A Pilot Study of the Influence of Gamification on the Effectiveness of an e-Learning Course

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Abstract. *Research articles on educational e-courses that contain only motivational elements of computer games but do not include playing computer games date from 2010. Such a concept of designing an online course is called gamification and is related to the use of game elements (mechanics, dynamics and aesthetics) for a purpose which is not a computer game [1],[6]. Numerous studies have shown that gamification has a positive impact on the pedagogical and psychological aspects of e-learning. A review of the literature in the field of e-learning courses in information technology studies reveals that the gamification of such courses has been inadequately explored. Therefore, the main topic of our investigation was the creation and analysis of a gamified e-learning course in the field of information technology. Through theoretical and empirical research, our work is focused on: 1) developing an instructional model and a set of recommendations for the implementation of a gamified educational system that would positively affect students' learning; 2) creating a gamified e-course in the field of teaching information technologies; 3) examining a potentially positive effect on students' achievement (measured by objective indicators) in an experimental group of students who used the gamified e-course.*

Keywords. e-learning, gamification, Moodle

1 Introduction

The use of games in education is commonly referred to as "serious games" when it is in the form of teaching using specialized educational games although some commercial computer games can be used for that purpose as well. The use of games can be motivating and interesting for most students since they have a more *dynamic* way of accessing a particular subject or object of teaching. Digital games have become a key component in daily human socializing activity where the notion of games expands and goes beyond the purpose of a pure entertainment form [12]. Deterding et al. [6] suggest that technology and computer games themselves greatly change the traditional boundaries of education as seen through an industrial approach and a growing number of studies on this theme. Studies confirm the positive attitude of respondents using dynamic interactive systems where the emphasis is on learning and which influence learning behavior by means of computer simulations (economic, political, military, construction, etc.) in which the student participates according to the scenario and monitors how his/her decisions are reflected in the goals and the results which are in fact his/her achievements. For this purpose commercial games or highly specialized educational games can be used which are developed for a specific area or topic of teaching and learning.

The beginnings of the development of educational systems that are based on the "dynamics" of playing computer games and have many elements which are seen in computer games but are not computer games, date from the mid-2010s [2], [5]. The term that is most commonly used for the design of educational systems which use game elements but are not games is *gamification* (it represents using game elements like mechanics, dynamics and aesthetics of computer games in the area that is not a computer game [2], [5]). From the research of literature it is evident that researchers, international companies and prominent educational institutions are attaching increasingly more attention and importance to the use of computer games elements [4], [14]. These elements are analyzed and implemented in systems that are the basis of communication, educational, organizational and business operation of the society [26].

In this paper the authors will briefly outline the theoretical rationale for the gamification of online courses and also present findings of their preliminary research on the influence of gamification on students' achievement after their use of a gamified course as an indication of course effectiveness.

2 Review of existing research

2.1 Gamification as modern technology

The first records of the phenomenon of the introduction of elements of computer games in the area which is not related to computer games were

made by Gabe Zichermann [31] and Yu-kai Chou [30]. Gabe Zichermann is the founder of Gamification.org and *GSummit* as well as a lecturer and author of books covering gamification. Yu-kai Chou is the creator of the *Octalysis* system for measuring the degree of gamification, as well as a lecturer at Stanford University and a consultant for gamification systems. Their work focuses primarily on business and marketing systems, while education systems are only marginally mentioned.

Oprescu et al. [17] analyze how the introduction of computer games elements in the workplace could lead to positive and innovative solutions in terms of solving organizational problems and identify ten principles that underpin the implementation of elements of computer games in business organizations.

Gamification is included in the Gartner's Hype Cycles [13] analysis of new innovative technologies since 2011. It was included among the *rising modern trends* in 2011 and 2012 [15], [o], to achieve the *highest ranking* [26], [27] among these trends in 2013. Some predictions are that by the year 2017 thousands of the world's largest organizations will have used elements of computer games as a model for education and/or recruitment of new customers [4].

Souza-Concilio and Pacheco [25] state that the implementation of elements of computer games is visible in various fields including education, healthcare and fitness, task management, environmental sustainability, science, user-generated content and others. For this reason, scientific and educational institutions as well as business organizations should focus on the creation of interactive and gamified solutions that encourage collaboration, motivation and innovative approach to problem solving [21]. According to M2 Research [14], in 2013 the value of the gamification market amounted to $513 million, in 2014 it was $980 million, while in 2016 it could rise to about $2.8 billion [20], [28], [29]. The European Union, as announced within the ICT-21-2014 tender, is seriously considering researching gamification technologies and has recently allocated eight million euros [10] for that purpose.

2.2 Introduction of motivating elements of computer games in education

Deterding [5] states that elements of computer games directly affect motivation and a sense of inclusion, which is widely used by the marketing companies and professionals working in the field of human resources. Ortega de Marcos et al. [18] report a positive attitude and higher motivation among the subjects who were exposed to gamification, while establishing better student achievement during the presence of elements of social networks in the educational system. In their overview of literature, Hamari et al. [9] conclude that research into gamification generally corresponds with the findings of Deterding and partly with the research by Ortega de Marcos, also stating that the reported positive effects are related to the target group and the context in which the gamification was carried out.

Within the academic education research literature Smole et al. [24] establish that, when working in an environment with elements of computer games, students can learn and develop their self-confidence in various ways such as: interaction and collaboration, critical thinking and problem-oriented learning, self-reflection on their work and activities, and immediate feedback on their success or failure, where failure is considered as a basis for new guidelines and effective learning through an effective online course. An effective online course in this context does not only represent a method of teaching where the teacher provides expert course design and delivery, implements appropriate assessment and encourages collaboration, but also presuposses greater student achievement measured by objective indicators in comparison to a more traditional course with the same learning content [8].

Iosup and Epema [11] present a three-year longitudinal research (2010-2013) in two courses that were attended by over 450 students of higher years of study. Their research is based on elements of computer games – three elements in the field of mechanics and four in the field of dynamics. The reported results are extremely positive, particularly with regards to the pass rate in the first exam period that exceeded 75%, greater interest in attending classes as well as performing non-obligatory work.

In their studies, Barata et al. [2], [3] introduce five motivational elements of computer games in the Moodle system with the goal of enhancing the interest of students in higher years of study. Although their first study lasted five years, motivational elements of computer games were only used in last two years. Their research was focused on motivation and student achievement. However, owing to its duration several notable deviations occurred in the implementation of the experiment concerning the unequal number of participants in the group, unbalanced educational materials, as well as diverse conditions in which the teaching process was realized. Their other study lasted two consecutive years. The result of both studies was the increasing interest of students for the lectures and for participating in e-courses, proactivity and greater use of teaching materials. Since their studies do not reveal direct effects of motivational elements of computer games on students' exam scores / course grades, the authors suggest that issue should be examined in more detail in further research.

Seaborn and Deborah [23] argue that only 8 of the 769 studies on gamification they investigated are related to educational systems, while at the same time meeting the following criteria: a) original empirical research, b) human participation, c) essential data collection through experimental approach and d)

using the mechanics of computer games. These investigations were published in the period from 2011 to 2013. They were based on the definitions of the mechanics of computer games that were proposed by Deterding et al. [6]. More than four motivating elements of computer games were used in only one study. Seaborn and Deborah report that none of the eight studies used the theoretical foundations of computer games when designing the experimental research framework, which was also identified as a major drawback.

Pedreira et al. [19] point out that most of the research related to the introduction of motivational elements of computer games in education systems cannot be considered sufficiently relevant because of the lack of empirical evidence on effects of such elements on motivation and student achievement.

Diaz [7] discusses the importance of computer games as well as the concept of student learning and proposes the adoption of elements of computer games as a potential means of influencing student behavior. In their comparison of the *traditional* approach to learning with the *gamification* approach, Kim and Lee [12] emphasize that the traditional approach fails to maintain students' concentration and therefore has a limit regarding the efficiency of teaching/learning. Since mobile devices and highly developed web based systems are currently in much greater use for education there is growing need for modernization of educational methods and approaches in form of gamification.

3 Pilot study

To investigate the effect of gamification on the effectiveness of e-learning courses (e.g. on student achievement in the course), the online module "Lighting and Rendering" was designed in two different versions: (1) as a *non-gamified* course in the Moodle learning management (LMS) system, with basic features like learning content and discussion forum; (2) as a *gamified* version of the course, with features like a toplist of best students, badges and certificates for accomplishment, among others.

These two pedagogically different versions of an e-learning course were used by two experimental study groups and two control study groups of students during the 2014/2015 academic year. A *pre-test* was used to evaluate the preliminary knowledge of students before they accessed the two versions of the online module "Lighting and Rendering" of the "3D Modeling" university course. After the two groups of students had been using the online modules for two weeks, a *post-test* was applied to measure the effectiveness of the *gamified* versus the *non-gamified* version of the course. In addition, a *survey questionnaire* was used with assessment scales to evaluate students' perception of specific characteristics of both versions of the "Lighting and Rendering" online module of the university course.

After the brief outline of our pilot study, a more detailed description of methodology is presented in the continuation of this paper.

3.1 Goals and hypotheses

The main goal of our pilot study was to investigate the effectiveness of *gamification* of an informatics online course in comparison with conventional presentation of online learning content with only text and illustrations. Therefore, the online module "Lighting and Rendering" of the "3D Modeling" online course was gamified. The intention was to develop and test this type of pedagogical design that could be applied in other topics of the "3D Modeling" university course as well as in other ICT/informatics university courses.

In accordance with the goals of the pilot study two main hypotheses were formulated:

H1*:* The use of the *gamified* online module "Lighting and Rendering" by the *experimental group* will result in statistically significant greater average achievement measured by the post-test in comparison to the average achievement in the post-test of the *control group* that will use the parallel *non-gamified* version of this online module.

H2*:* The average score for the self-evaluation scale "Course achievements" will be statistically significantly higher for the *experimental group* that will use the *gamified* version of the online module "Lighting and Rendering" in comparison to the average score in the same self-evaluation scale of the *control group* that will use the *non-gamified* version of this online module with the same learning content.

3.2 Instruments

The first step in our research was creating 2 parallel versions (*gamified* and *non-gamified*) of the online module "Lighting and Rendering". Both versions were designed for a study period of 2 weeks regarding the amount of learning content and administered predominantly as a *self-paced* e-learning course. The following learning topics were included in both versions of these e-learning courses:

- Mental Ray Rendering Engine
- Raytrace and Depth Map shadows
- Global Illumination
- Final Gathering
- Image-Based Lighting
- Basic and Advanced

The main design features of the ***gamified*** version of the online module included [16,22]:

- Learning content (text + illustrations)
- Multimedia
- Forum
- Chat
- Blog
- Surveys

- Profile pages
- Visual status of student assignments
- Visual status of progress and course completion
- Actual achieved points for completed tasks
- Bonus learning material
- Top-list of best students
- Badges

However, the ***non-gamified*** version of the online module included only the following elements:

- Learning content (text + illustrations)
- Forum

The *first instrument* in our study was a ***pre-test*** that was intended to measure knowledge of the following topics of the "3D Modeling" university course that preceded the use of the online module "Lighting and Rendering": Autodesk Maya basics, 3D Modeling, texturing etc. It consisted of 26 multiple-choice items and 6 open-ended items.

The *second instrument* was a ***post-test*** with items related to the previously mentioned topics of the online module "Lighting and Rendering". The post-test also consisted of 26 multiple-choice items and 6 open-ended items.

Finally, after completing the post-test the subjects in our study also completed an extensive ***survey*** (the *third instrument* in our study) for the evaluation of the two versions of online modules "Lighting and Rendering", as well as of the factors that influenced their achievement. However, in this report on our pilot study only the data collected with the self-evaluation scale "Course achievements" used in this survey will be presented. This scale consisted of 9 items. The Cronbach alpha coefficient for this scale was 0.95 when calculated for the 55 subjects in our pilot study. Examples of the items of the "Course achievements" scale are: "The use of the e-course has increased my knowledge"; "The e-course has enabled the acquisition of skills for practical application of knowledge"; "I wanted to learn as much as possible about the subject or the e-course".

3.3 Subjects

The subjects in our pilot study were 55 students (31 male and 24 female) of a Croatian university who enrolled in the "3D Modeling" course. The students were divided in 4 study groups that attended lectures in a computer laboratory. Two study groups with a total of 28 students formed the ***experimental group*** that used the *gamified* version of the online module "Lighting and Rendering". The other two study groups with a total of 27 students who used the *non-gamified* version of the online module formed the ***control group*** of subjects in our study. The experimental and control group were similar regarding the gender ratio of subjects. Also, in the ***pre-test*** the *experimental group* achieved the average score of 16.00 points, while the control group achieved the average score of 15.37 points (the difference in the average score on the *pre-test* between the two groups of subjects was not statistically significant).

3.4 Method

The online module "Lighting and Rendering" was designed as a "3D Modeling" university course at a Croatian university. This online module lasted for two weeks and was delivered in *two separate versions* with equal learning content, but a different pedagogical design. One version of the course was *gamified* with numerous features designed to increase student motivation and engagement, while the other – *non-gamified* – version only contained the theoretical content and a forum. The *experimental group* consisting of 28 subjects was provided with the access to the *gamified version* of the online module "Lighting and Rendering", while the *control group* with 27 subjects used the *non-gamified version* during the same time period. The content of the online module "Lighting and Rendering" was not part of the oral lectures or written practicums in the course. The students in the control group used the online module for two weeks during which the instructor interacted with the group through the instant messaging system and forums. Interaction between students occurred through team work on their assignment, i.e. problem based exercises. Students in the experimental group could choose to be more active and make use of the extra educational materials and activities in the gamified version of the online module "Lighting and Rendering".

A *pre-test* was administered before the students were provided with access to the two versions of the online module "Lighting and Rendering" to ensure that there is no statistically significant difference between the experimental and the control group in terms of their initial knowledge of the course topics. After two weeks of access to the two versions of the online module "Lighting and Rendering", a *post-test* was administered in the experimental and control group to measure their learning achievement. In addition, a *survey* was used to measure the subjects' evaluation of the courses as well as to investigate other factors which may have influenced their achievement.

3.5 Results of data analysis

As mentioned earlier, regarding the results of the *pre-test* there was no statistically significant difference in the average test score between the *experimental* and the *control* group. To analyze the difference between the *experimental* and *control group* regarding the average score on the *post-test*, the t-test for independent samples was used. The results of the post-test for the two groups are presented in Table 1.

Table 1. Results of *post-test* for achievement in the online module "Lighting and Rendering"

Group	N	Mean	Standard deviation
Experimental	28	20.89	5.78
Control	27	15.30	4.50

The results of the t-test indicate that there is a statistically significant difference (t=4.00, p<0.00) in favor of the experimental group regarding the average results of learning with the gamified version of the online course. This finding confirms the first hypothesis (H1) of our study.

To illustrate the effects of the use of the gamified version of the online course in comparison to the non-gamified version for all four study groups of students who participated in this research their *average grades* (on a 1-5 scale) in the pre-test and the post-test are presented in Fig. 1. The data in Fig. 1 indicate that on average, despite similar *average grades* in the pre-test, the two study groups of students that were included in the *experimental group* of subjects and used the gamified version of the online module "Lighting and Rendering" achieved greater learning success (measured in grades from insufficient/1/ to excellent/5/) than the other two study groups of students that were included in the *control group* of subjects.

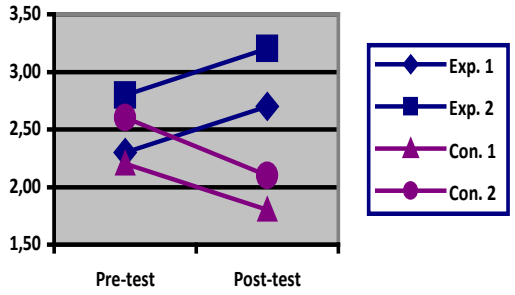

Figure 1. Results of pre-test and post-test for different study groups presented as *average grades*

To identify one potential reason for such diverse outcomes of attending the *gamified* versus the *non-gamified* version of the online module "Lighting and Rendering", the results of the self-assessment scale "Course achievements" are presented in Table 2.

Table 2. Results of self-assessment scale "Course achievements"

Group	N	Mean	Standard deviation
Experimental	28	32.79	7.31
Control	27	20.89	6.53

The results of the t-test for independent samples indicate that there is a statistically significant difference (t=6.40, p<0.00) between the average results in the scale "Course achievements" of the *experimental group* in comparison to the *control group* of subjects. The *experimental group* of subjects evaluated the effectiveness of learning with the *gamified* version of the online course more favorably in comparison to the *control group* that used the *non-gamified* version. This result confirms the second hypothesis (H2) of our study.

4 Conclusion

In the pilot study that is presented in this paper the authors investigated the effects of gamification on the results of e-learning activity associated with 3D Modeling that lasted for two weeks. It must be mentioned that for the subjects in the *experimental group* of our study this was their first experience with a gamified e-learning course (i.e., to be more specific, an online module entitled "Lighting and Rendering" of a university course), which may have increased their motivation and interest. The short duration of the gamified e-learning course (i.e. the use of the online module "Lighting and Rendering" by the students) and the selection of subjects for our study prevent the authors from the generalization of the results of this study in relation to other online learning environments, different learning topics, as well as more extensive and repetitive use of gamification in online courses.

However, the results of this pilot study seem to indicate that gamification of online courses related to 3D Modeling may increase student engagement and result in greater online course achievement. This finding encourage us to investigate the gamification of online learning content for other topics of the university course "3D Modeling", as well as other ICT related courses of the authors of this paper.

The literature on gamification and serious games generally states that gamification may provide positive effects on learning. However, these effects are greatly dependent of the context of learning and characteristics of learners. Therefore we would recommend that before investing time and effort in more extensive gamification, a module of a larger university course is gamified and its effects tested on a specific set of subjects, which is the approach taken by the authors of this paper. It is noteworthy that in another more recent and still uncompleted pilot study that we performed on a much smaller set of subjects who attended a different course at another university in Croatia no significant difference was found in the post-test between the experimental and the control group of subjects.

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