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Quick Quiz: A Gamified Approach for Enhancing Learning

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QUICK QUIZ: A GAMIFIED APPROACH FOR ENHANCING LEARNING

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Abstract

Gamification has the potential to improve the quality of learning by better engaging students with learning activities. Our objective in this study is to evaluate a gamified learning activity along the dimensions of learning, engagement, and enjoyment. The activity made use of a gamified multiple choice quiz implemented as a software tool and was trialled in three undergraduate IT-related courses.

A questionnaire survey was used to collect data to gauge levels of learning, engagement, and enjoyment. Results show that there was some degree of engagement and enjoyment. The majority of participants (77.63 per cent) reported that they were engaged enough to want to complete the quiz and 46.05 per cent stated they were happy while playing the quiz. In terms of learning, the overall results were positive since 60.53 per cent of students stated that it enhanced their learning effectiveness.

A limitation of the work is that the results are self-reported and the activity was used over a short period of time. Thus, future work should include longer trial periods and evaluating improvements to learning using alternative approaches to self-reported data.

Keywords: gamification, learning, engagement, enjoyment

1 INTRODUCTION

In the higher education sector, it is becoming increasingly important to motivate students to learn because of a number of factors present in their environment that compete against valuable study time and the way the new generation of students learn. One factor is the substantial increase in the number of undergraduate students in either part-time or full-time paid work while studying at university and this has adverse consequences on their studies. A survey conducted by Universities Australia found that 22.7 per cent of full-time students and 33.0 per cent of part-time students regularly miss classes because of the need to attend employment (Universities Australia, 2007). Another factor is the phenomenal growth and widespread acceptance of the Internet and mobile devices causing students to spend a lot of time online either playing computer games or socialising with friends using social media such as Facebook and Twitter (Kirschner & Karpinski, 2010). Technological changes such as those resulting in increased playing of online games and online socialising have a dual impact on students since they not only take away valuable time from studies; they also affect the way the new generation learn. Finally, as a result of mass education, more students from all backgrounds are attending college than ever before, and this results in great diversity in the student body in terms of academic capabilities (Biggs & Tang, 2011). All these factors are potential distractors preventing students to fully engage with their main occupation, that is, to study (especially for full-time students).

Similarly to technological changes altering the way students learn, they can also be used by educators to alter the way subject content is delivered. This fact has long been recognised in academia and has seen the introduction of online learning, online discussion boards and serious video games, etc. in the classroom. Numerous research studies have been conducted into the effectiveness of computer games for instruction with mixed results reported (Kapp, 2012).

A recent trend in using games to influence behaviour (not just learning behaviour but any type of desirable behaviour) is called *"gamification."* A popular and broad definition of gamification is "*the use of game design elements in non-game contexts*" (Deterding et al., 2011). The term originated in the digital media industry and widespread adoption started to occur in the second half of 2010. To date, gamification has been used in a wide variety of industry categories such as: art, call center, commerce, education, entertainment, environment, design, government, health, life, marketing, market research, mobile, social good, web sites and work[1].

Given the broad definition of gamification, it can be viewed as a continuum ranging from serious games at one end of the spectrum to normal activities to which game elements have been added at the other end of the spectrum. Although, it does not make any difference to the learner whether a serious game or a gamified activity is used, to the designers/creators it does as heavy investments in terms of graphics design and programming have to be made (Deterding et al., 2011).

The work reported herein forms part of a larger study in which student perspectives on game elements were obtained and analysed, and the results were used to design, develop, trial, and evaluate a gamified multiple choice quiz software tool, named Quick Quiz. However, in this paper, we focus our discussion on the use of Quick Quiz and its evaluation. In particular, we present a gamified learning activity in which Quick Quiz is used and we evaluate its ability to influence students to become better learners. Our goal is to gauge student enjoyment and engagement with the gamified activity and the impact on learning. In so doing, we wish to further the understanding of the gamification phenomenon as a persuasive system in the context of education.

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[1] http://www.gamification.org/wiki/Gamification_Examples

2 BACKGROUND

Computer games and simulation have the potential to improve instruction. Games created using multimedia technologies permit constructive, situated and experiential learning as a result of active experimentation and immersion in the game (Hainey et al., 2011; Squire, 2008). Serious games, a term coined by Rejeski in 2002 (Stokes, 2005), are purpose-built games with an educational intent as they use pedagogy to incorporate instruction into the game play experience. Creating a video game that accurately represents the underlying context while being sufficiently engaging to maintain the attention of the learner is a very challenging task (Kelly et al., 2007). When creating video games, the development team has to blend "story, art, and software" into the finished product (Zyda, 2005). The story is crafted by the design team and provides the entertainment component, the art team provides the appearance of the game while the programming team develops the code that implements the story requirements, user interface features, communication requirements, scoring systems, artificial intelligence, game engine changes and just about anything that requires coding (Zyda, 2005). Serious games include more than just story, art and software as they also include pedagogy, that is, activities that educate or instruct learners to impart knowledge or skills. Furthermore, since a serious game is a game, the entertainment component must come first so that the pedagogy is subordinate to the story.

Serious games tend to be rather static and course/program specific and hence are not transferable to a broad range of disciplines because of the high costs of labor and technical development involved (Longstreet & Cooper, 2012). There have been attempts to reduce the design complexity of serious games. One example is a conceptual framework based on scenario-based games (Westera et al., 2008) and another one is through the use of a meta-model (Longstreet & Cooper, 2012).

Given the high costs and unpredictable production timelines of serious games (this is a common feature of software products), a lower cost alternative that is becoming increasingly popular is gamification. That is, the addition of game-driven structures and incentives to non-game contexts. Irrespective of the fact of whether a serious game or a gamified activity is used, the purpose is still the same, that is, for educational purposes and to the learner, it also does not matter whether serious games or gamification are employed. Thus, in the literature, serious games are also referred to as gamification, although strictly speaking they are not. From the developers' perspective, creating a serious game is very different from creating a gamified activity because the inherent complexity of serious games demand large development efforts.

Although a large number of researchers are convinced about the effectiveness of serious games and gamification for educational purposes, there is a lack of high quality empirical evidence that they improve learning outcomes (De Freitas & Jarvis, 2007). A number of meta-analyses have been conducted for empirically evaluating the use of serious games and gamification to increase the effectiveness of training and learning and there are still no firm conclusions (Connolly et al., 2012; Girard et al., 2012; Ke, 2009; Sitzmann, 2011). More rigorous evidence of the effectiveness of gamification to improve learning is needed as well as improving our understanding of the nature of engagement in games (Connolly et al., 2012).

Since it is more cost effective to build a game around the general aspects of the learning process that are common to most forms of study, Bustard *et al.* (2011) awarded points to students for activities such as: class attendance, contribution to tutorial questions, work of high standards, completion of quizzes, group assignment, answering of exam revision questions, and group presentations. The gamified e-learning system was designed to achieve six key engagement factors present in digital games, namely: fun (enjoyable experience), social (support from other students), identity (every one has a visible role), challenge (competitive drive created by social pressure), structure (clear and acceptable objectives and constraints) and feedback (explicit feedback of achievements). The gamified system was found to improve students' learning outcomes in terms of pass rates achieved.

The approach we follow in this study is similar to Bustard *et al.* since it is more cost effective to use normal learning activities to which game elements have been added rather than create a full-fledged

game in the tradition of serious games. However, one key difference is that instead of awarding points to a range of class activities, we focus on the in-depth gamification of a single class activity, namely a quiz, to make it enjoyable enough to enhance engagement and learning in face-to-face classes. The proposed tool has low development and maintenance costs as well as universal applicability.

3 APPROACH

The gamified quiz software tool, named Quick Quiz, was developed as a mobile web application. As the tool was relatively simple for undergraduate IT students to use, students were not provided with any substantial training. Instead, they were given a quick overview of Quick Quiz and its purpose. Students carried out the gamified learning activity using the tool twice per tutorial over 4 weeks, after which students' opinions about Quick Quiz were collected for analysis.

The general consensus among educational researchers is that computer games by themselves are not sufficient for learning to occur (O'Neil et al., 2005). Rather, it is the activation of certain game elements within an instructional context that may enhance the learning process (Garris et al., 2002). Although, strictly speaking our tool is not a computer game since it is essentially an educational quiz to which game elements have been added, we are also of the opinion that learning would be facilitated when due consideration is given to the instructional context and support provided to learners.

Thus, the tool was used in a context aimed at continuously motivating students to revise past course materials taught since the beginning of the semester. In order to motivate students to learn while making the activity enjoyable, Quick Quiz was embedded in an instructional strategy that included: (1) posing multiple choice questions that did not require too much thinking to avoid placing heavy cognitive loads on students, (2) short time limits to answer questions to put some moderate pressure on students, and (3) allowing participation to be voluntary and hence not assessing the activity.

Another important part of the strategy was the active involvement of the instructor and the students during the wrapping up session after the game was closed. Results are summarised and displayed on a large screen. During this phase of the activity, the role of the instructor is not simply to go through the answers, but to ask students why particular answers were correct or incorrect and stimulate their interest in the topic. The support provided to students in terms of feedback given to them futher facilitates their comprehension of the topic and hence can be perceived as some form of scaffolding of their learning. In the following sub-sections, we discuss Quick Quiz briefly and the gamified learning activity in detail. We also describe our data collection process to evaluate the usefulness of Quick Quiz and the gamified learning activity.

3.1 Quick Quiz: Gamified software tool for quizzes

As the focus of this paper is on the use of Quick Quiz to facilitate the learning activity, we do not describe the development process here. Instead, we describe significant features of Quick Quiz for students and instructors so that we can elaborate on how they are used as part of the learning activity. The following sub-sections describe the features for the *player* role (assumed by the students) and the *quiz master* role (assumed by the instructor).

3.1.1 Quick Quiz Features for the Player Role

The two main features of Quick Quiz for students are for them to "play" (i.e., undertake) a quiz and to review their performance on the quiz. Figure 1 shows a screenshot of Quick Quiz in which students answer a question. As can be seen, the question is listed at the top of the screen, followed by a list of four possible answers. There is also a progress bar that decreases as time passes. The objective is for the student to select the correct answer within the time limit (one minute by default).
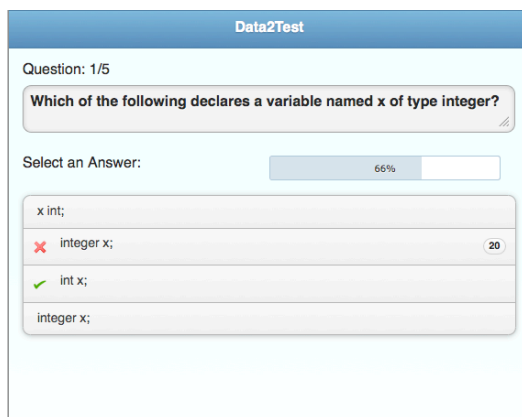
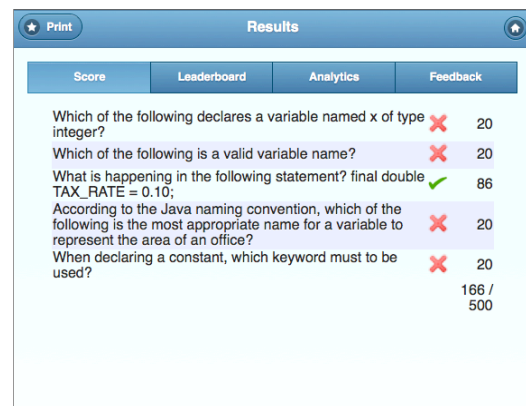*Figure 1.*   *Incorrect answer selected (Player)*

Figure 2.   *Quiz result (Player)*

The game mechanic employed for the quiz is based on points. If a student does not select an answer and time runs out, the student is awarded zero points. If the student selects an incorrect answer, he/she is awarded 20 points. If the student selects the correct answer, the number of points he/she is awarded is based on how quickly the answer was selected. The maximum number of points per question is 100 by default. To obtain 100 points for a question, a student must select the correct answer within 1 second.

After a student selects an answer, the correct answer and the number of points awarded is revealed to him/her before the next question is presented. In the case of Figure 1, the student has selected an incorrect answer (has a red cross next to it), thus, the correct answer is revealed (has a green tick next to it) and the number of points (20) obtained is also shown.

When a student has completed all the quiz questions, he/she is presented with a result screen (refer to Figure 2). The result screen displays the total number of points obtained for the quiz as well as the student's performance on each question of the quiz (including the number of points obtained for each question).

After viewing his/her individual result, a student can compare his/her performance against the rest of the class by viewing the leader board, which displays the rank, display names (names that players choose for themselves), and scores. The leader board is personalised as it highlights the player's position for easy identification.

To provide students with more holistic feedback on their performance, Quick Quiz features a comparison of individual performance against class performance for quiz results (refer to Figure 3) and on various categories (refer to Figure 4).

3.1.2   Quick Quiz Features for the Quiz Master role

The primary Quick Quiz feature for the Quiz Master role is to allow instructors to conduct games. This involves starting and ending games. In addition to this feature, Quick Quiz also facilitates the communication of feedback to students. This is achieved through the leader board feature, which is similar to the player's leader board (but is not personalised), and graphs of student responses (Figure 3 and Figure 4).

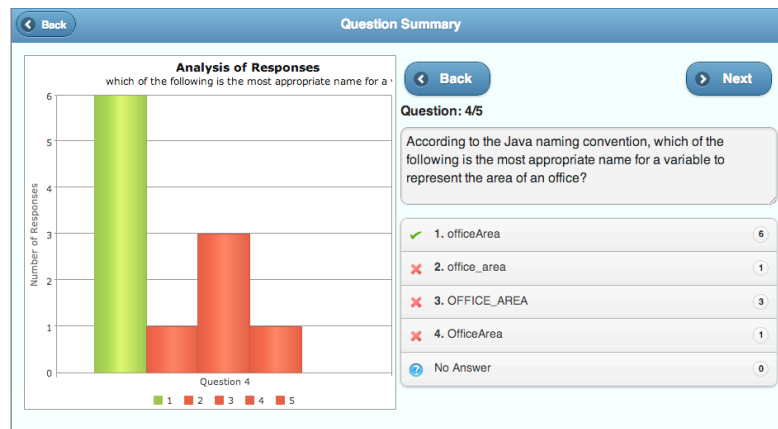*Figure 3.   Graph overview of quiz responses (Quiz Master)*

Figure 4.   Graph of individual question responses (Quiz Master)

Both the leader board and the overview of quiz response graph (Figure 3) can be used to support broad feedback. The leader board displays individual player performance on the entire quiz (5-question quiz with 100 points maximum per question, scores of 100 points identify students who have not answered any questions correctly). The overview graph shows more detailed information as it displays how the class performed on each question (showing only correct and incorrect selections).

The graphs of individual responses (Figure 4) can be used to discuss individual questions in detail. It displays detailed information for each question, showing the number of students who selected each answer and those who did not attempt to answer. Quick Quiz also graphs the average class performance on all quizzes to date.

It should be noted that the game elements included in Quick Quiz are not merely concrete elements such as points and leader boards. In fact, other more abstract elements, such as game mechanics (competition and feedback) and game dynamics (time constraints; i.e., the time-based points system) forms part of the game elements added to Quick Quiz.

3.2   Gamified learning activity

As Quick Quiz appeared to be a very simple and intuitive tool to use, students and instructors were not provided with any formal training. Instead, the concept of gamification and Quick Quiz were discussed and they were given a brief walkthrough of Quick Quiz (shown screenshots). To support instructors, a member of the project team was present when Quick Quiz was being used in class for the first time (but not for subsequent times). Students were informed that the number of points awarded was based on how quickly a correct answer was selected. As Quick Quiz is a mobile web application, students had the option of running in on laptops, computers or mobile devices such as smartphones and tablets.

The gamified learning activity was composed of two parts. The first part involved the students "playing" the quiz and in the second part the instructor discussed the results of the quiz with the students.

In the first part, the instructor would start the game and then display a projection of the leader board to the class. The quizzes are not synchronised; that is, students can start the quiz at different times and they also complete the quizzes at different times (depending on how quickly they answer the questions). In practice, all students started the quiz at around the same time and all finished well before the maximum 5-minute duration. As a student completed his/her quiz, his/her result would appear on the projected leader board. This had an effect of changing player rankings as new results were added to the leader board and was a point of excitement and discussion for students.

When all the students completed the quiz, the instructor initiated the second part of the activity by providing some brief commentary on the projected leader board (to acknowledge student participation and performance) and then displayed and discussed the graphs.

The overview graph (refer to Figure 3) was displayed first and instructors provided broad feedback about the graph. Instructors then moved on to display and discuss the graph for each individual question (refer to Figure 4). As part of this, instructors were able to not only discuss why particular answers were correct, but also discuss why other answers were incorrect (i.e., providing formative feedback). The instructors also enquired as to why students selected particular answers, whether correct or not.

3.3   Data collection

After the fourth week of using the gamified learning activity, students were given the opportunity to volunteer to be part of the research. Those who participated were required to complete a questionnaire enquiring about their experience with the gamified learning activity.

The questions for the survey instrument were obtained from various previous studies that examined the effect on games on learning. Our survey instrument evaluated the impact of the gamified learning activity based on the dimensions of engagement, enjoyment, and learning. The "engagement" and "enjoyment" constructs from Whitton (2007) and Feng et al. (2008) were used to measure engagement and enjoyment respectively. To measure the learning dimension, questions from the "Usefulness" construct from Bourgonjon et al. (2010) were used.

Of the cohort of 119 students, 84 decided to participate in the research and completed the survey questionnaire. Of the 84 responses, 8 were incomplete and were not considered for this study. The remaining sample of 76 participants was found to be representative of the population in terms of gender, age group, mode of study, and student type (refer to Table 1).

Characteristics	Population		Sample	
	Count	%	Count	%
Gender				
Male	97	81.51%	62	81.58%
Female	22	18.49%	14	18.42%
Age Group				
18 – 21	81	68.07%	55	72.37%
22 – 28	33	27.73%	20	26.31%
29 – 48	5	4.20%	1	1.32%
49 – 65	0	0%	0	0%
> 65	0	0%	0	0%
Mode of Study				
Full time	113	94.96%	71	93.42%
Part time	6	5.04%	5	6.58%
Student Type				
Local	96	80.67%	61	80.26%
International	23	19.33%	15	19.74%

Table 1   Demographics of surveyed students

4   RESULTS AND DISCUSSION

The effect of the gamified learning activity was evaluated along three dimensions: engagement, enjoyment, and learning. For each of these dimensions, participants indicated their agreement or disagreement on a 5-point Likert scale (strongly disagree, disagree, neither agree or disagree, agree, strongly agree) to a number of related statements. The results for each dimension are discussed in detail next.

4.1   Engagement

An important effect of gamification is that it engages users. Furthermore, engagement can lead to improved learning. Thus, it was important to determine how engaged students were in the gamified learning activity. Statements related to engagement are shown in Table 2.

Item Code	Statement
ENG1	I wanted to complete the quiz.
ENG 2	I wanted to explore all the options available to me.
ENG 3	I did not care how the quiz ended.
ENG 4	I found the quiz satisfying.
ENG 5	I felt absorbed in the quiz.
ENG 6	I felt that time passed quickly.
ENG 7	I felt excited during the quiz.

Table 2   Questionnaire items to evaluate "engagement" dimension

From the responses, it appears there was some degree of engagement with the activity as the majority of participants were engaged enough to complete the quiz (77.63%) and only 17.11% did not care how the quiz ended. More than half of the participants (55.27%) found the quiz to be satisfying and

slightly less than half found that time passed quickly and were excited during the quiz (44.74% and 40.79% respectively). Only 27.63% stated they were absorbed in the quiz. Nearly half of the participants wanted to explore all the options available in Quick Quiz (46.05%). Figure 5 displays the responses for each of the questionnaire items for the "engagement" dimension.
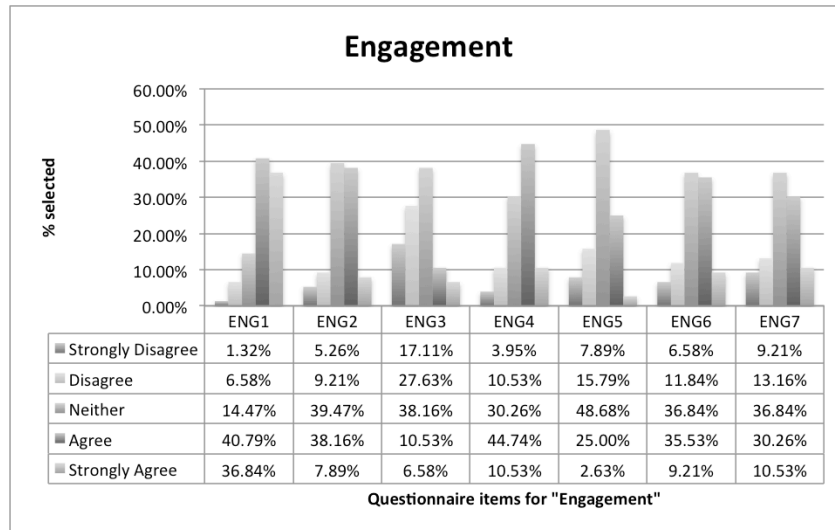

Engagement

	ENG1	ENG2	ENG3	ENG4	ENG5	ENG6	ENG7
Strongly Disagree	1.32%	5.26%	17.11%	3.95%	7.89%	6.58%	9.21%
Disagree	6.58%	9.21%	27.63%	10.53%	15.79%	11.84%	13.16%
Neither	14.47%	39.47%	38.16%	30.26%	48.68%	36.84%	36.84%
Agree	40.79%	38.16%	10.53%	44.74%	25.00%	35.53%	30.26%
Strongly Agree	36.84%	7.89%	6.58%	10.53%	2.63%	9.21%	10.53%

Questionnaire items for "Engagement"

Figure 5.   "Engagement" questionnaire item responses

4.2   Enjoyment

As gamification should impart a game-like feel to the learning activity, the questionnaire also enquired about the enjoyment of undertaking the activity. The questionnaire items for the "enjoyment" dimension are presented in Table 3.

Item Code	Statement
ENJ1	I feel unhappy when playing Quick Quiz
ENJ2	I feel worried when playing Quick Quiz
ENJ3	I feel happy when playing Quick Quiz
ENJ4	I feel exhausted when playing Quick Quiz
ENJ5	I feel miserable when playing Quick Quiz

Table 3   Questionnaire items to evaluate "enjoyment" dimension

When asked if they were unhappy while playing Quick Quiz, 30.26% of participants disagreed and 36.84% strongly disagreed (a total of 67.10%). When asked the opposite, i.e., if they were happy while playing Quick Quiz, 38.16% agreed and 7.89% strongly agreed (a total of 46.05%).

Of the participants, 63.16% were not worried, 63.16% did not feel exhausted, and 64.48% did not feel miserable while playing Quick Quiz. Figure 6 presents a graph of the participant's responses.

While there is some ambivalence about the participants' feelings of enjoyment while playing Quick Quiz, it seems that most felt some degree of enjoyment while a small number of participants did not specifically enjoy the activity.
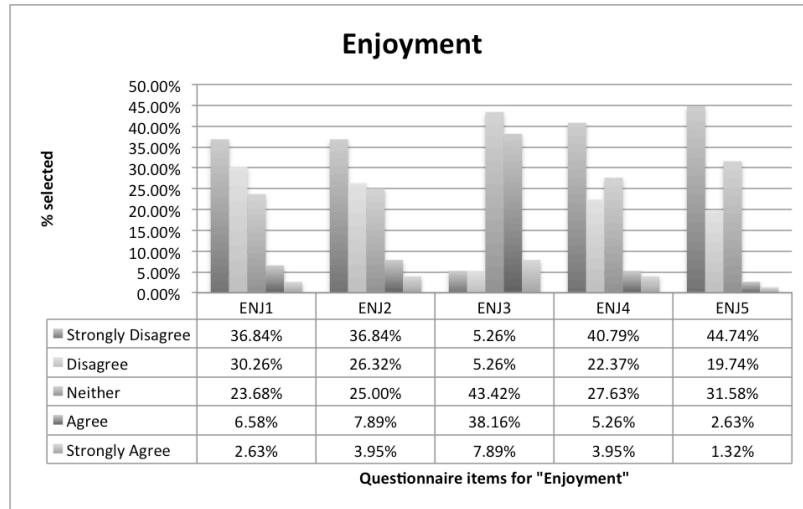
Enjoyment

	ENJ1	ENJ2	ENJ3	ENJ4	ENJ5
Strongly Disagree	36.84%	36.84%	5.26%	40.79%	44.74%
Disagree	30.26%	26.32%	5.26%	22.37%	19.74%
Neither	23.68%	25.00%	43.42%	27.63%	31.58%
Agree	6.58%	7.89%	38.16%	5.26%	2.63%
Strongly Agree	2.63%	3.95%	7.89%	3.95%	1.32%

Questionnaire items for "Enjoyment"

Figure 6.   "Enjoyment" questionnaire item responses

4.3   Learning

The effect the gamified activity has on learning is the most important of the three dimensions used for evaluation as improving the learning process is the primary aim of this work. The learning dimension was evaluated using by asking participants to state their agreement or disagreement to the statements in Table 4.

Item Code	Statement
LEA1	Playing Quick Quiz improves my learning performance
LEA2	Playing Quick Quiz increases my learning productivity
LEA3	Playing Quick Quiz enhances my learning effectiveness
LEA4	Playing Quick Quiz helps to achieve better grades

Table 4   Questionnaire items to evaluate "learning" dimension

The overall responses were positive: 59.21% of participants felt that the gamified learning activity improved their performance, 56.58% believe that it increased their learning productivity, 60.53% thought that it enhanced their learning effectiveness, and 50.00% believed that it helped them achieve better grades. Figure 7 displays a graph of the results.
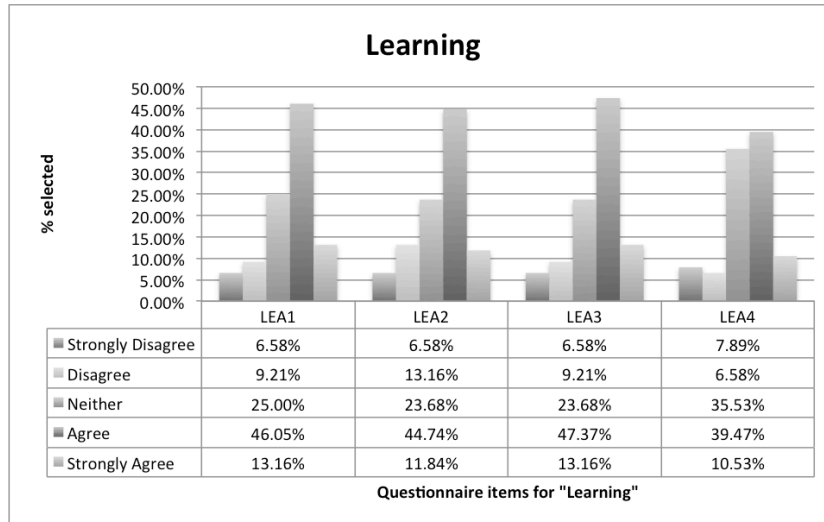
Figure 7. "Learning" questionnaire item responses

4.4 Student experience

At the end of the questionnaire, participants were asked what the best and worst aspects of the gamified learning activity were. Based on word frequencies, participants found the competitiveness, leader board, knowledge acquisition, and learning to be the most salient positive effects. The worst parts of the activity were generally about the time pressure and the questions. Additionally, quite a notable number of participants responded with "nothing" as the worst aspect of the activity.

Specifically, participants found the activity to be enjoyable and to contribute beneficially to learning. For example, one participant noted, *"it was not only fun to play, but also informative,"* and another stated, *"the fact that the questions will help me improve in this subject and provide revision for the exam."* Another participant indicated that the activity provided him/her with feedback, *"the best part is that it helped me know where my knowledge stood with the subject."*

Another participant provided an interesting response which implied that there was a distinction between the points awarded in the quiz and marks awarded for assessment purposes: *"it was fun, there was time pressure without the pressure of grades which is useful of [sic] getting used to the time constraints."*

On the negative side, some participants indicated that the time limit of one minute was not adequate to answer the questions, *"the time for each question. The answering time is too short."* There were also some comments related to some of the technical issues encountered initially but which were resolved afterwards. A particularly important issue that was noted is that of embarrassment: *"feeling embarrassed if low on the leader board."*

4.5 Implications for pedagogy

The results of the study are very positive, particularly toward enhancing learning, which is the primary objective of the work. The majority of participants felt that the gamified learning activity improved their learning. Furthermore, the activity did engage the participants and result in some degree of enjoyment.

From our experience running the activity and the results of the study, we recommend the following for this particular activity. Two parts of the activity are important as they provide different types of feedback to the students. The first part of the activity (students playing the quiz) provides primarily summative feedback to students about their own performance and the performance of their peers. The

second part of the activity (the instructor using the graphs to analyse the class response) is particularly important as it is an opportunity for the instructor to provide formative feedback. This is arguably where most of the learning occurs.

The quizzes should be kept short to avoid boredom. The configuration of five one-minute questions as we have used seems to be a good initial combination. As the time for each question is limited, the type of questions should test the lower levels of Bloom's hierarchy, such as retention and recall.

Two key recommendations for developing gamified activities for learning in general are: (1) use gamification as an activity and not as an assessment task and (2) participation should be voluntary. These are two important recommendations to ensure that the activity retains its game-like feel. If the activity is used as assessment or students are forced to undertake it, it takes away from its gameful nature and will likely been seen as another learning task (which will reduce students' motivation to complete it).

4.6   Implications for research

From the results, it can be seen that gamification can have a positive effect on learning. However, it should be noted that the results are self-reported and that the results are about one particular implementation of gamification in education. Further research should be conducted to determine if gamification improves learning using a variety of methods (e.g., triangulation) and to determine other ways in which gamification can be implemented in education.

One of our intentions in the development of the gamified learning activity and Quick Quiz was to develop an approach and supporting tool that is not discipline-specific. However, thus far, it has only been trialled in IT-based courses. Trials in courses from other disciplines would be useful to ascertain that the approach and tool are non-discipline specific.

This particular implementation of gamification targets the lower levels of Bloom's hierarchy, which forms the foundation for learning, however, further research should also investigate how gamification can be used to improve learning at the higher levels of Bloom's hierarchy, for example, using gamification to improve higher order thinking skills.

5   CONCLUSION

The objective of our work was to develop an approach in which gamification is used to motivate and enhance learning. To that end, a learning activity, supported by a gamified quiz software tool named Quick Quiz, was developed. Quick Quiz was specifically developed to facilitate the gamified learning activity.

The approach and tool were trialled in three IT-based courses in an undergraduate program and 76 participants completed a questionnaire survey for evaluation purposes. The approach was evaluated along three dimensions: learning, engagement, and motivation. It was found that 59.21% of participants believed the approach to be useful in improving their learning performance and 60.53% though it increased their learning effectiveness. Furthermore 56.23% of participants also believed the activity increased their learning productivity, and 50% believe it assisted them to achieve better grades.

The effects on engagement and enjoyment were not as pronounced as those on learning, however, they were still significant. The majority of participants (77.63%) reported that they engaged enough to want to complete the quiz and 40.79% were excited during the quiz. Of the participants, 46.05% stated they were happy while playing the quiz and 67.10% said they were not unhappy while playing the quiz.

The results show that this particular implementation of gamification to improve learning has beneficial effects and warrants further research into the matter. We have also provided two key recommendations for the use of gamification in education: do not use gamification for assessment and student participation in gamified activities should be voluntary. These two recommendations will ensure that the gamified activity retains its "game-like" attribute.

Although our work is only one particular use of gamification in education, our results are promising and other applications of gamification in education should be investigated.

6 ACKNOWLEDGEMENTS

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