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Implementation of a game element in educational software

An experiment about the effects of gamification in the learning environment

Bachelor of Science Thesis in the Programme Software Engineering & Management

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Abstract

The concept of gamification revolves around implementing game elements in an object or process that is lacking one. With the rise of technology and the way software is readily available, introducing a game element to software dedicated towards educating people can potentially increase the user's interest as well as the speed at which they absorb knowledge. The goal of the paper was to investigate the effects of gamification within an educational application and the performed experiment gathered quantitative data showed that while an experiment on a small scale cannot prove gamification within learning software to always be proven better, it can still observe a relatively small increase in the participants' acquisition of knowledge.

Keywords—Gamification; Learning; Mobile Application; Education.

1. INTRODUCTION

In the last few decades there has been an exponential advancement in the use of technology in our daily lives and the amount of individuals that study and acquire new knowledge from other places than traditional physical schools has greatly risen. In the United States alone, the total amount of students enrolled in degree-granting postsecondary institutions that studied online courses increased from 9.6% to 25.3% between the years 2002 and 2008 [1]. Considering that education have always played an important role in the continued economical and sociologic development of countries, especially in developing countries, striving to improve the learning process is in that regard of utmost importance [2].

One course of action to improve the overall learning process that has been suggested lately is the process of gamification, the action of adding a game element to an operation or practice that did not previously contain one. This aims to enhance potential positive patterns as well as improving aspects in the learning process regarding user interactivity and engagement [3][4].

A survey conducted in 2015 showed that 64% of American adults, and as high as 85% of adults between the ages 18-29, own a smartphone. As such, a majority of the citizens in their society have constant access to a device which grants them the opportunity to access a wide variety of mobile application [5].

By taking these figures into account, should the learning process be improved within software that can easily be accessible by smartphones, it is highly probably that these improvements will reach a lot of users that have the wish to further their knowledge and education.

The goal of this paper is to assess what impact the use of gamification can have with regards to educational learning through the use of software. To achieve this, two research questions regarding user preference and concrete changes in knowledge will be analyzed using quantitative data gathered from an experiment. The methodology used to realize the experiment will be to use a design research approach, where two separate learning-oriented applications will be developed, where one of them contains a game element and one of them does not.

The following section will contain related work to this study. Section three and four will contain information about this study's purpose and research questions. Section five explains the research strategy. A full explanation of the applications and the experiment can be found in section six and seven, respectively. The results of the experiments are disclosed in section eight. Following the results, section nine is dedicated to discussion and section ten concludes the paper. The brief three final sections overview future works, acknowledgements and references in that order.

2. RELATED WORK

There has been quite a few research papers published these last years that questions the use of gamification. One of them proposed the use of a discovery-based learning aspect in the form of a jigsaw puzzle (see figure 1) in order to teach people how to use a complex software, such as Adobe Photoshop [6]. In this scenario, the authors concluded that the addition of a game element in this otherwise difficult and complex task transformed the task from “..an otherwise serious training activity into an active game-like experience for learning complex software applications.”

Learning through the use of a mobile device is not a new concept, and personal digital assistance (PDAs) have been used in teaching scenarios both outside and inside the classroom

setting [7]. Research has been made regarding how these mobile devices can enhance and improve the learning process [8]. There is however a lack of studies that focuses on the inclusion of gamification within this field.



Figure 1. The jigsaw Adobe Photoshop software. [6]

One literature review that specifically targeted the inclusion of a game element in the learning process analyzed 24 empirical studies regarding gamification [9]. In this review, the authors compared the different results from all the studies reviewed and came to the conclusion (see table 1) that most of the studies that included a game element yielded an overall positive result. They did however point out that “..more rigorous methodologies ought to be used in further research on gamification.”. This review contained analyzed both included studies made conducted in software environments and in physical environments. As such, considering no specific research has been specifically conducted regarding gamification and the learning process within a strictly software scope, a suggestion would be that further research is made on a smaller scope within the software development field to better access the outcome of using a game element in a software learning environment.

Results	Papers
All tests positive	2
Part of the tests positive	13
All tests not significant	-
Only descriptive statistics	7

Table 1. The results of the literature review. [9]

3. PURPOSE

The main purpose of this study is to investigate whether or not using the concept of gamification in an educational software will improve the knowledge the user acquires from it.

In addition to this, the study also attempts to reveal an overall view of whether or not the users themselves think that they would benefit from having game elements in a learning-based application. With this purpose fulfilled, this study could then serve as an inspiration to study these types of correlations on a bigger scale and potentially be helpful for developers aiming to develop applications that are created for learning purposes.

4. RESEARCH QUESTIONS

To be able to investigate what effects on knowledge and the participants’ attitude towards the concept of gamification within software in the learning environment, the following research questions are suggested:

1. How does implementing the concept of gamification in educational software influence the learning process?
 - 1.1. What differences in knowledge will a user have after being exposed to an educational software application that has a game element present compared to users exposed to one without it?
 - 1.2. Is a learning-based software that includes game elements more or less preferable to one that does not contain any game elements according to users who have tried both?

5. RESEARCH STRATEGY

In pursuance of answering the research questions, data will need to be gathered. To do this, an experiment will be performed where participants are divided into two separate sample groups. To assess whether there will be any difference between the sample groups, one of the sample groups will receive and a learning-based application that contains a game element and the other sample group will receive the same application that has been modified to have the game element removed.

Design Research was chosen as the suitable research approach, as it is concerned with “devising artifacts to attain goals” and is used to identify and evaluate problems within an artifact [10]. In the interest of standardization and avoiding any learning biases, both applications will need to contain the exact same information and not be that dissimilar from one and another. Since no applications were found to suit this need, two application will need to be developed that fits the needs of this experiment.

When it comes to extracting data from the experiment, this study will follow a quantitative research approach. Should the data gathered be of a quantitative nature, this allow any potential differences to be more easily distinguished and comparable [11].

6. THE APPLICATIONS

Two applications were developed to suit the needs of the experiment. Both application were adjusted to focus on teaching its user a specific subject. For the purpose of this study, a subject was needed that the general population is familiar with but also only have a limited knowledge of. As such, the elements and their symbols in the periodic table were chosen as the subject of choice. The reasoning behind this is that the periodic system is taught to most people at an early age, but few people master it. The application that contains a game element will henceforth be referred to as “Periplay”, which focuses on the periodic system and playing the game element. The application that does not contain a game element will be referred to as “Perilearn”, which focuses on the periodic system and simply learning by looking instead of interacting with a game.

When Periplay is started, it prompts the user with a main screen (see figure 2) which lets the user pick between two choices. The competitive mode, which is where the main focus of the game element is contained, and the practice mode which allows to user to figure out how the application works without worrying about any wrong answers or the speed at which they guess.

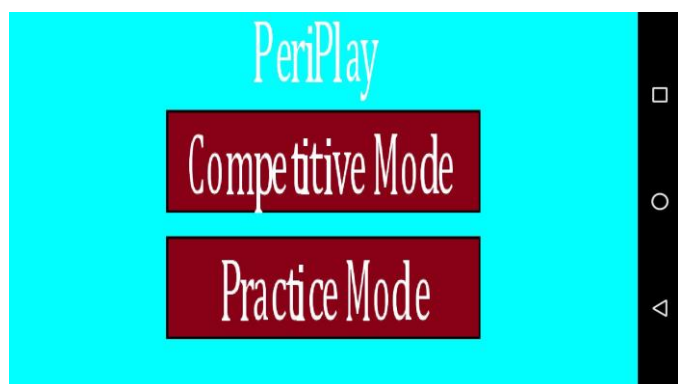


Figure 2. The main menu of Periplay.

The competitive mode starts by showing one of the elements of the periodic table at the top of the screen. After a brief delay, circles that contain symbols for different elements in the periodic table will start falling down (see figure 3). In order for the user to increase the score, the user must use his finger to press the correct element. If the correct element is pressed, a “positive” sound effect is activated and the score increases. A new element is then randomly selected from the elements that have yet to be chosen and the game continues. If the correct element were to fall off the screen, or if the user presses the incorrect element, a game over menu is rendered along with a “negative” sound effect and the user will need to start over again (see figure 4). To allow the users to improve the correct symbol for the element that they were unable to select the correct symbol for will be shown when the game over screen is rendered.



Figure 3. The playing screen of Periplay.

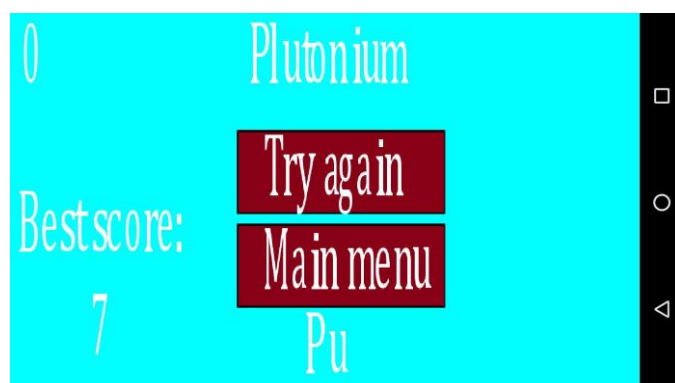


Figure 4. The game over screen of Periplay.

The practice mode in Periplay works in a similar matter, but does not have a “lose”-condition. As such, if any of the correct falls off the screen, or if an incorrect element is pressed, the score is decremented. This allows the user to practice the game and understand the basics of the game for as long as they should want.

To make the application a bit more consistent two algorithms were implemented. One algorithm uses a mathematical function to make elements from the earlier part of the periodic table a bit more frequent in the beginning of a game iteration. Since each element is shown only once, all elements will eventually be shown if the users is good at the game, however this will make the earlier stage of the game a bit more easy as to encourage users to continue to improve. The other algorithm was created to progressively increase the chance for the correct element symbol to fall down. This was implemented to make sure that a user does not lose focus if there should be any occasions were the time between a new element and its correct symbol is to long.

Perilearn was developed as a simplified version of Periplay, where the game element has been completely removed. When Perilearn is started the user is prompted with a main menu screen (see figure 5) which simply contains a button with the text “learn” on it. When clicking the button a learn session is created where an element is shown at the top of the screen, determined by the same mathematical algorithm as in Periplay. Together with the element name, the element’s symbol is shown in the circle (see figure 6). After short period of the

time, the element will be changed to another not previously shown element. If the user clicks the circle this will prompt a premature element change. By waiting or clicking the element symbol, the user can iterate through all the elements and their symbols that currently exist in the periodic table.

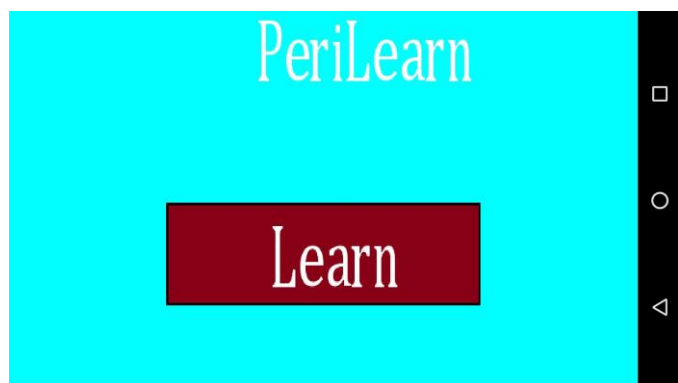


Figure 5. The main menu of Perilearn.

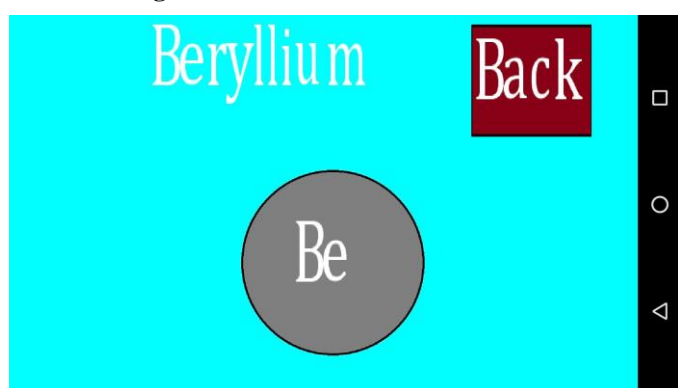


Figure 6. The learning screen of Perilearn.

7. THE EXPERIMENT

The experiment was conducted over the course of a two day period where randomly selected individuals from the campuses of Gothenburg University were asked to volunteer. When a participant was approached, he or she was briefly introduced to the study and asked to partake in the experiment anonymously. When a participant agreed to be part of the experiment, the participant were allocated to one of the two sample groups. Each participant took on average 10 minutes to complete the experiment, which consisted of three phases.

In phase one, the participant was handed a form that contained instructions and a list of 23 elements, which is roughly one fifth of all the elements that are currently in the periodic system. In the interest of avoiding any bias when choosing the elements that the participants should write the correct symbols for, the elements were randomly picked with the use of the application. The 23 elements were therefore chosen by picking the elements that showed up the most when averaging the number of the times an element showed up as one of the 23 first elements when iterating through the application ten times. The instructions stated that the participant should fill in any corresponding element symbols

that they knew. This was done in order to establish their initial knowledge of the elements and their symbols in the periodic table.

After the participant had finished filling in the form, the second phase began which was the main part of the experiment. The participant was presented with the respective application corresponding to their sample group and was given a brief oral explanation of how to use it. The participant was then allowed to use the application for five minutes.

Finally, the last part of the phase was conducted by having the participants once again fill in the same form in order to see if there was any changes in their knowledge compared to the first attempt. The difference between the results of the two forms gathered from each participant in the experiment will be the basis that this paper uses to answer RQ 1.1. The participants was then allowed to try the application that did not correspond to their sample group. After the participant had tried both applications, they were asked which ones they personally thought that they would find most useful and effective regarding their learning process. These answers will be used in order to answer RQ 1.2. This concluded the experiment, and this process was then repeated for the next 19 participants.

8. RESULTS

Over the course of the experiment, 20 individuals participated, forming two sample groups containing ten participants each. For the purpose of reading the results, the sample groups will be referred to as the players, whom used the Perilearn application, and the learners, whom used the Perilearn application.

The first form filled in by the participants which was used for the purpose of seeing their initial knowledge of the symbols in the periodic table yielded and the second form that the participants completed in order to see any potential differences in their knowledge can be seen in Figure 7 for the players and figure 8 for the learners.

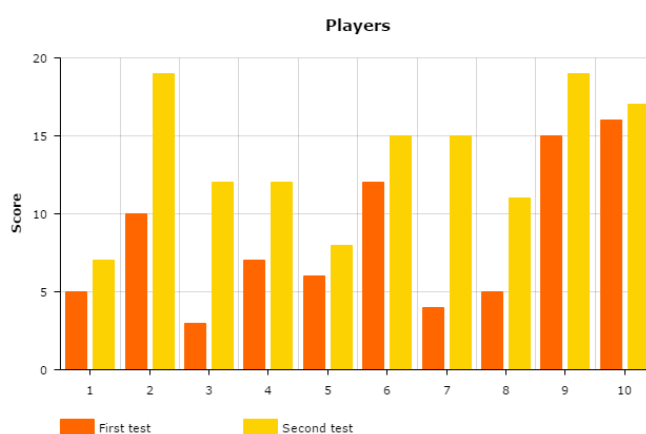


Figure 7. Results of both tests for the players.

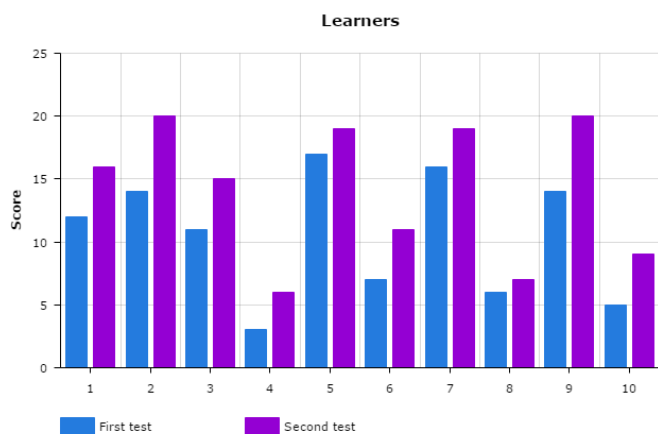


Figure 8. Results of both tests for the learners.

The players had an average score of 8.8 or 38.2% correct answers in the initial test and had an average score of 13.5 or 58.7% correct answers in the second test. The learners had an average score of 9.8 or 42.6% correct answers in the initial test and had an average score of 14.2 or 61.7% correct answers in the second test.

When comparing the respective sample groups results from the first form with the second, the average increase in knowledge for the players were 4.7 score wise and 53.7 percentagewise. For the learners it was 4.4 score wise and 44.8 percentagewise for the learners. See figure 9 for the individual percentagewise increase comparisons for the players and figure 10 for the learners.

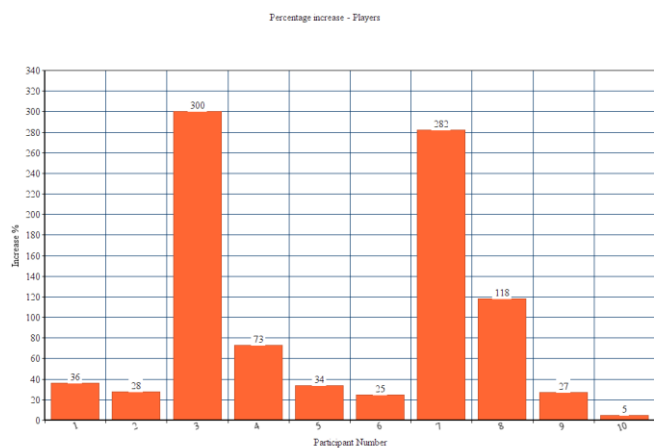


Figure 9. The relative increase in knowledge of the players.

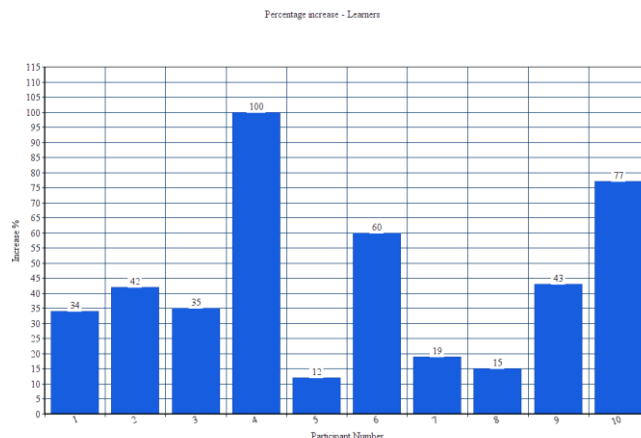


Figure 10. The relative increase in knowledge of the learners.

When comparing those that had a low and high initial knowledge of the periodic system, the players that scored more than ten points on the first form had an average increase of 21.5% in their correct answers after using the application. The players that scored less than that had an average increase of 140.5% in their correct answers.

The same learners on the other hand had when comparing the average increase in correct answers a 30.1% when looking at the learners with a score of over ten on the first form. The group of learners that scored lower than ten had an average increase of 45.5% in their correct answers.

When presented with the application the participant did not use initially and asked which they would prefer to use in a learning context, ten of ten participants in the sample group that tried Periplay thought Periplay to be their preferred application. While not as unanimous as the other sample group, the learners still chose the Periplay application as their application of choice eight out of ten times.

9. DISCUSSION

One thing that immediately becomes obvious is the differences in the participants' initial knowledge of subject, in this case, the elements and their symbols in the periodic table. When it came to an increase in result, the increases were in general often much bigger for a participant that had a limited prior knowledge of the subject regardless of which of the sample group the participant was in. Because of this, it is likely that it would have been better to adjust the subject the experiment tried to teach to something that it is rarer that people know or a concept that is entirely made up.

When only looking the average increase in score between the first and the second form, the sample group called players show a slightly higher increase in knowledge about the subject. This could suggest that the concept of gamification and the inclusion of a game element did improve the user's ability to passively absorb knowledge. The most noticeable difference appears when comparing the sample groups while only looking

at the participants who scored a low score on the first form. Arguably, the use of a game element in a learning-based application could drastically quicken the learning process, but only for users who are relatively unknowledgeable about the subject initially.

The results of the final question after the participants had been introduced to both version of the application were in most part unanimous. The sample group that initially used the Periplay application all preferred it to the Perilearn application. For the other sample group, most of the participants felt like the Periplay application would be their preferred choice, with the exception of two participants who felt that the game element seemed only to complicate the objective of the application. One possible reason for this might be that participants who were focused on learning thought the use of the Perilearn application found the Periplay application to be a lot more complex and thus were averted to the perceived confusing aspect of it.

In order to collect more relevant data, the experiment would have to be performed on a bigger scale. With a larger number of participants the experiment would most likely have yielded different results with a much higher confidence level. Since this experiment was performed using a subject that where the participants are differently knowledgeable about beforehand, collecting participants from other places than a university campus would probably have yielded different data.

10. CONCLUSION

Initial estimation was that the inclusion of a game element in a learning-based software application would drastically improve the user's knowledge in a specific subject, mainly because of the competitive and fun aspect of games. While the results from the experiment can arguable be observed as slightly skewed the favor of gamification, it did not show any major differences in increased knowledge. As such, RQ 1.1 is left relatively unanswered.

Conclusions that this experiment can show is that when people are introduced to two applications aimed at teaching a subject, one with and one without a game element, nearly all of them give their subjective opinion that the one containing a game element would be more interesting for their personal learning-process. As such, the answer to RQ 1.2 is a definitive victory for including a game element in educational software as this would probably at least keep its user interested for a longer period of time.

Finally, the main limitations of this study came in two parts. The first being that the subject chosen was so variably known by the experiment participants, and the second being that it was conducted on to few participants. This study could however be seen as an inspiration to further investigate the subject of gamification within software not designed to include game elements on a more broad scale, while still containing the relatively small scope of the research questions.

11. FUTURE WORKS

More extensive research needs to be made into the concept of using game elements to further the learning process through the use of new software. Education and learning new skills will always be something of want, and researching which sort of game design that could help users absorb new knowledge and how to effectively implement these could have a great potential for success.

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