Using Gamification for Teaching UML in Information System Design Course

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***Abstract*—Nowadays the practice of introducing gamification into areas such as education became quite popular. In this paper, we are examining the effects of applying gamification into the process of teaching the Information System design using Unified Modelling Language. In gamified UML course, we focused on introducing such game elements as points, levels, badges, leaderboard, and bonuses into the teaching process. Students' activities during the course were logged and later analyzed. During analysis a positive influence on the student grades was observed. Moreover, a positive effect was noticed on the student intrinsic motivation.**

Keywords— gamification; education; UML; RUP; modelling.

I. INTRODUCTION

Gamification is described as a practice of using game elements in a context, which has no direct association with games [1]. Recently the practice of introducing gamification into areas such as education, sales, banking, customer loyalty programmes etc. became quite popular [2]. Various degrees of success in applying gamification in education are observed as gamification provides common structure for motivating and engaging students into the learning process [3].

In this paper we are analyzing the process of applying gamification into the process of teaching the information system design using Unified Modelling Language (UML) [4].

UML provides a standard for visualizing and specifying the design of software systems and is commonly used during the software engineering process [5] [6] [7]. UML notation is introduced and taught in various higher education institutions [8] [9] [10].

UML is a graphical notation which enables modelling software engineering concepts represented in structure and behavior diagrams. These diagrams are taught during the course for undergraduate students in Kaunas University of Technology Informatics faculty's curated study programmes. Students are tasked in preparing specification and documentation for software projects.

Other higher education institutions also often use UML in their software engineering courses' curriculum [5] [6] [7] [9] [10]. Some courses try to automate the process of teaching and evaluating students, although for now this automation covers just two out of fourteen UML diagrams [7]. Other courses use UML class and sequence diagrams as tools in improving student comprehension of software code [6] [7].

In Kaunas University of Technology Information Systems Design course fourth year undergraduate students are extensively taught of using UML in object-oriented development of Information Systems. The course encompasses a broad range of UML diagrams and their uses in requirements engineering, design and implementation of Information Systems.

Unified Modelling Language provides only the notation for describing visual models but does not define the process and context of using these models. Many software engineering processes exist, but the one used in this course is Rational Unified Process (RUP) [11]. RUP is use case driven, iterative development framework, which helps to mitigate risk, defines easily visible progress, provides early feedback and helps managing software projects of varied complexity [12].

Student's motivation and engagement play a huge role in the teaching process, many of the students tend to lose their motivation and thus the quality of teaching diminishes. To combat this problem and to increase student engagement into the learning process an idea of gamifying the Information System Design course was proposed. When applied correctly, gamification tends to increase motivation, helps to engage students [13]. Unfortunately, no gamified courses or tools for teaching UML were found.

At the start of 2017 autumn semester student were invited to participate in the gamified course. Students' activities during the course were logged and later analyzed. Results show that gamification had a positive effect on student grades. In addition to the logged data, students were surveyed measuring their intrinsic motivation. Surveys' results indicate that students' intrinsic motivation increased, provided they used the gamified system regularly.

The rest of the paper is organized as follows. The second section analyzes related work in the area of applying gamification in education. The third section presents the proposed methodology for gamifying Information System Design course, course structure and its implementation in

Moodle learning management platform. The fourth section is dedicated to analyzing the results of application of the gamified course in practice. The last section overviews the paper, outlines the major outcomes and provides a glimpse into future research ideas and upcoming planned tasks.

II. RELATED WORK

Gamification in education helps to enhance courses in order to increase user engagement, productivity and motivation [1] [2] [3]. Gamifying the educational material improves comprehension of difficult topics and helps to better understand area such as software engineering [14]. There exists a number of case studies on applying gamification in education that had direct ties with software engineering, but not with applying UML. The case studies gamified course themes ranged from C programming [14], Service Oriented Architecture [15] to national budget forecasting [16].

The case study presented on Gamification for Engaging Computer Science Students in Learning Activities [14] tried to measure the effectiveness of gamified C programming language teaching platform Q-Learning-G and student engagement into the process. The authors of the study analyzed what kind of learning activities are the most attractive to students.

The research by Buckley and Doyle [16] focused on finding out whether the gamification has any positive effect on student motivation. They used the gamification for introducing the national tax system. The results of this study show that gamification has the bigger effect on students that are already inherently motivated.

The research on Gamification in Higher Education [15] tried to determine whether gamification has any positive results for student development. The authors tried to discover the most effective gamification methods or elements. The case study had a sample size of 62 graduate students in four different groups. Two groups were taught in a traditional course, and other two were taught using gamification elements like points, badges and leaderboards.

A case study on The Gamification Model for E-Learning Participants Engagement [17] performed by Kaunas University of Technology Informatics faculty developed an online system for teaching programming. The online system was intended for secondary school students. The system was developed on the proposed gamification model and with a goal of confirming the model's validity for usage in an educational context.

Although no gamified courses for teaching UML were found, it is clear that the principles and methods used in the aforementioned case studies could successfully be applied to the gamification of Information System Design course.

In order to test the gamification effect on students researchers tend to formulate hypotheses [14] [16] or outline goals [14] [17]. Other authors formulate questions or problems [15]. Our research would also benefit from outlining a goal, which would determine whether motivation and engagement of students increases with the implementation of gamification.

Reviewed case studies mostly consisted of applying such game elements as badges [14] [15] [17], levels and point gathering for raising levels [14] [15] [17]. Thus, environment is required, which gives instant feedback and tangible results for students' activities. In various degree of success, leaderboards were used [14] [15] [16] [17]. This helped to facilitate competition among students and enable comparing personal results that of their peers. Additionally some studies used virtual currency for trading between users (one for forecasting changes in market and maximizing the profits of transaction [16], the other for unlocking further tasks and activities [17]).

Authors of [14] [16] used questionnaires to measure the effects of gamification as well as analyzed system data, for the confirming the proposed hypotheses. The questionnaires were conducted twice, before the start and after the completion of the gamified courses [14] [16]. In all cases, the most common used method of data gathering was the platform itself [14] [16] [17]. Other authors [15] compared the results of two different group sets for determining the effects of gamification.

After reviewing the relevant case studies, it was determined that the most common and effective gamification elements are points, levels and badges and these elements should be applied in the proposed gamified Information System Design Course. The gamified course should also include a leaderboard. During the gamified course, at least two surveys should be executed. An Intrinsic Motivation Inventory scale [18] was found for measuring student intrinsic motivation and is suitable for preparing the questionnaires. Additionally, students' gamified Information System Design course usage should be logged, as it can provide a different perspective for finding insights on the gamified course. These insights could later help to improve the course. It is also important to outline a clear measurable goal for easier confirmation.

III. PROPOSED METHODOLOGY FOR GAMIFYING THE INFORMATION SYSTEM DESIGN COURSE

The goal of our research was to increase student motivation and engagement into the learning process in Information System Design course. A relevant way to attain the set goal is to gamify the course by implementing some game elements into the course curriculum and teaching process.

In gamified UML course, we focused on introducing such game elements as points, levels and badges into the teaching process. In order to encourage the competition among students, a leaderboard was introduced. However, we decided not to focus on grade bonuses for rewarding students, and instead to use the complete example UML models for the upcoming laboratory practical works as bonuses.

During the analysis of the teaching material of existing course, it became clear that some restructuring of the material itself was required in order to facilitate the gamifying process. A new course structure was proposed to include levels and points, which would help to guide students through the learning process. We based the structure of the course on the Rational Unified Process disciplines and diagrams used in this process. Rational Unified Process disciplines like business modeling, requirements, requirement analysis and design, implementation and deployment provide developers a clear platform on which to build their project [12].

Levels and points would not only provide structure, but also engage students, by giving them an instantaneous feedback on the result of the tasks. Levels and points serve two purposes – guiding student behavior and giving student feedback at any point in time, signaling the students' progress. At any point when the student completes a task, he would be rewarded with points. Achieving the base level of completion additionally would reward a student as well.

With levels and points, badges were also introduced into the course. Students would receive a badge at any point when they would level up in the course.

Lastly, we decided that students should also be able to receive some useful rewards, like example UML models. Such items would be used for increasing student motivation as external motivators.

A. The contents of Information System Design course

During the base course curriculum, students were taught of eight UML diagrams out of total fourteen, and their various application in software engineering process based on Rational Unified Process (RUP).

The set of UML diagrams used in this course includes class diagram, use case diagram, state machine diagram, activity diagram, package diagram, robustness diagram (specific for RUP), sequence diagram, component diagram and deployment diagram.

Class diagram is used to describe domain entities, their structure and relations. State machine is used to represent entity lifecycle's states and transitions between them. Use case diagram is used to represent system functional requirements, system users as actors and their relations with designed systems use cases. Activity diagram is used to specify use case scenarios, by defining system and user interaction in the most abstract way possible. Package diagram presents the initial logical architecture of the system under development. Robustness diagram is a stereotyped communication diagram used for robustness analysis. It is used to fill the gap between system requirement analysis and design steps. After the class definition in robustness diagram, sequence diagram is used to specify the interaction between system objects and the external actors. The basic logic of sequence diagram is supposed to correspond to the use case scenarios in the previously defined use case activity diagrams. Component diagram is used to define system components that are later realized by previously defined class objects. This diagram also represents component manifestation by artifacts. And lastly deployment diagram is used to define the system physical architecture and its artifacts' distribution inside various nodes, such as devices, execution environments and so on.

The course curriculum is based not only on the UML diagram notation, but also on the Rational Unified Process disciplines and their respective requirements. Business modelling is used to define goals. Business analysis provides opportunities to determine possible enterprise process improvements. Requirements discipline provides framework for identifying and describing application functional requirements (such as use cases). Design discipline encapsulates all aspects of design, including but not limited to architecture, objects, classes, databases. Other disciplines such as implementation, test and deployment are only partly covered the curriculum scope by several diagrams, as these disciplines deal more with actual programming, building and realization of the application and is not the focus of the course curriculum.

B. The proposed structure of the gamified course

Based on the course curriculum, ten levels were introduced into a course. Five for teaching the basics of UML diagrams' syntax and five for teaching the semantics, and their usage in RUP. The course progression was locked behind the levels and structured in such a way that the student would not be overwhelmed with vast amount of information from the get-go. Student at the start only had access to a few resources and only after achieving some levels the course would open up.

Syntax levels in the gamified course were divided by diagrams and for each diagram a task was designed. Use case and activity diagrams were described in the first syntax level, in the second syntax level class and state machine diagram were introduced. Third syntax level consisted only of robustness diagram. Fourth syntax level introduced class diagram elements, previously not explored in second level and sequence diagram. And lastly fifth syntax level consisted of component and deployment diagrams. A total of 97 questions were created to test student knowledge on the UML diagram syntax.

Other five levels for teaching the semantics of UML diagrams were based on the Rational Unified Process engineering disciplines. Business modelling for the first semantics level, requirements for the second, analysis and design for the third, implementation for the fourth and lastly fifth for deployment. The course did not include test discipline as it falls outside the course curriculum scope.

Level order was chosen based on the curriculum material as well as introducing diagrams based on their role and usage in the RUP lifecycle and its respective system model. Each level is composed of at least one test and lecture material for the corresponding topic.

The very first level was business modeling which had one test, which introduced business modeling and RUP business profile stereotypes and their usage. After achieving, the passable result students could access the example UML models. Second level presented tasks for the most common UML diagrams, class (attributes, classes and relations) and use case diagram (actors, use cases and relations). The third level was composed of state machine diagram and its elements states, pseudo states and transitions, as well as activity diagram and its elements – actions, objects, flows, nodes and partitions. The fourth level had tasks, which outlined the use of previously introduced diagrams and their adoption in RUP requirements discipline model. Completing this level unlocked access to the second example of UML model. The fifth level introduced robustness diagram for class syntax with specific stereotypes. The sixth level dealt with object-oriented analysis and design step in RUP discipline process. The seventh level introduced sequence diagram and its elements – lifelines, fragments and messages, as well as class diagrams with previously not analyzed elements such as operations, interfaces and specific relations between them. The eight level introduced implementation discipline and its place in

the UML system model. The ninth level introduced component and deployment elements – components, artifacts, nodes and relations between them. Once the ninth level was completed, students gained access to the complete example UML models. Lastly, the tenth level described deployment discipline and diagrams used in this discipline and their semantics.

C. Implementation of the proposed course structure

Learning management platform Moodle [19] was chosen for the implementation of the proposed methodology because of the extensiveness and adaptability of the platform.

A Moodle course (Fig. 1) was created where the designed model of levels was implemented, and 230 test questions were created to check student knowledge on the UML diagrams syntax or semantics.

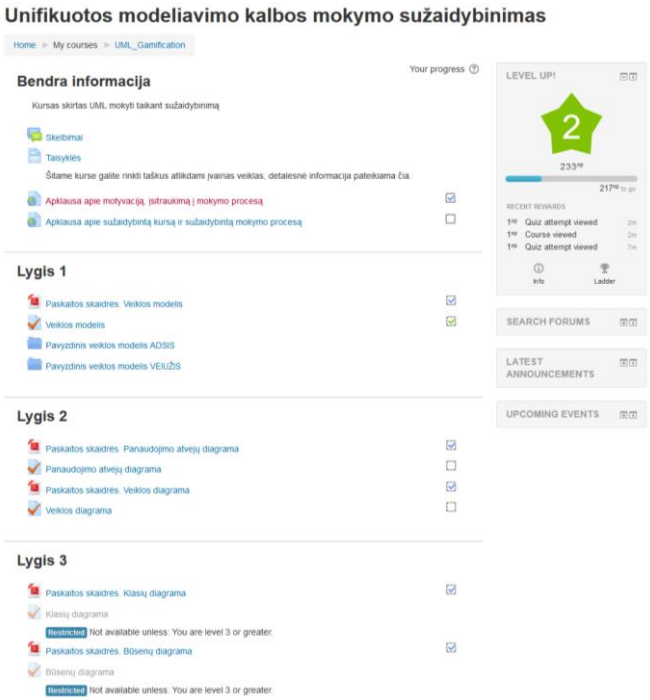

Fig. 1. Gamified Information System Design Course

In syntax levels, nine tasks were created for each diagram type. Each diagram task consisted of test. Each time while attempting the task, student received a grade, which if passed awarded student 100 points only once. Under no circumstances, students' failure was meant withholding the award. In case of failure, students were awarded only for attempting the task. The example of the Moodle test, used in the course is presented in Fig. 2.

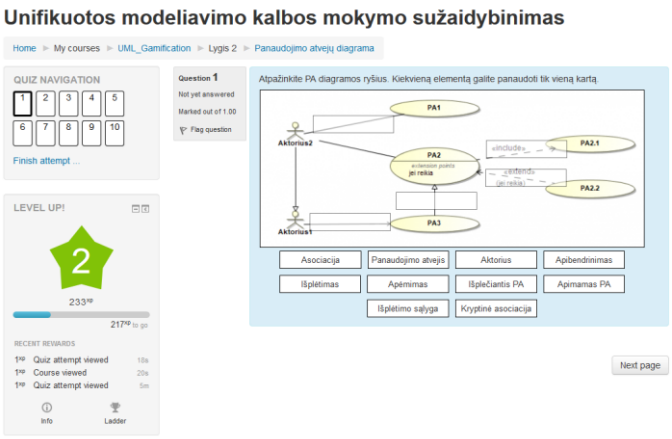

Fig. 2. The example of the test from the gamified Moodle course

In addition to the nine tasks for syntax, five tasks were created for semantics levels. Each semantics task was worth 200 points. Like in the syntax levels, students were only awarded full points once, when meeting the passable requirements for the task.

Additionally, students who were able to reach passable grade in semantics levels 1, 2 and 4 were rewarded with example UML models.

As basic Moodle environment does not have the functionality for awarding points based on task results, and levels. A plugin [20] was used to implement levels and the handing out of points. The plugin also included a leaderboard for rating the students based on their level and earned points (Fig. 3).

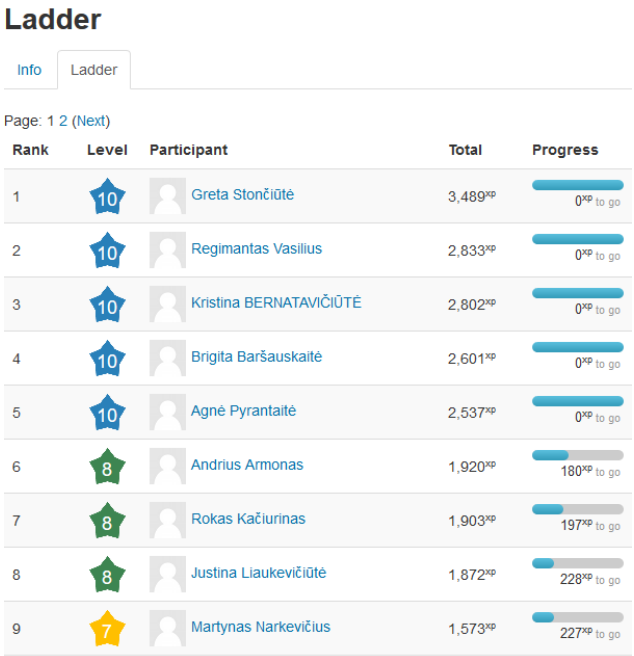

Fig. 3. Gamified Information System Course leaderboard after the course completion

A plugin Level UP! [20] was used to implement the required changes for gamification of the course. During the course implementation, the plugin was adapted to work seamlessly with Lithuanian language, as the course curriculum material and language of instruction is Lithuanian.

The proposed course structure was implemented by locking contents based on student level. The maximum attainable points of the levels tasks' determined each level point requirements.

Overall, the syntax levels had a set of 129 questions. Respectively each diagram task had the set of ten questions, except for the robustness diagram as it had five.

Likewise, the semantics levels were composed of 97 questions over all five tasks. Business modeling task had ten questions of the available 23. Requirement task had 16 questions out of the 34 available questions set. Requirement analysis task had 5 questions out of 10 available. Implementation/ Design task had 8 questions out of 15 available. Lastly, the deployment task had 6 displayed question in a task, out of the 15 questions set.

The implemented course consisted of 10 levels, in total of 2300 (Fig. 4) required points to achieve the maximum level, leaderboard, badges, structured curriculum content and additional rewards like example UML models.

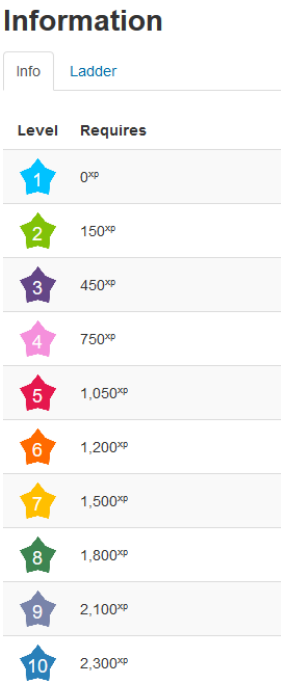

Fig. 4. Gamified Information System Design Course levels requirements

The proposed changes to the course were successfully implemented into a local Moodle platform used by Kaunas University of Technology Informatics faculty. A question bank of 230 questions was created, ten levels for structuring the material, a leaderboard, example UML model rewards and 13 tasks were effectively put into practice.

IV. Results of Experiment Performed Using the Gamified Course

A. *Experiment environment setting*

At the start of semester in autumn 2017 students were invited to partake in a gamified course for the duration of the whole semester. A total of 27 students were added to the Moodle course on September 21st.

Students were also asked to provide responses to the questionnaire based on the IMI scale [18]. In order to assess the base group level of intrinsic motivation a 17 question questionnaire was created. In total two questionnaires were prepared, one to measure the base level of motivation, the other to assess the level of student motivation during the gamified course.

The first questionnaire was available from the September 28, a week after the student introduction into the course. 22 students completed the first questionnaire.

The second questionnaire became available after the final exam of the course, on the 15 of January, 2018. 18 students completed the second questionnaire. Respectively each question in the second questionnaire directly corresponded to the question from the first questionnaire (e.g. "I enjoy studying" in the first questionnaire and "I enjoyed doing activities in the gamified course" in the second questionnaire). Both questionnaires were anonymous, and the collected results were calculated based on the averages.

Students participated in the gamified course activities mostly from October 2017 to January 2018, as of writing this paper the last visit by a student was made on 22nd of January.

B. *Analysis of experiment data*

For determining the experiment results, an exploratory data analysis was performed for the data compiled during the experiment. The data from Moodle platform was used, as it provides extensive reports for user participation in the courses.

In addition to the exploratory data analysis, two questionaries' results were compiled to measure the intrinsic motivation of the student group. The questionnaire was anonymous, and results are based on the averages. Each question is grouped by a type which the question measures. These types can be used to determine not only the intrinsic motivation but also aspects that have effect on motivation in general. IMI scale supplies seven question group types. Any survey can be tailored to meet the specific needs of the study. For the experiment four group types were selected – interest/enjoyment, perceived competence, effort/importance and value/usefulness.

An additional question was introduced into the questionnaire, where gamified course was evaluated. The question asked to specify the frequency of students activity in the gamified course.

By comparing the data, we can see that students who did not use the gamified course, had much lower intrinsic motivation results except for the interest/enjoyment group (Fig. 5). This could mean that students were interested in the idea of gamification, but were not attracted enough to participate in the course.

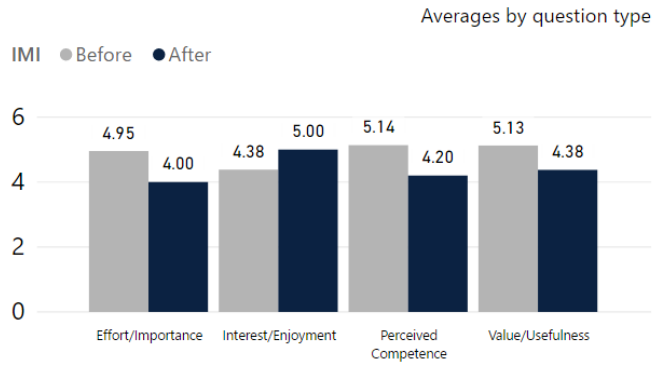

Fig. 5. Intrinsic motivation of students which did not participate in the course

For the students, who used the gamified course less than once a month, results indicate that student motivation increased in all levels comparing to the base student level, except for the third question type, which measures perceived competence (Fig. 6). This could mean that students feel that the questions were too difficult and should be simplified for the gamified course.

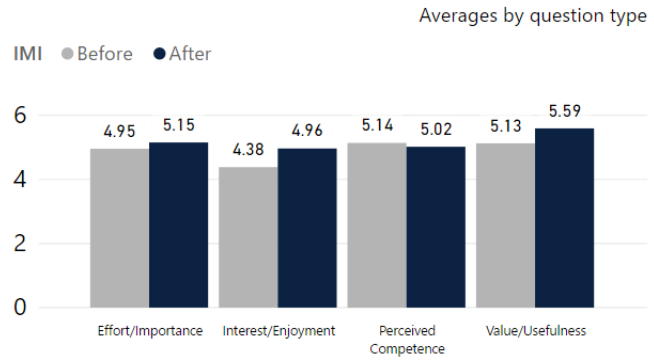

Fig. 6. Intrinsic motivation of students who participated in the course less than once a month

In addition, the last response group, which say that they used the gamified UML course at least once per month or more frequently, have even more favorable results (Fig. 7). The responses of students, which used the gamified course regularly, indicate that the motivation increased across all measured aspects.

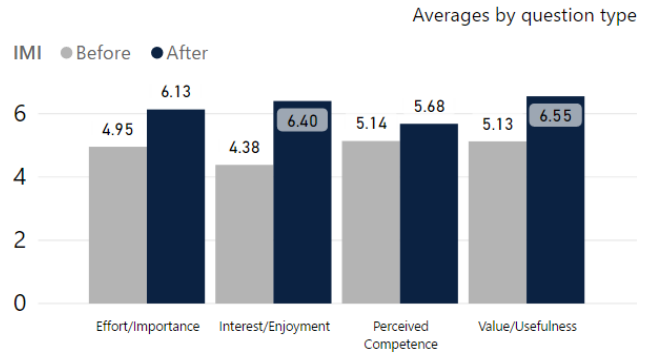

Fig. 7. Intrinsic motivation of students which participated in the course once a month or more often

Lastly comparing the overall results (Fig. 8), we can see that the students' general intrinsic motivation increases with the frequency of activity in the gamified UML course.

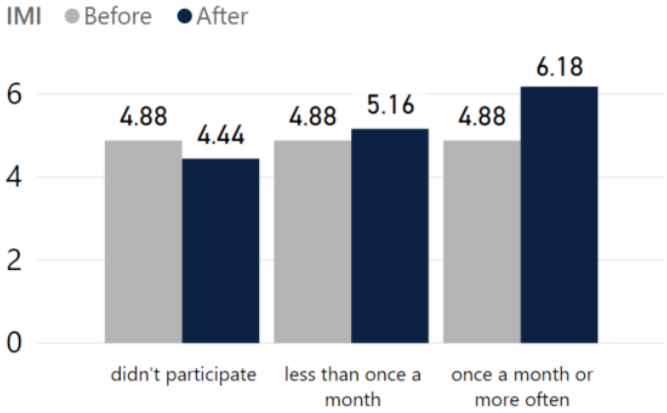

Fig. 8. Intrinsic motivation of students grouped by the frequency of usage in the course

Additionally, student results were compared to evaluate gamified UML course effect on students' grades (Fig. 9). Two sets of data were compiled. The first set consisted of the students grades for the 2016 course, during which students did not use or had access to the gamified material. The second set encompassed students' grades for 2017 course, where students were able to use gamified Information System Design course. The grades are represented as follows: for the test, which is the quiz evaluating student theory knowledge of UML; for the exam, which consists of the test and a practical task for creating an UML model with CASE tool; the suggested grade, which student earns during the semester; and the final grade, which is the final grade of the course.

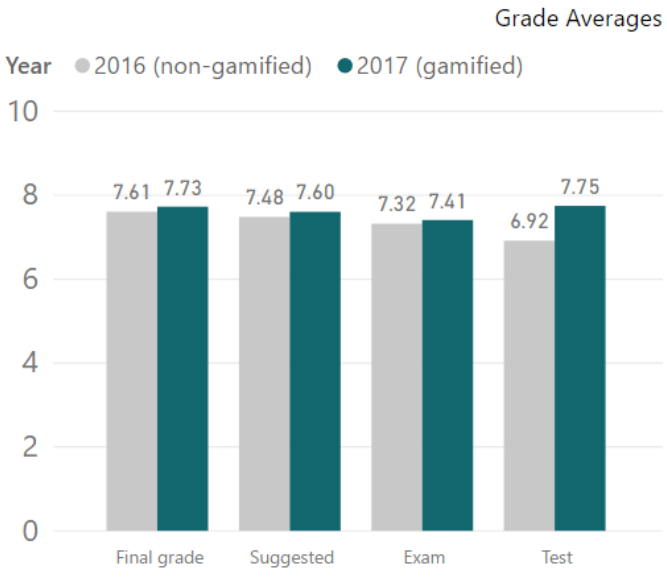

Fig. 9. The grades of the students in the course, with and without gamification

Traditional and gamified courses were organized to take place in parallel. Student participation in gamified course was voluntary and students were not offered any other incentives

except for rewards in the gamified course such as practical work examples. The complied data includes all students regardless of the fact whether they used gamified course or not. The averages are being compared to previous year of 2016 students' grade averages, who did not have access to gamified course.

It is clear that students' results in test portion increased drastically around 0.8 point on average, more than 10 percent. Other results do not show any dramatic change and therefore could not be attributed as the effect of gamified UML course. Although other three group results exhibit an overall small positive change.

V. Conclusions and Future Work

Most of the studies that we have analyzed, place their focus mostly on gamifying the learning material to improve the understanding and student engagement. The case study described in this paper aims to engage students and attempts to increase student motivation. We have proposed the structure of the gamified course, the required gamification elements and implemented the proposed course in Moodle platform. The experiment was carried out during 2017 autumn semester, which had 27 participating students in the gamified course. While analyzing the results gathered during the experiment, a positive influence is observed on the student grades. A marginal difference is recognized in the student intrinsic motivation.

Though we have to admit, that the results are inconclusive, because of the small sample of participants. For that reason, we plan on having a second round of the experiment. The new experiment will have a larger sample size and would be using an improved version of the same course. In order to better understand the gamification effects on the student motivation, more gamification elements will be introduced into the second iteration of the course. According to the feedback from the first experiment, the reducing of requirements for passing the task and the larger sets of questions will be included as well.

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