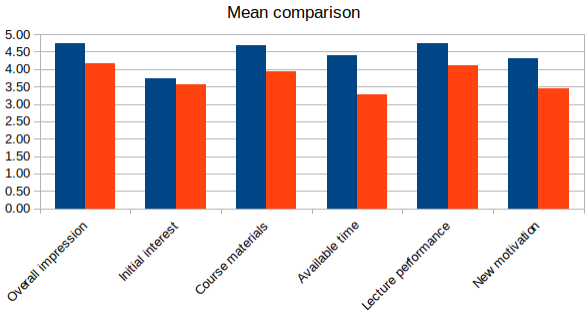

Figure 5: Mean Comparison (blue/left - students which have used the gamified platform, red/right students which haven't used the gamified platform)

Regarding the last two open-ended questions in groups A_G and B_G most student responded that their liked the actual tool their used, the process of customizing their character, that it was fun and some even liked everything. In groups A_N and B_N however, most students responded they liked the fact that there were learning about programming games, but also the answer "nothing" was pretty common. On the question which they didn't like, students from groups A_G and B_G responded most often with "nothing" or "everything was nice", with only a few answers related to the difficulty of the programming task or the summer heat. On the other hand in groups A_N and B_N most answers were related to the difficulty of the programming task or were complaints that they didn't program more interesting games.

While the survey results are interesting, the performance results especially for the exercise require special attention. Students using the gamified platform had al-

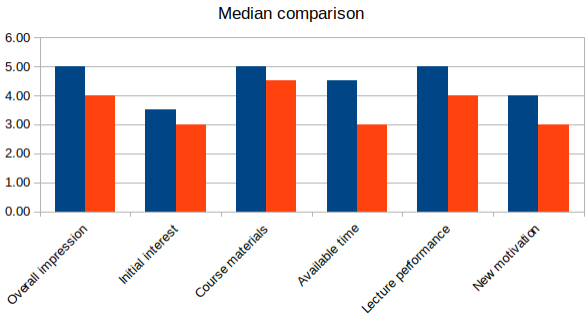

Figure 6: Median Comparison (blue/left - students which have used the gamified platform, red/right students which haven't used the gamified platform)

most 30% better results then students which haven't used the platform. For this reason we have investigated further to see what were the reasons for such a significant difference. We have reviewed the students usual performance and compared it with the results at hand. The analysis has shown that usually well performing students have performed well regardless of using gamification or not. Average students have shown a slight increase of performance when using gamification as opposed to a slight decrease when not using it. The biggest change has occurred with usually low performing students which had a more dramatic increase of performance with regard to the programming exercise. Low performing students had almost no change in performance when not using gamification.

5 Conclusion

In this study we have provided an empirical case study in which we have compared high school students' motivation and performance in learning game programming when using gamification. For this purpose we have conducted an exepriment in which two classes were divided into two groups, one using the gamified platfrom ClassCraft and the other using the Edmodo e-learning system which they use on a daily basis.

We have designed a series of tasks which the students had to solve in a self-paced environment. For the gamified platform we have disguised these tasks as a game quest to see if the motivation and performance would significantly change.

In addition to the tasks we have designed a survey to get additional insights into the opinions of students about the lecture, course materials, available time and motivation.

The results show that the students that have used

Table 2: Statistical analysis of survey results

	Mean		Median		Stddev		t-test
	G	N	G	N	G	N	p-value
Overall impression	4.75	4.17	5.00	4.00	0.44	0.92	0.0226
Initial interest	3.75	3.56	3.50	3.00	0.97	1.25	0.5978
Course materials	4.70	3.94	5.00	4.50	0.47	1.35	0.0350
Available time	4.40	3.28	4.50	3.00	0.68	0.83	0.0001
Lecture performance	4.75	4.11	5.00	4.00	0.44	1.08	0.0287
New motivation	4.30	3.44	4.00	3.00	0.66	1.20	0.0125

the gamified platform have outperformed their peers in both theoretical and practical knowledge. Especially the practical part (actual game programming) has shown an increase in motivation and performance for average and usually low-performing students.

Students which have used the gamified platform had a better overall opinion about the lecture. The have rated the course materials higher, even if they were the same in both cases. Interestingly, they estimated that they had enough time to solve the tasks, while their peers were complaining that time was scarce. They also rated the performance of the lecturer higher and had greater motivation to further study the field of game programming.

In the end, this study is of course limited: the sample included only 38 computer technician students for a lecture of a hour and a half. The students which used the gamified platform haven't seen it before and their enthusiasm might stem from a *halo effect* which might fall off and fade if the platform is used repeatedly. Nevertheless, the results are interesting and allow us to possibly design new experiments with gamification of game programming.

Future research might include a more comprehensive study on a larger sample during a longer time period that might lead to deeper insights into the matter.

Acknowledgement

The research was conducted within the project "e-Schools: Development of the System of Digitally Mature Schools (Second Phase)" being financed from the European Regional Development Fund, European Social Fund and the state budget.

References

Akpolat, B. S. & Slany, W. (2014). Enhancing software engineering student team engagement in a high-intensity extreme programming course using gamification. In *2014 ieee 27th conference on software engineering education and training (csee&t)* (pp. 149–153). IEEE.

Ampatzoglou, A. & Stamelos, I. (2010). Software engineering research for computer games: A systematic review. *Information and Software Technology*, *52*(9), 888–901.

Classcraft Studios Inc. (2018). Classcraft – engagement management system. Retrieved May 30, 2019, from https://www.classcraft.com/

Combefis, S., BERESNEVIČIUS, G., & Dagienė, V. (2016). Learning programming through games and contests: Overview, characterisation and discussion. *Olympiads in Informatics*, *10*(1), 39–60.

de Sousa Borges, S., Durelli, V. H., Reis, H. M., & Isotani, S. (2014). A systematic mapping on gamification applied to education. In *Proceedings of the 29th annual acm symposium on applied computing* (pp. 216–222). ACM.

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2014). Du game design au gamefulness: Définir la gamification. *Sciences du jeu*, (2).

Dicheva, D., Dichev, C., Agre, G., Angelova, G. et al. (2015). Gamification in education: A systematic mapping study. *Educational Technology & Society*, *18*(3), 75–88.

Hamari, J., Koivisto, J., Sarsa, H. et al. (2014). Does gamification work?-a literature review of empirical studies on gamification. In *Hicss* (Vol. 14, *2014*, pp. 3025–3034).

Huang, W. H.-Y. & Soman, D. (2013). Gamification of education. *Research Report Series: Behavioural Economics in Action, Rotman School of Management, University of Toronto*.

Huotari, K. & Hamari, J. (2012). Defining gamification: A service marketing perspective. In *Proceeding of the 16th international academic mindtrek conference* (pp. 17–22). ACM.

Kapp, K. M. (2012). *The gamification of learning and instruction*. Wiley San Francisco.

Khaleel, F. L., Ashaari, N. S., Meriam, T. S., Wook, T., & Ismail, A. (2015). The study of gamification application architecture for programming language course. In *Proceedings of the 9th international conference on ubiquitous information management and communication* (p. 17). ACM.

Panagiotis, F., Theodoros, M., Leinfellner, R., & Yasmine, R. (2016). Climbing up the leaderboard: An empirical study of applying gamification techniques to a computer programming class. *Electronic Journal of e-learning*, *14*(2), 94–110.

Papadakis, S. & Kalogiannakis, M. (2017). Using gamification for supporting an introductory programming course. the case of classcraft in a secondary education classroom. In *Interactivity, game creation, design, learning, and innovation* (pp. 366–375). Springer.

Swacha, J. & Baszuro, P. (2013). Gamification-based e-learning platform for computer programming education. In *X world conference on computers in education* (pp. 122–130).