Abstract

When studying in traditional environment can be boring and not efficient, introducing game features into learning routine can lead to high increase in motivation and engagement in learners. This technique of involving game modules into process called gamification.

Even though the gamification tends to provide good results on learning outcomes, the research in the area has some limitations. Many of these systems were not evaluated within in-class environment, to identify if they really help to learn subject or not. On the other hand, if there was experiments within course, the number of samples are and time frames of experiment are small.

The following study was conducted to understand the result of gamified learning platform on student performance. Also to identify in which cases external learning systems are usable. The study shows that learning platform become more engaging after introducing gamification techniques and it helps to improve overall student learning performance. Also we notice some correlation between effectiveness of professor and platform usage. Used testing system.

1 Introduction

With a fascinating growth of technology, educational system also faces drastic changes. With a huge interest in MOOC systems, e-learning becomes one of the vivid examples of advances in education. But on the other hand with a great portion of online classes and online learning tools the need to engage and motivate students is of great importance. It is very hard to identify external impulses that will force student to learn a subject. But while for some students solving math or programming moderate problem can be cumbersome, they can spend hours and hours playing hard strategical games. This kind of observation gives an idea of incorporating game features into learning environment as well.

The use of game mechanics and design techniques in non-game context is known as gamification [31]. The goal of gamification is to digitally engage and motivate people to change their behaviours or learn new things for achieving their own goals [7]. The other technique of using game techniques to make learning fun is serious gaming. Like gamification, the goal of serious games is to solve the same problem: to motivate and enhance learning with game-based thinking and mechanism [21]. But on the other hand, in contrast with the gamification, which uses only game features in non-game disciplines, serious games are digital games that used for learning purposes [22].

Gamification is used in a wide range of domains, such as marketing, sport, health and so on. An example of such system is Swarm or former foursquare, which was one of the early systems that uses badges to motivate users to check-in in places using that software.
Memrise and Duolingo are other examples of successful commercial products for learning foreign languages. The world’s leading business gamification solution for enterprises is known to be badgeville, which provides means to increase employee engagement.

The problem with motivation and engagement arises in any domain, but when technology grows so rapidly, the need of students in technical areas represents an important issue. The number of students interested in STEM is growing rapidly, but on the other hand the students who finish their education in engineering is decreasing. The reasons for this are diverse: low grades, poor teaching, lack of interest and many others. Consequently the problem of effective teaching in engineering courses becomes very crucial. To address this problems, many web-based gamified systems were created.

The positive impact of gamification on the education seems very obvious and natural. Studies show that introducing simple game techniques in educational systems affects positively student’s learning outcomes. Also gamification helps to enhance student’s motivation and engagement and increase their participation as in class and outside of the class. The gamification of technical courses not only beneficial for university students, but also for employees and employers. The costs on employee trainings are reduced by e-learning, moreover gamification can provide more motivated professional training.

Even though the gamification tends to provide reasonably good results, the research in the area has some limitations. Many of these systems were not evaluated within actual university courses, to identify if they really help to learn subject or not. On the other hand, if there was experiments within course, then the limitations are in number of samples.

In the following work, we present how gamification can improve the engagement of students and their overall course score. The experimental results are acquired on significantly more samples than the similar studies. The experiment time frame is also considerably more, about one year long.

2 Literature Review

In the following chapter we investigate how gamification affected the education, which kind of techniques are most used and how the evaluation of the results are performed until now. The detailed description of the most prominent studies in the field are presented with a concluding summary in the table.

While gamification is used to motivate and engage student in learning activity, it can also have opposite outcomes, such as ‘Overjustification effect’ or addiction. But those
side effects can be eliminated in the phase of system design. To solve that Cheong at al. [8] used design science research to create and evaluate and instantiation of a Quick Quiz tool. The Quick Quiz software is a multiple choice quiz, which was tested in IT-related undergraduate course over four weeks. Tool was iteratively improved based on the data collected from the system. The effectiveness (effect on student learning, future use, and effect of specific features) of the tool was measured based on the questionnaire. The number of usable answers was 76, and about 77% on each evaluation metrics was positive.

Most extensively used gamification techniques are points, levels, badges, leader boards, prizes and rewards, progress bars, storyline, feedback. A review by Nah at al. [26] shows the impact of those elements on the learners’s outcomes, in a sense of motivation, enjoyment or productivity. In particular the badges and prizes boost motivation, or goals and visual elements enhance performance and so on. The mechanism of earning badges was shown to have a positive impact on students’ motivation [11] in an educational platform like PeerWise [3], which is used by more than 300 institutions worldwide. PeerWise is a system that provides course assessment content creation environment for learners, and has a significant impact on students’ learning. But as tests are generated by users, there is need again of motivating them for generating content. The experimental results acquired from more than 1000 student class, indicated, that the group of the students (512 student) who used the PeerWise system with badge-based achievement system increases the number of answered questions by 22%, compared to badge-off group [11].

Gamification is widely used in learning almost any subject. With the advances of science and technology, there is a need of motivating and encouraging students to take technical classes and succeed in them. And in this case gamification again shows positive effects [9]. There are also attempts of adapting gamification in software development procedure [13] [27]. As Barata et al. [9] show, introducing game features into real class environment have a significant effect on student motivation and increases the highest and lowest grades. In contrast with the other works, in this experiment they introduce gaming elements into real class environment, by simply replacing grading idea with experience points, and keeping track of achievements via leader-boards and badges. It is also very important that gamification is positively accepted by students [6, 9].

The other important results of gamification is the improvement of students’ grades and engagement [6, 12, 13, 25]. In particular Brusilovsky et al. [6] show that usage of QuizPACK platform for learning programming language semantics improves by 15.3% student’s grade. In another study conducted by Domínguez et al. [12] showed that the group of students who practised with a gamified plug-in increased students’ motivation and received higher final scores. Esper et al. [14] tried to recreate learning experience by developing CodeSpell system [2], for learning JAVA language. The objective of the study is to identify the self-learning features and enable students to continue learn even outside of the classes. The system designed mostly for introductory level learners and represents video game and have
The most recent and successful research projects conducted by Microsoft research is *Codehunt* [1], which helps to learn programming on Java or C#. This platform used by more than 140,000 students and enthusiasts around the globe. It consist of worlds and many levels, user have to discover hidden code segment and fill it. Based on the *Codehunt* database the data mining is performed to identify a set of hints (automated feedback) that can be given to the player, in order to made playing more engaging with instant feedbacks [28].

Beside the gamification mechanism, the other approaches also used to design educational systems. As learning is strongly individual activity, machine learning techniques can provide significant information for the individual educational material creation. In that sense many intelligent tutoring systems show high positive impact on learning engineering courses, particularly programming languages [30] [23] [17] [18]. The other approaches are learning outcome visualization, beside displaying achievements and rewards, as a way of analysis of the overall learning data [32].

Even though the gamification of education seems to have a positive impact on the learning [19], up until 2014 only 14% of research work in gamification were addressed to gamification in education [10]. Moreover some of pair-reviewed works have couple of limitations, such as small sample size, limited experimental time-frame or usage of only questionnaires in evaluating the impact of system [19]. Some studies even do not provide statistical evidences about positive impact of gamification on effectiveness of learning or cognitive outcomes of students [11] [5] [14], even though acquiring these information is in the future plans for the CodeHunt system [29]. Literature review shows that the existing works in gamified learning of programming are limited by the number of students [1] which is at most 520. The other significant lack of the studies is that most of the successful systems such as *Codehunt* [1], was not tested in a real course settings, to identify the learning results of the system. Moreover, described systems have very narrowed learning objectives, such as debugging skills, guessing code structure, learning language semantics and so on [6] [1]. Finally to identify when and how to apply gamification in university courses, it should be identified what is the professor’s impact on student’s engagement and motivation in using additional learning system?

The objective of this paper is to present the outcomes of gamified web-based platform for learning C++ programming language, in the real class environment. The experimental results are gathered in a scale of one year, during undergraduate programming course, with 600 students??.
<table>
<thead>
<tr>
<th><strong>Paper</strong></th>
<th><strong>Application field</strong></th>
<th><strong>Methodology</strong></th>
<th><strong>Evaluation type</strong></th>
<th><strong>Participating group</strong></th>
<th><strong>Outcomes</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheong et al. [8]</td>
<td>IT course</td>
<td>quiz, score, feedback, leader-board</td>
<td>questionnaire</td>
<td>76 students</td>
<td>77% positive responses</td>
</tr>
<tr>
<td>Denny P. [11]</td>
<td>Health ugrad course</td>
<td>student generated quiz, badges</td>
<td>activity statistics, survey</td>
<td>1000 students, 512 badge-on</td>
<td>22% increase in participation, unchanged quality</td>
</tr>
<tr>
<td>Dubois and Tamburrelli [13]</td>
<td>Software development</td>
<td>rules, scores, competition</td>
<td>project’s final grade</td>
<td>32 group in each 2-3 students</td>
<td>increase of grades average by 0.4</td>
</tr>
<tr>
<td>Brusilovsky and Sosnovsky [6]</td>
<td>C/C++ progr. course</td>
<td>quiz, parametrized questions</td>
<td>regression analysis, survey</td>
<td>101 surveyed</td>
<td>knowledge, participation</td>
</tr>
<tr>
<td>Domínguez et al. [12]</td>
<td>ICT class</td>
<td>trophies, levels, achievements,</td>
<td>quantitative analysis, survey</td>
<td>200 out of which 58 in game-on group</td>
<td>motivation, unchanged quality</td>
</tr>
<tr>
<td>Kumar et al. [24]</td>
<td>C++ progr. course</td>
<td>levels, scores, leader-board</td>
<td>pre-survey for designing system</td>
<td>207 students in pre-survey</td>
<td>—</td>
</tr>
<tr>
<td>Esper et al. [14]</td>
<td>Computer science</td>
<td>video game, worlds, achievements</td>
<td>interview designing system</td>
<td>40 girls in 10-12 ages</td>
<td>non-institutional education, engagement</td>
</tr>
<tr>
<td>Tillmann et al. [29]</td>
<td>Java and C# programming</td>
<td>worlds, levels, badges, scores, instant feedback</td>
<td>—</td>
<td>140 000 users</td>
<td>—</td>
</tr>
<tr>
<td>Akpolat and Slany [4]</td>
<td>Software development</td>
<td>???</td>
<td>—</td>
<td>50 students</td>
<td>—</td>
</tr>
<tr>
<td>Barata et al. [5]</td>
<td>Computer science related course</td>
<td>XP, levels, leader-boards,</td>
<td>in average 48 students for 5 year span</td>
<td>statistical analysis, questionnaire</td>
<td>engagement, increase of grades</td>
</tr>
<tr>
<td>Moreno [25]</td>
<td>Programming</td>
<td>video game leader-boards,</td>
<td>123 students, 60 in test group</td>
<td>statistical analysis, questionnaire</td>
<td>engagement, increase of grades</td>
</tr>
</tbody>
</table>
References


