GAMIFICATION FOR ASSESSMENT OF OBJECT ORIENTED PROGRAMMING

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Abstract

There has been a focus in the ICT industry on the education of programming during the last decade, given that a lot of students who have taken programming courses at the third level, could not meet the industry requirements in related fields, due to lack of engagement or motivation. Java programming language, in an online setting, requires the provision of special gamification components, in order to lead to a better quality of teaching and learning. The aim of the project was to gamify, test and evaluate a specific course on Introduction to Java within GeNIE, a portal for gamification of higher education.

Introduction

Gamification, which means using game elements in non-game environments, was studied a lot in recent years and was used in a lot of fields, such as education, marketing, and business (Burke & Hiltbrand, 2011). In recent years, educators began to investigate the effects of different gamification elements within the context of education (de Sousa Borges, Durelli, Reis, & Isotani, 2014). There has been a considerable debate regarding the actual effects of gamification on the intrinsic motivation of students towards learning, and much research has been conducted to discover the results of *gamifying* in any specific course curriculum (von Ahn & Dabbish, 2008). Each research study has in turn revealed another impediment, whereas multiple review studies revealed significant problems with some of the methods of most studies in the research area now known as *the gamification of education* (Lee & Hammer, 2011). This project's aim is to implement and gamify a course online for teaching the object oriented programming language Java, using a portal for gamification in higher education (Çubukçu, Goodman, & Mangina, 2016).

First, the project focused on the review of gamification concepts, especially for online education and programming, the recommendation system and the GeNIE oriented framework. Second, the Introduction to Java module for undergraduate students was embedded within GeNIE, and software components for the implementation of the gamification functionality towards the learning task of Introduction to Java were designed and developed. Third, this project built a recommendation system to filter information according to student's profile and peer learners. Also, justification and evaluation of the game elements and the game design techniques applied were executed. The

project also processed the software evaluation regarding the software components and the user's interactions for students within the third level institution.

Gamification for Programming Education and Online Teaching Environment

For university education, especially for teaching a computer science course, engagement seems to be of high importance, and gamification is likely to be a way to deal with this issue (Wood & Reiners, 2012). Gamification could let the system be "more fun and engaging" (Zichermann, 2011). Shahdatunnaim, Noorminshah, and Norasnita (2015) did a literature review on gamification in online collaborative learning for programming courses, where they analysed the challenges for programming students, discussed the elements for students' participation in the OLC (Online Collaborative Learning) environment and game elements for facilitating it, and then presented the methods on gamification in OLC. The authors claimed "Gamifying learning activities for programming language subjects is an effective solution to solve the programming challenges faced by first-year computer science students." pg. 18091, (Shahdatunnaim et al., 2015). Knutas, Ikonen, Nikula, and Porras (2014) presented a case study on "Increasing Collaborative Communications in a Programming Course with Gamification" utilizing a gamified communication system to motivate and improve the communication among students. The study was very successful, and they found that collaboration was increased and students' response time was decreased, while the course communication was made 88% more efficient. Gamification is also helpful in terms of lectures. In Sazkia, Gumilang, and Hasibuan, (2015) the authors claimed that the lecturer could also benefit from the platform by monitoring the progress of students, seeing missions, levels and badges for students. Dubois and Tamburrelli (2013) proposed a method for understanding the gamification about software developing in different cases. They found that for their software engineering courses in Politecnico di Milano, gamification worked well, and the work of students using the gamification approach was of higher quality than that of those without it.

Olsson, Mozelius, and Collin (2015) have identified in an online education environment some specific problems, such as the boredom and loneliness. The authors claimed that learner control and motivation seems to be the key for the success of online education, and gamification is a method to improve the motivation of study. But gamification could not work well for every subject, since students have various learning styles, and some extra specific methods could be used to deal with special problems. Besides, the content of the gamification needs to be set carefully and be nearly, even totally impossible, to use the system just for fun. The designer should manage to avoid a situation where, although gamification seems to have larger effects on them, students' attention is more easily turned away from gamified content (Erenli, 2013).

Recommender Systems for Online Education

Recommendation systems provide users with personalised information and recommendations among a lot of items or services. These can be divided into three categories: content-based, collaborative, and hybrid recommendation

approaches (Adomavicious & Tuzhilin, 2005). The content-based system uses the information of the items or users to make recommendations. Differently, the collaborative technique does not use any detailed information about the items. Instead, it uses the similarity between users or items to make the recommendation. The recommendation system has been used in a lot of contexts, including education. Zaïane (2003) made a recommendation system in the online education environment to make recommendations depending on the history of students' activity. The system could then navigate students to experience a better learning path and make the continuous assessment more convenient. This study presents the potential of a certain method of using the recommendation system in the e-learning environment.

The recommendation system might also be used in education with gamification. For example, Gondova, Labaj, and Bielikova (2016), presented a method of navigation in a gamified education system that used two recommenders. They chose questions for students from simpler to more complex and questions that made the students navigate between different spaces, which included a set of items. They did an evaluation in a software engineering course that showed the activity of students grew by a considerable level with the inclusion of the recommendation system.

GeNIE

There are many gamification platforms that help learn to program, from those for beginners such as Codecademy with badges and achievements or FightCode for JavaScript, to those for advanced learners, like Checkio, which encourage people to share their problems and deal with them together. There are various forms of gamification. For example, CodeSchool combines video content, coding in the browser and gamification altogether, while TreeHouse includes quizzes, and CodinGame uses actual games to help in the learning process. There are also some platforms for learning Java, such as the Code Hunt, which improve the programming skills of users through a game (Thom, 2016).

The platform this project uses is GeNIE: a portal for gamification of higher education (Çubukçu et al., 2016). GeNIE is an enterprise level web portal for gamification of higher education developed for providing computerised assistance to enable instructors to implement gamification for their classes easily. This is for dealing with the shortage of the software assistance in terms of gamification for some advanced education courses. GeNIE has User Pages including Login, Register, Password Recovery Page, Profile Page, and Setting Page. Game Elements are controlled by the gamification management page, which also controls gamification settings. GeNIE uses Java, Spring, Apache Software Foundation, PrimeFaces and JSF, Hibernate and MySQL. It uses Model-view-Controller (MVC) model as the architectural pattern.

Gamifying Java

There are two recommenders in this project. One of them is for selecting MCQs for students. After a test starts, the MCQBean judges whether it is a test page or test result page. Then, if it is a test page, the recommender would

select the questions at a certain difficulty level that belong to the selected topic. The students who take the MCQ test records decide the difficulty level. If the latest record of the student who is doing the test shows a correct ratio no less than the *Difficulty Border Percentage* for that topic, the higher difficulty level than that for the record would be used. The order of the difficulty level is from the lowest one, *easy*, to *medium*, then to the highest level, *hard*. On the opposite, a lower difficulty level would be used if the record shows a correct ratio lower than the *Degrade Border Percentage* for the selected topic. A student without any record for that topic would be shown the questions in the *easy* level. Ten questions would be shown for each test. If the number of questions for a certain difficulty level were not enough, questions in a relatively lower level in other levels would be selected.

The second recommender developed is for the topics. A hidden button named "*Test past, Try Other Topics*" would appear in the test result page when a student passes an MCQ test with a correct ratio higher than the *Difficulty Border percentage*. By clicking this button, the student could see all other topics in this course and set to be Used ordered by the recommendation level in descending order. The most recommended topic is on the top of the new window and separated from other topics. They are ranked by the overall correct ratio for each topic. The overall correct ratio is calculated depending on all the students who have tested for that topic and would be updated on each test. By clicking a recommended topic, the student would be led to a new test page for that topic as shown in Figure 1.

Points, leader boards, badges, and achievements are used in this project. First, the gamification part was further developed, and three different types of achievements are developed and become possible to be added by an instructor. The mechanisms for judging and recording their progress and rewarding them are also further developed in this project. The leader board only shows the top 10 students, and the username is set to be displayed on the leader board. Four different badges are used in this project for different stages of study process. The one for new learners is called *Start*, while the one for the students in the medium of the study process is named *GoodWork*. A badge called is relatively harder to get and getting the *Unbelievable* badge would still be a challenge for those who have completed the learning of that course. Each badge has a title, image, and description of itself.

Achievements are also divided for different stages of the study. This is because earning rewards early and continuously would let the "game" be more attractive and motivate students more. Their engagement is expected to increase because of this. The premise is giving rewards even in an early stage would not only encourage students who are easy to be or already motivated, but also let those who are harder to be motivated feel they are engaged and motivate them. Otherwise, these students with lower motivation would not feel so much difference by having this gamified course.

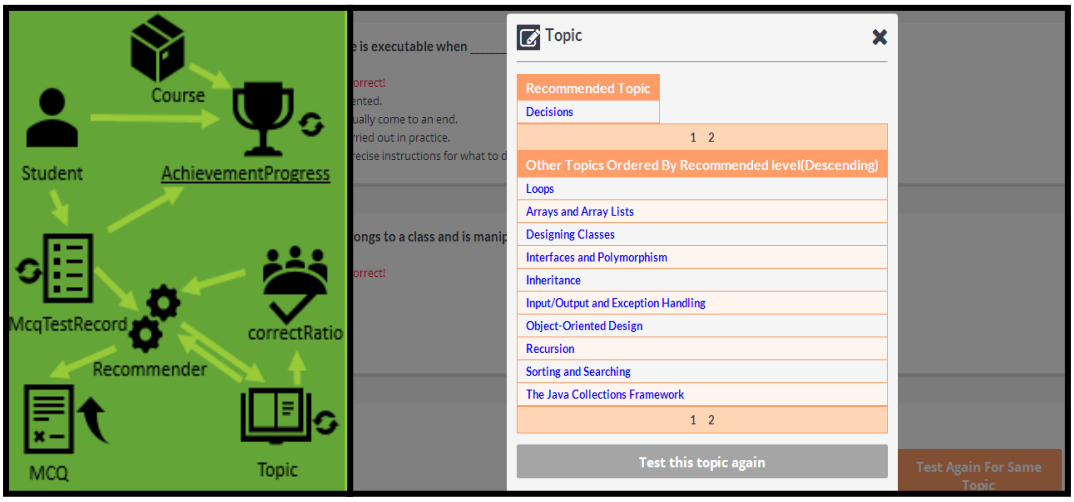

Figure 1. Flow for MCQ testing and the recommendation for topics' page.

The achievements for a starter are the *AnswerStart* for students who answered MCQs for at least 1 topic with the rewards of 10 points and 1 score, and *CorrectStart* for students who answered MCQs with at least a 40 percent correct ratio for at least 1 topic, with the rewards of 15 points, 2 scores, and the *Start* badge. The achievements for the next learning stage are *Answer* (answering MCQs for at least 10 different topics in this course), *Pass* (answering MCQs with at least 60% correct ratio for at least 2 topics in the hard level), and *Correct* (answer MCQs with at least 80% correct ratio for 3 topics in any level). The rewards for the *Answer* are 150 points and 5 scores, while the rewards for each of the other two achievements are 50 points, 10 scores, and a *GoodWork* badge. The achievements for next learning stage are *Master* (answering MCQs with at least 80% correct ratio for at least two topics in the hard level), and *Precise* (answer MCQs with at least 90% correct ratio for 8 topics in any level). The rewards for each of them are 150 points, 15 scores, and an *Expert* badge. The achievements for the next stage are the most difficult to get and are only set to be a challenge leading the students to continue to study to some degree. They are *Legendary* (answering MCQs with at least 90% correct ratio for at least 13 topics in the hard level), and *Perfect* (answer MCQs with at least 90% correct ratio for 13 topics in any level). The rewards for the *Legendary* are 250 points, 25 scores, and an *Unbelievable* badge while the rewards for *Perfect* are 200 points, 20 scores, and an *Unbelievable* badge. For the students, they could change the preference to enable or disable each gamification element in the course detail page. In the evaluation, all of these four game elements are enabled. The leader board, grades, badges and achievements are shown to students in the course detail page. The ranking of top 10 students is shown with their points. For the badges, all badges are shown with name and description of them, while only those badges received by the student would show the image. For the achievements, the name, image, description, rewards for each of them would be shown in this page. The image of an achievement would be filled with colour (black) after that achievement is completed. What is important is that the progress bar of the student is also shown for each achievement, so that students know what they have done and what is needed to be done to complete

each achievement. When a student submits the answers for a MCQ test, McqBean would call the method in the GamificationService to record the process of achievements. The criteria and process for achievements are judged during this process, and DAO (Data Access Object) classes are used for coordinating with the database. The different gamification elements are shown in Figure 2.

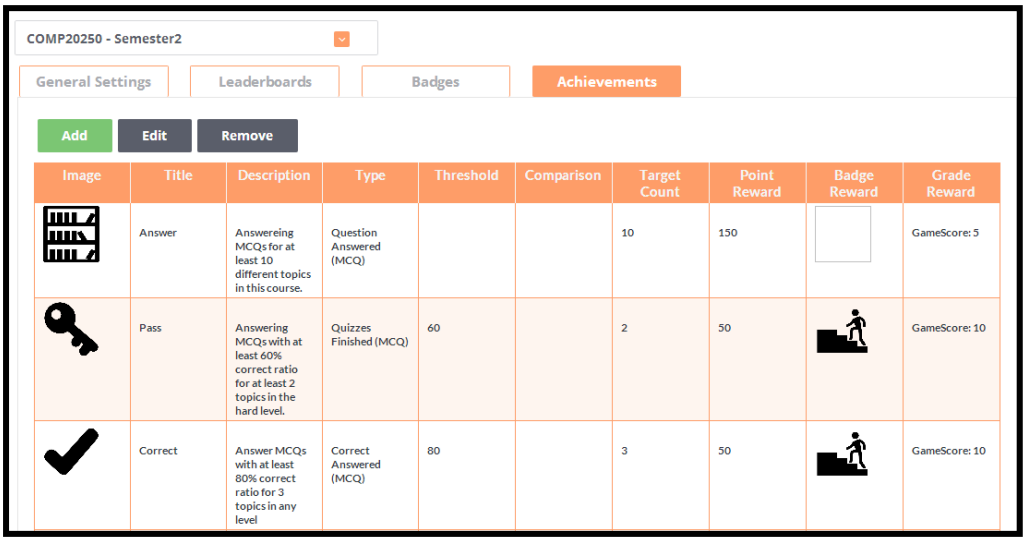

Figure 2. Gamification elements.

Evaluation

The evaluation is among the students in a School of Computer Science in higher level education. Since most of them have completed the module on Introduction to Java, their feedback tends to be relatively more reliable. Students in the evaluation had an experience of GeNIE in terms of the embedded course module on Introduction to Java and used the MCQ system. Then, their feedback was collected through a survey created using Google forms. There are eight multiple-choice questions in this survey asking the opinion of the students towards GeNIE. The evaluation lasted 20 days, and till the end of the evaluation, 27 responses were collected.

Table 1

Average Value and Standard Deviation for Questions 1-8

Questions 1-8	Average	Standard Deviation
1. Does the system help you understand the concepts that are being taught better?	4.185185	0.721985
2. Can you relate the activities to the subject matter?	4.185185	0.862255
3. Would you put in more time and effort to achieve a Badge?	4.185185	0.721985
4. Would you put in more effort and time to see your name on the Leaderboards?	4.555556	0.566558
5. Do you want other users to be able to see your progress?	3.518519	1.10119

6. Would you put in more effort and time to unlock an achievement?	4.074074	0.899627
7. Does the points system have any effect on your usage behaviour?	4.111111	0.955814
8. What is your opinion about using achievements as overall progression indicator?	4.037037	0.744435

From the results of the evaluation, the project seems successful since most students in the evaluation gave positive feedback. The standard deviation is less than 1 for all questions except for question 5, which means for all question except for question 5, students have similar ideas. Question 5 is about showing the progress to other students, which is not accepted by some students. But generally, the responses for other questions about the improvement of motivation, engagement, and knowledge learning showed relatively positive results.

Understanding. Responses indicated that most students understand related course knowledge better. Nearly 90% of the students said this system helped them to understand the concepts that are being taught better, while 33.3% strongly agreed with this idea. Most of them also claim that they can relate the activities to the subject matters as Figure 3 indicates.

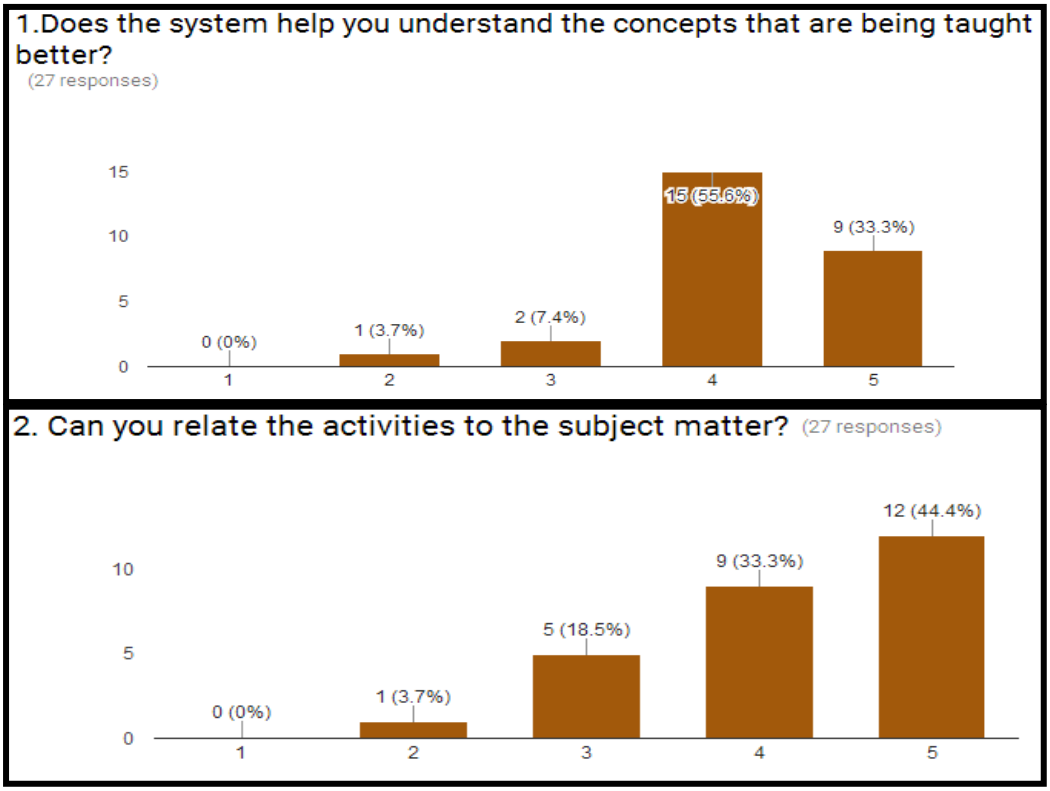

Figure 3. Responses for the evaluation from students - Questions 1 & 2.

Extrinsic Motivation. The data shows that most students are motivated by the badges and leaderboard elements. But nearly half (44.4%) of the students are not so willing to show their progress to other students, where 25.9% of the students explicitly claimed the disagreement for it as we can see in Figure 4.

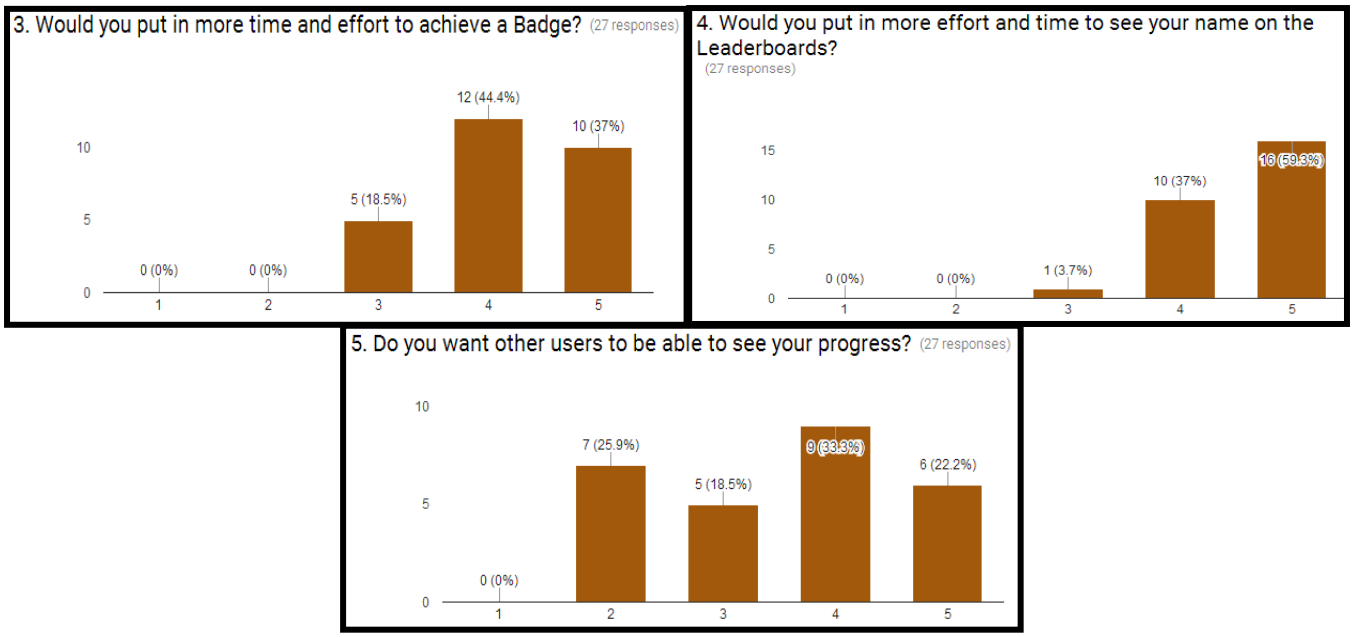

Figure 4. Responses for the evaluation from students - Questions 3,4,5

Intrinsic Motivation. Based on the responses, most students are motivated to get achievements and think it is a good idea to use them as overall progression indicator (see Figure 5).

Behaviour Change. Many people strongly agreed that they would continue to use this system because they want badges or achievements as Figure 5 indicates

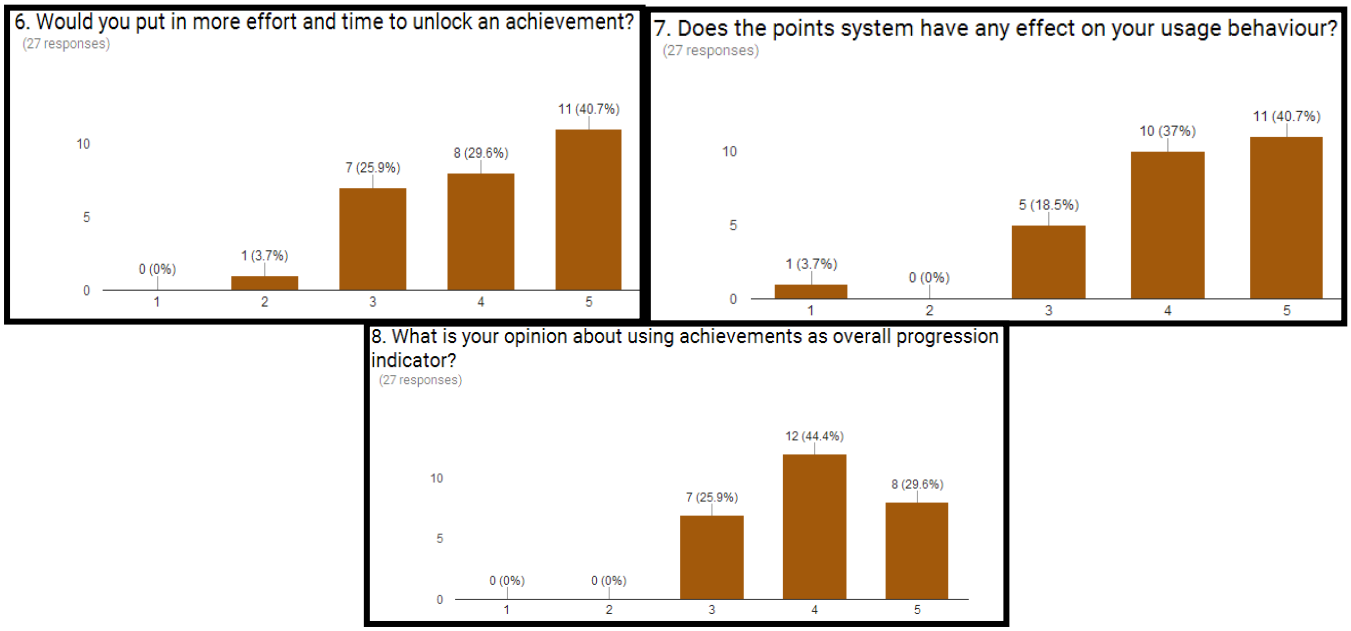

Figure 5. Responses for the evaluation from students - Questions 6,7,8

Reasons to use the system. Question 9 asks students why they would continue to use the system in this project and each of the seven reasons mentioned in the question has a similar average value of the extent of agreement. However, learning something useful and higher rank on the leader board have slightly higher value, as shown in Figure 6.

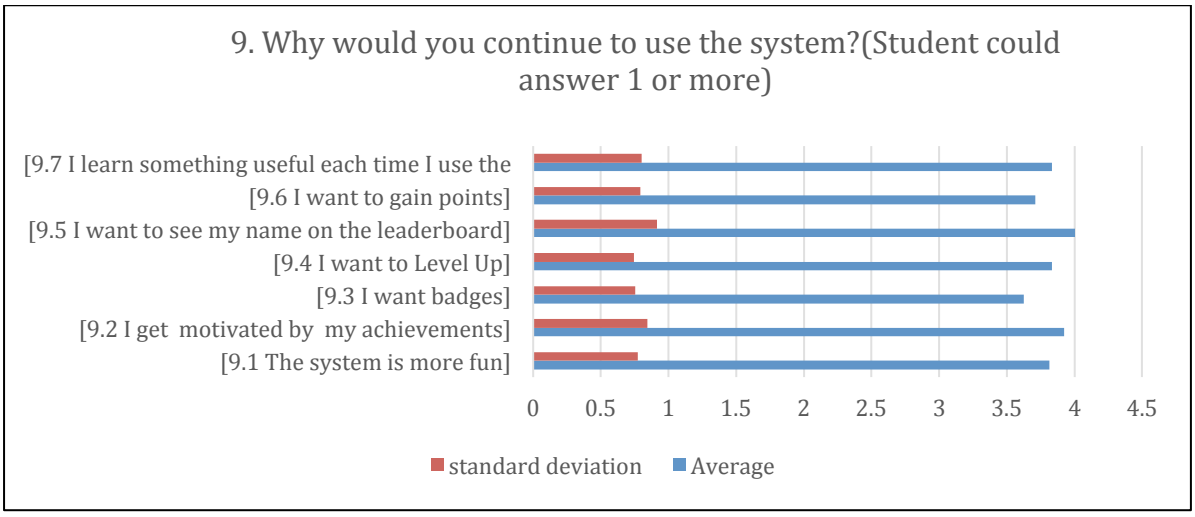

Figure 6. Responses for the evaluation from students - Question 9.

Conclusions and Future Work

This project embedded an Introduction to JAVA course in GeNIE and developed a MCQ system, recommender system and related game elements within an online tutoring mechanism. Object-oriented testing was used and showed the system works well regarding usability and the performance, with

the small response time that could be ignored by the users, except for seeing the result of MCQ tests or uploading/downloading files.

An evaluation was done among the students, who are in a related major and tend to have completed the learning for that course. Responses showed that this system works for improving the motivation and engagement of the students. Nearly 90% of the students claimed they understand the knowledge that is taught better because of this system. In conclusion, GeNIE could be used in the Introduction to JAVA course and tends to work well for improving the motivation, engagement and the understanding of knowledge for the students. But 12 (44.4%) students said they did not support showing their progress to other students, while 7 of them showed obvious disagreement. So, in the future, the gamification should also be possible to be set for each student to be only visible to the user himself/herself and the instructor.

Besides enabling the setting to not show the progress for each student to other students, there are some other further developments in progress. The MCQs for the course need to be uploaded by the instructor now, although it is both possible to add questions in the MCQ management page and upload multiple questions from RTF files. In the future, it should be possible for students to add MCQs. If a question uploaded by students were set to be valid by the instructor or those students with a special badge, this question would be used for the tests. This type of special badge could be allocated or removed both automatically and by the instructor.

If GeNIE is used in multiple colleges, the content of the MCQs should be also distributed and shared. The questions could be filtered and selected by the first recommender, which is only a simple content-based recommender system for now. It would be changed to be a complex adaptive recommender when the number of questions increases to a large number. The similarity of students' behaviour would also be considered in that system. If the number of questions is still not enough, technologies for finding questions from the Internet could be added.

For showing the badges or achievements in the future, those special images would be shown following the name of the students in GeNIE on the leader board and other places where the students' name could be shown. Besides, these images should be possible to be simply shown in some popular social networks, like Facebook or Twitter. A picture could be shown after the username or automatically shown on the corner of the profile photo. This, of course, would involve sharing content of the user profiles with social networks' databases. More achievements would be set for the progress of the students, which tends to motivate all students to a larger degree, especially those who lack motivation.

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