# USING DESIGN SCIENCE RESEARCH TO INCORPORATE GAMIFICATION INTO LEARNING ACTIVITIES

Christopher Cheong, School of Business IT and Logistics, RMIT University, Melbourne 3000, Victoria, Australia, christopher.cheong@rmit.edu.au

France Cheong, School of Business IT and Logistics, RMIT University, Melbourne 3000, Victoria, Australia, france.cheong@rmit.edu.au

Justin Filippou, School of Business IT and Logistics, RMIT University, Melbourne 3000, Victoria, Australia, j.filippou@student.rmit.edu.au

## Abstract

*Gamifying learning activities can be beneficial as it can better engage students and result in improved learning. However, incorporating game elements into learning activities can be difficult because it requires an appropriate mix of science, art, and experience. Design science research can help to address this issue. In particular, its search process for determining an appropriate solution for a given problem is useful as it allows for a number of iterative cycles over which the solution is incrementally refined, and ultimately resulting in a successful implementation.*

*Our objective in this study is to develop a non-discipline-specific instantiation that can be embedded into a learning activity to motivate students and improve the quality of their learning. We provide a detailed explanation of how we designed and developed a gamified multiple choice quiz software tool over multiple iterations.*

*The tool was trialled in three undergraduate IT-related courses and evaluated using a questionnaire survey. Results showed that the tool was well received as 76 per cent of students believed it was effective for learning and would for it to be used in their other courses.*

*Keywords: design science research, gamification, engagement, education, learning, information system, artifact, instantiation*

# 1 INTRODUCTION

The application of games to non-game domains is appealing because, properly done, it can create a highly engaging experience that may motivate individuals to repeat or master the task. This approach, known as *"serious games,"* has been used in a number of domains, including education, for a long time. A more recent trend, however, is the concept of *"gamification,"* which applies game elements and game design techniques to non-game systems (Deterding et al., 2011; Werbach & Hunter, 2012). A significant difference is that serious games are primarily games to which a pedagogical component has been added whereas gamification refers to non-game activities to which game-like features have been added. Unsurprisingly, as gamification is gaining prominence in various domains, it is also of increasing interest for educational purposes.

One particular challenge is the game design process, whether for gamification or serious games. It is difficult because it is a mixture of science, art, and experience (Werbach & Hunter, 2012). In fact, the game-like feeling experienced when using a gamified system results from the interaction of game elements and game design techniques.

Our long-term objective is to improve student motivation using gamification, which is a form of motivational design (Werbach & Hunter, 2012). We are particularly interested in improving student motivation as this can result in better quality learning (Deci & Ryan, 1991). In this paper, our objectives are more modest, but they form part of our long-term objectives. We report and discuss the design, development, use, and evaluation of a prototype software implementation that uses gamification techniques to motivate students. We use design science to guide us through the design and development process of the prototype. Design science's search process allows us to determine where we can apply gamification and how much gamification to apply.

The prototype we developed is an instantiation of a gamified learning tool and instantiations are considered central to the information systems discipline (Orlikowski & Iacono, 2001; Weber, 2003). Although still in its infancy, the prototype makes a number of contributions to the fields of design science, information systems, and education. The mere construction of the artifact demonstrates the feasibility of the design process we employed (Nunamaker & Chen, 1990). The evaluation of the artifact's usage in a learning environment shows that it can improve motivation and, in turn, has positive impacts on learning. Additionally, the artifact can be an object of study in IS behavioural-science research (Hevner et al., 2004) to determine its impact on individuals and organizations (e.g., intention to use, perceived usefulness, etc.).

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 using design science research to develop and evaluate an instantiation of the tool.

# 2 BACKGROUND

The implementation of gamification can be complex as it is not simply a matter of selecting individual game elements and game mechanics to add to existing activities or systems in order to create something that is game-like. In the particular case of gamifying learning, it is important to first determine what the learning objectives are and then to address the gamification aspect. The gamification of the learning activity or system should be aligned with the learning objectives and not hinder or detract from them. Thus, determining the appropriate game elements and mechanics, and the extent to gamify the activities or systems is complicated.

Design science is an approach that is useful to address this issue as it can be used as a search process to determine an appropriate solution given a problem environment. In our study, our primary objective is to increase learning, which is affected by students' motivation and engagement. So, in order to increase learning, we sought a solution to better motivate and engage students. As gamification is a known approach to increase motivation, we used it and related theories to develop our solution. In this section, we discuss gamification and learning, and how design science can be used to implement gamification.

## 2.1 Gamification and learning

Gamification is an approach that is currently gaining popularity (McGonigal, 2011; Reeves & Read, 2009). It involves making non-game systems into something more "game-like" by incorporating game elements into them (Deterding et al., 2011; Werbach & Hunter, 2012). A benefit of gamifying systems is to increase user motivation to participate and use the system, and improve engagement with the system. Gamification can also be used to encourage users to change their behaviours in a beneficial manner (Werbach & Hunter, 2012). An example of gamification is the Nike+ system in which users equipped with wireless pedometers are able upload data about their runs to Nike's online service (Werbach & Hunter, 2012). They can then view their performance and progress online, and can also challenge their friends to determine who can run the fastest or the farthest.

Gamification can be applied to many domains, including business, marketing, health, and education. In education, gamification can be used to encourage learning as many of its elements are based on educational psychology and have commonalities with education, such as allocating points to activities, providing feedback, and encouraging collaboration (Kapp, 2012). Gamification is not about turning activities into games, instead, its purpose is about assisting individuals to find some degree of meaning in the activities (Werbach & Hunter, 2012). Thus, similarly, the gamification of learning is not about turning learning into a game. It is to enhance the learning process in order to help learners find more meaning and improve their learning. It is not about tricking individuals to learn. Furthermore, gamified learning activities are not necessarily easy, as they should reflect their game-like origins. That is, they should be motivating and engaging, but also challenging and stressful at times (Kapp, 2012).

Game design is difficult and so is gamification. This process is difficult as it is not a matter of just adding game elements to an existing activity or system. Gamification is not about individual game elements, instead it is about the interaction of these different elements that provides a motivating and meaningful experience for individuals. The act of mechanically adding common game elements such as points, leaderboards, and badges to activities or systems without thought in order to gamify them has brought gamification some disrepute. Game designers have labelled such as approaches as "pointsification" (Robertson, 2010), while others have raised concerns about how some gamification implementations can exploit users and have attributed the term "exploitationware" to it (Bogost, 2011).

However, when used appropriately, gamification can have a beneficial impact to learning. Gamification can, and should, transcend the superficial usage of game elements. For gamification to be meaningful to learners, it must connect to the non-game elements of the learning activities (Nicholson, 2012). The application of gamification in learning is particularly important as traditional instructional approaches are no longer engaging learners as much, and meta-studies have found that learners find game-based learning to be more interesting (Kapp, 2012). In the context of learning, gamification can be used to help students learn problem-solving and higher order thinking skills (including quick decision making). It can also be used to better engage students in live classrooms and test their knowledge and performance (Kapp, 2012).

## 2.2 Design science, information systems, and gamification

Design science research is a problem-solving paradigm in which innovations are created. As the guidelines in Table 1 show, these innovations take the form of artifacts that must address significant and relevant problems, and its construction and evaluation should be informed by research rigor. These design artifacts can be contructs, models, methods, or instantiations. These constructs have been used to develop models for specific circumstances and the methods for developing such models have been investigated (Hevner et al., 2004). Instantiations are typically in the form of intellectual or software tools and demonstrates feasibility in the design process and of the product (Hevner et al., 2004), i.e., it is "proof by construction" (Nunamaker & Chen, 1990).

| # | Guidelines | Description |
|---|---|---|
| 1 | Design as an artifact | Design science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation. |
| 2 | Problem relevance | The objective of design science research is to develop technology-based solutions to important and relevant business problems. |
| 3 | Design evaluation | The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods. |
| 4 | Research contributions | Effective design science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies. |
| 5 | Research rigor | Design science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact. |
| 6 | Design as a search process | The search for an effective artifact requires utilising available means to reach desired ends while satisfying laws in the problem environment. |
| 7 | Communication of research | Design science research must be presented effectively both to technology-oriented as well as management-oriented audiences. |

*Table 1. Design science guidelines (reproduced from (Hevner et al., 2004)).*

Design science is a search process to determine an effective solution, i.e., the design artifact, to a problem. The search process is an iterative one that is described by a Generate/Test Cycle (Simon, 1996), in which design alternatives are generated and then tested against requirements or constraints. The results of the tests are then used to improve the next iteration of the design alternatives. The design artifacts, which are produced from the design process, are not typically full-grown information systems that are used in practice (Hevner et al., 2004).

The design science approach can be useful in the implementation of gamification. Gamification is a combination of art and science; it requires an understanding of elements such as fun, play and user experiences, but it is also about developing measurable and sustainable systems to achieve particular objectives (Werbach & Hunter, 2012). The search process of design science, especially the Generate/Test cycle, can be used to iteratively design and improve artifacts to achieve an effective mix of creativity and technical feasibility (Werbach & Hunter, 2012) to address underlying objectives.

# 3 APPROACH

Our objective was to develop a non-discipline-specific instantiation as the design artifact for a number of reasons. Firstly, with an instantiation, we would be able to demonstrate the effect of gamification on motivation, engagement and learning. This is important due to some of the negative views surrounding games and their application in education. Secondly, with an instantiation that is non-discipline specific, instructors can develop methods involving the artifact to teach a wide range of courses in various disciplines. In the following sub-sections, we describe our development approach and the resulting design artifact.

### 3.1 Design artifact: Quick Quiz

Through the use of the design science methodology, we designed and developed an instantiation as our design artifact. The instantiation, is a gamified quiz software tool named *Quick Quiz*. A quiz was chosen as it is a commonly used activity in learning and is applicable to a wide range of disciplines. It also has a number of benefits for both learning and teaching, and through the use of technology, some types of quizzes can automatically assess students. Quizzes can also be used to provide students feedback on their individual performance and also a comparison of their performance against the class average. Instructors are also able to receive feedback about the student cohort by reviewing the aggregated class results, which is easily achieved by technology. Additionally, the design artifact can be customised for a range of purposes simply by using different questions. Thus, this would result in a design artifact that could be used in a flexible manner.

Quick Quiz was refined through the Generate/Test cycle (Simon, 1996) and the final features are presented in this section. The features can be broadly categorised based on the role of the user: *Player* or *Quiz Master*. In the context of learning, students act as players and instructors act as *Quiz Masters*. For the sake of brevity, although present, we do not describe features of Quick Quiz that are typical to online systems. These include logging in, logging out, settings, and main menus. Instead, we focus on what we consider to be the main or most salient features of Quick Quiz.

Two main Quick Quiz features for players are to enable play and to provide feedback. The question screen, as shown in Figure 1, displays a multiple choice question to the player, which he or she must answer within the time limit indicated by the progress bar. In a typical quiz, a player answers a number of these questions. At the end of a quiz, players are provided with summative feedback on their performance on the result screen, as shown in Figure 2.

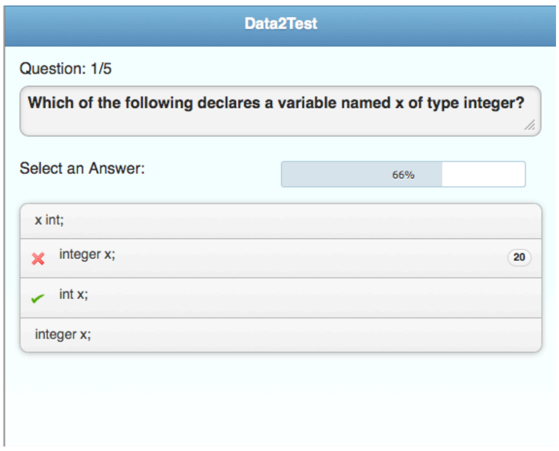


*Figure 1. Question screen. Allows users to answer quiz questions.*

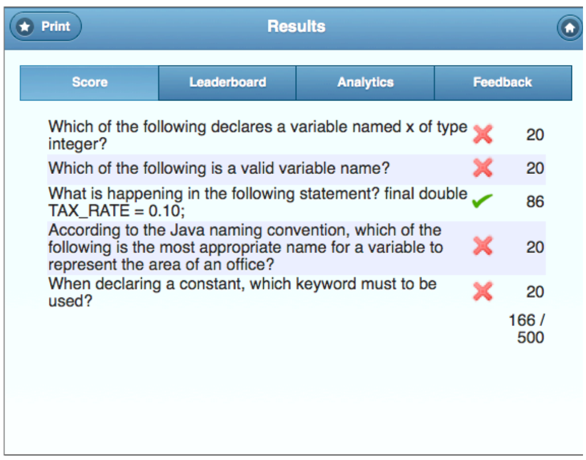


Figure 2. Quiz result screen. Provides users feedback about their performance.

A player's final score is a summation of his or her scores for each quiz question. The score for an individual question is calculated as follows. If no answer is selected and time runs out, a score of zero is awarded. If an incorrect answer is selected before time runs out, a score of 20 points is awarded. If the correct answer is selected before time runs out, the score awarded is proportional to the speed the answer was selected. That is, the faster a player selects the correct answer, the more points are awarded. The maximum points for a question is 100. However, to achieve this score, a player would have to select the correct answer within 1 second. A key feature in the scoring system is that it encourages participation by awarding points for incorrect answers.

After the result screen, players are able to view a leaderboard for the quiz. The leaderboard displays the ranks, display names (names which players choose for themselves), and scores (in points). The leaderboard is personalised in that it highlights the player's position and it provides players with feedback about their performance relative to their peers.

Although it appears that the points system and the leaderboard are simple and common game elements, there are a number of other unapparent elements in the system. The points system is time-based and it, together with the leaderboard, creates competition amongst learners. Game elements such as competition and constraints are classified as game mechanics and dynamics respectively. These are more abstract elements than game components, such as points (Werbach & Hunter, 2012).

Players also have access to various graphs that provide them with more feedback using various visualisations and data. For example, players have access to an interactive graph that shows them an overview of their performance compared to the class average for all quizzes played to date. The interactive graph provides players with more detailed feedback compared to the class average on various selectable categories. The instructor defines the categories by allocating word tags to each quiz question. These two graphs are useful visualisations as they facilitate the students' understanding of their performance. In particular, the detailed performance graph can be used to identify the weaknesses for each student before a test or examination to prioritise their revision. Alternatively, the instructor can use this type of graph to identify general weaknesses in the student cohort and provide remedial or supplementary materials.

In addition to enabling and disabling quizzes for the class, Quick Quiz provides quiz masters with two types of graphs to analyse quiz results and provide feedback to the players. The quiz analysis graph, shown in Figure 3, provides an overview of the quiz results. For each question, it displays the number of correct and incorrect answers. This provides an artifact over which the instructor and students can discuss the class performance. It is particularly useful to identify questions that have a high number of incorrect answers. Such cases could indicate common misconceptions, common lack of understanding, a difficult question, or an incorrect question.

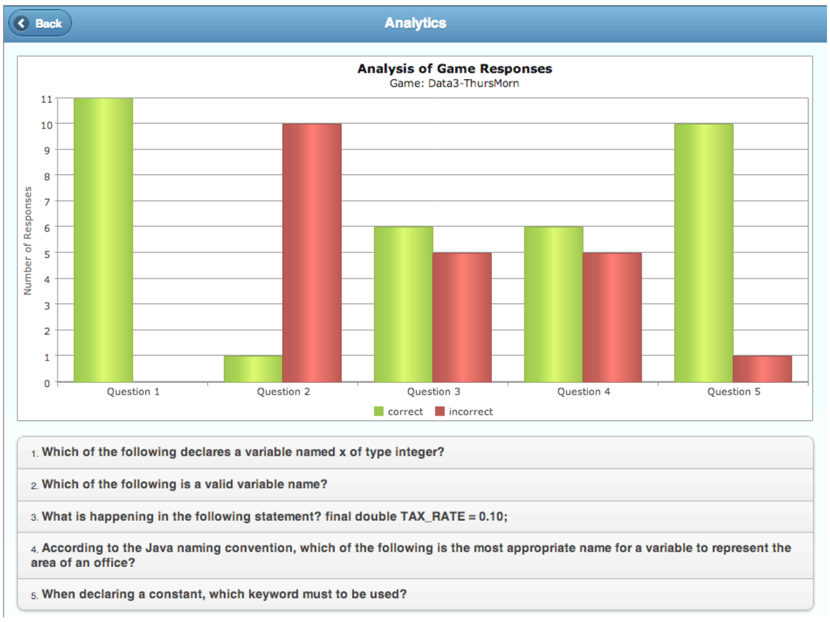


*Figure 3. Quiz analysis graph providing feedback for the overall quiz.*

The second type of graph, displayed in Figure 4, presents instructors and students with more detailed feedback for a single question. It displays the number of selections for each answer of a multiple choice question and the number of players who did not answer before time ran out. This type of graph provides more fine-grained feedback about each quiz question. It is useful to identify what common misconceptions are. For example, why did such a high number of students select option B when the correct answer is option A?

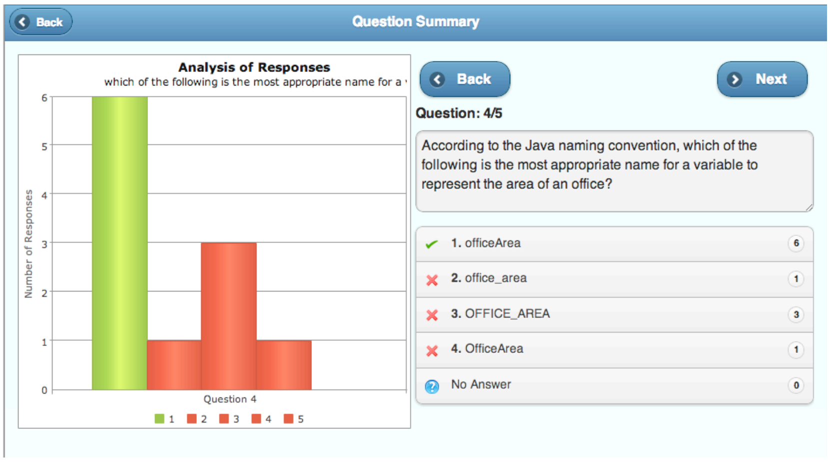


*Figure 4. Question response analysis graph providing detailed feedback for a single question.*

### 3.2 Design and development of Quick Quiz

The design artifact presented in Section 3.1 shows only the final client application and does not discuss any of the design decisions made or the underlying architecture of the entire application. In this section, we discuss our use of design science to design and develop Quick Quiz, which resulted in a successful implementation. We firstly discuss environmental constraints and how they impacted our design decisions and then proceed to discuss the development of Quick Quiz.

#### *3.2.1 Constraints and design decisions affecting the design artifact*

In addition to the aforementioned constraints of developing a non-discipline-specific artifact that used gamification techniques, there were a number of other constraints that needed to be addressed in the design and development of Quick Quiz. The two types of users of the system, players and quiz masters, formed the focus of our development. For both types of users, Quick Quiz should be easy to use and appealing.

To appeal to students, we wanted to leverage the ubiquity of smart mobile devices, such as smartphones and tablets. However, there are a number of issues associated with this. Firstly, although the majority of students have such devices, not all students have them and these students should not be disadvantaged. Secondly, as we have limited resources, we could not develop a native Quick Quiz application for each of the popular smartphone platforms, such as iOS and Android. Lastly, it would be more convenient for instructors to use Quick Quiz on a computer as it is intended to be used in class and should shown to all the students (i.e., projected to the class).

We initially envisioned Quick Quiz to be used in tutorials, in which there are up to 30 students, however, we think that there may be benefits of using Quick Quiz in lectures, in which there may be more than 100 students. Furthermore, although we were currently limited to developing Quick Quiz for a single platform, we did not want to rule out the possibility of developing future implementations of Quick Quiz for various platforms. Thus, considering these current and future constraints, we decided to develop a web-based architecture with a mobile web client application.

The Quick Quiz client was developed as a mobile web application as it had a number of advantages. It would be able to accommodate the maximum types of clients, namely a web browser on any type of device. Thus, it could be used on smart mobile devices, laptops and computers. Additionally, using a mobile layout increased the appeal of the application in terms of look and feel for the students.

To account for future implementations, we developed a number of lightweight web services and stored data in a database backend. Micro web frameworks were used to decrease the development time of the web services. Using web services allowed for flexibility for future implementations of Quick Quiz clients. For example, if iOS and Android clients were to be developed, they would simply use the web services, which would reduce development time and ensure processing consistency across the various client implementations.

#### *3.2.2 Development of design artifact*

Since we developed software as our design artifact, the Generate/Test cycle (Simon, 1996) was appealing and aligned with our use of a rapid application development (RAD) approach in which prototype software is implemented, trialled by users, and improved over a number of cycles. In the first cycle, we developed and presented the initial version of Quick Quiz to the students. As part of their tutorial, students played two quizzes using Quick Quiz. We gathered feedback by asking the students for their comments and observing them while using the tool. We then refined the tool for the next cycle. We continued this Generate/Test cycle until there was little negative feedback about Quick Quiz. This took approximately four one-week cycles.

In the first cycle, the version of Quick Quiz presented to students had only essential features. These included the "play" feature (i.e., answering questions; refer to Figure 1), which allowed students to undertake the quiz, and the quiz result feature (refer to Figure 2), which provided students feedback on their individual performance for one quiz. The point scoring system was also present. In order to promote intrinsic motivation, the points were linked to meaningful feedback, namely, students' performance on the quiz (Nicholson, 2012). Students generally thought Quick Quiz to be interesting and enjoyable. They also identified minor issues with the user interface and mentioned latency issues as a major distraction.

Our observations also revealed that some students were cheating. Quick Quiz is implemented as a mobile web application and students have a time limit of one minute to answer each question. Some students deduced that refreshing the browser while on the question screen re-started the timer for the question. By re-starting the timer, they were able to obtain maximum points for each question (as the number of points awarded depends on how fast the correct answer is selected). Cheating in gamification is to be anticipated and is not necessary detrimental. The actual act of cheating can be viewed positively to some degree; players determine ways of "gaming the game" if the goals of a gamified system are interesting to them (Werbach & Hunter, 2012). In this particular case, the cheating was not desired as it awarded more points to players, which resulted in inaccurate performance results.

In the second cycle, in addition to addressing the user interface issues, the cheating issues and the latency, a leaderboard was introduced. The cheating issue was resolved by terminating a student's quiz if he or she refreshed his or her browser, which meant that the student would not be able to submit any results and would receive no points. The leaderboard is a game element that promotes competition between players as it ranks them based on their performance. This provided students with a different type of feedback than in the first cycle: direct comparison between their performance and those of their peers.

The instructor can also display the leaderboard to the class while students were playing the quiz. As games were not synchronized (students submitted their quiz responses at different times; i.e., as quickly as they answered all of the quiz questions), their scores and ranks are displayed on the leaderboard as they completed their quiz. This created an interesting effect: as more students submitted their completed quiz, the rankings would change. The effect generated excitement, discourse, friendly competition, and generally increased the social atmosphere in the learning environment. That is, it demonstrated that gamification can be used to create an engaged and lively classroom environment (Kapp, 2012). More importantly, it motivated students to perform better.

Although the leaderboard in the second cycle was successful, it provided ranking for a single quiz. As the quiz is a very repetitive activity, to alleviate boredom and to encourage students to attend successive tutorials (in which more quizzes were played), a cumulative leaderboard feature was added in the third cycle. This leaderboard aggregated all of the individual quiz results and displayed an overall ranking for the course.

To provide more detailed feedback to students and instructors, two types of graphs of responses were made available. The first type of graph, the quiz analysis graph displays an overview of the quiz results (number of correct and incorrect answers per question). The second type of graph, the question response analysis graph, presents more detailed information about a single question (how many students selected each answer).

As feedback can be an effective source of motivation in gamification (Nicholson, 2012), the idea of the graphs was to provide students with even more feedback than already present in Quick Quiz. Additionally, these graphs were a more direct connection to the underlying objectives of the learning activity and, thus, made the gamification more meaningful for students (Nicholson, 2012). These graphs provided a visual representation of results, which the instructor used to generate class discussion. As part of the discussion, the instructor gave students formative feedback directly after their quiz activity. This had a positive impact on learning as it created an environment conducive to learning that students seemed to enjoy.

During the third cycle, instructors noticed another type of cheating taking form. Some students formed informal groups and during each quiz, one student would “sacrifice” himself or herself for the benefit of the group. That is, the student would complete the quiz first and let the group know what the correct answers are. The other members of the group would then answer the quiz quickly and correctly, earning them a large amount of points. Although this type of cheating also results in inaccurate performance results for individual students, it created a social dynamic that was not intended, which is a positive effect. This particular form of cheating is also beneficial if students actually learn and understand what the correct answers are and why they are correct, which is the learning objective of the activity.

In the fourth cycle, along with minor refinements, new types of graphs were introduced. The most significant of which was an interactive radar graph that displayed individual student performance compared to the class average on various selectable categories. In order to be able to categorise questions, a tagging system was also developed. In essence, tags, which represent categories defined by the instructor (e.g., “week 1”, “programming basics”, or “if statement”), are added to quiz questions. When students select particular tags, their performance on questions with these tags are graphed against that of the class average.

This type of graph was quite an important addition to the software as it allows students to better understand their knowledge on various components of the course. It could be used, for example, to identify their weaknesses before a test or examination to prioritise their revision. Alternatively, the instructor can use this type of graph to identify general weaknesses in the student cohort and provide remedial or supplementary materials. Another type of graph added in this cycle was a chart that displayed a student’s performance on each quiz against the class average. This is used for students to gain an overview of their performance relative to that of their peers on various quizzes.

At the end of the fourth cycle, it was decided that further development on the artifact would stop as it was deemed to be a good and usable instantiation of gamification in education. Furthermore, informal feedback through questioning and observing students revealed that they found Quick Quiz to be enjoyable, motivational, and useful for learning. Notably, we initially intended to include a “lifeline” feature that would assist users in selecting the correct answer. For example, a lifeline could be removing two incorrect answers from the possible four answers. However, by the end of the fourth cycle, it became evident that this was not only unnecessary, it would have actually hindered the objective of the learning activity by encouraging the students to guess rather than deduce the answers. Had we not used a Generate/Test cycle, we would not have discovered that this feature was unnecessary. The Generate/Test cycle also assisted us to incrementally incorporate more and more relevant and detailed feedback to the students. The students found each new type of feedback to be useful.

# 4 EVALUATION OF THE DESIGN ARTIFACT

At the end of the Test/Generate cycles, we evaluated the design artifact through the use of a questionnaire survey. The questionnaire enquired about three aspects: (1) what were the effects of particular game elements, (2) what were the effects of the design artifact, Quick Quiz, and (3) would students be interested in using Quick Quiz in other courses?

We discuss the data collection process and results in the following sub-sections.

## 4.1 Data collection

To evaluate the impact of Quick Quiz, it was trialled in three IT-related undergraduate courses over a period of four weeks. Students were then able to volunteer to participate in the project by filling out a questionnaire that enquired about their experience using Quick Quiz. Of the 119 students, 84 volunteered. Of those 84 responses, 8 were incomplete and thus, only 76 were usable.

Table 2 displays the demographic of the surveyed students. As can be seen, most of the participants are male, studying full-time, and aged between 18 – 21 years old.

| **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 2 Demographics of surveyed students*

## 4.2 Results

A questionnaire survey was used to collect data from students to evaluate the artifact. The questionnaire enquired about the effect of specific elements in Quick Quiz, the overall effect of Quick Quiz, and if students would like to use Quick Quiz in their other courses. Students answered the questions on a 3-point Likert scale (yes, unsure, no). The questions are shown in Table 3.

| ID | Category | Question |
|---|---|---|
| ELE1 | Effect of specific element | Do you feel that the introduction of the progress bars improved the game experience? |
| ELE2 | Effect of specific element | Did the use of the leaderboards motivate you to do better in the game? |
| ELE3 | Effect of specific element | Did being shown the graphs at the end of the game help you learn? |
| EFF1 | Effect of Quick Quiz | Did playing Quick Quiz have a positive effect on you? |
| EFF2 | Effect of Quick Quiz | Did playing Quick Quiz in general help you learn? |
| EFF3 | Effect of Quick Quiz | Do you think Quick Quiz is effective for learning? |
| FUT1 | Future Use | Would you like to see Quick Quiz be used in your other courses? |

*Table 3. Questionnaire items.*

From Figure 5, it can be seen that the various elements used in Quick Quiz had their intended impact. Of the students surveyed, 76.00% reported that progress bars improved the game experience (ELE1). Additionally, as intended, leaderboards motivated better performance (ELE2; 78.67% agreement) and the use of graphs at the end of Quick Quiz helped students learn (ELE3; 66.22%).

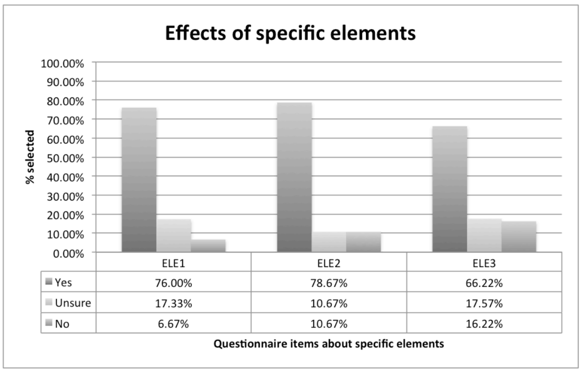


*Figure 5. Effects of specific elements.*

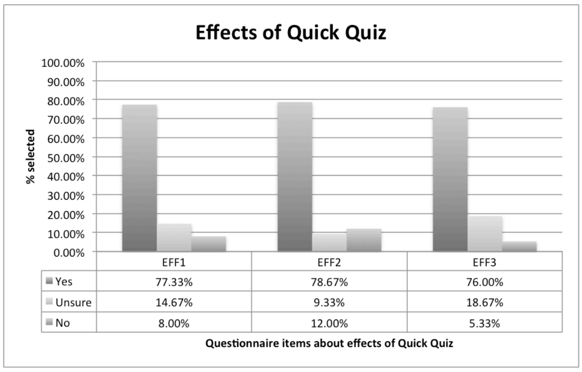


*Figure 6. Effects of Quick Quiz.*

Of the participants, 77.33% believed that Quick Quiz had a positive effect on them (refer to Figure 6, EFF1). 78.67% of participants reported that Quick Quiz helped them learn in general (EFF2) and 76.00% believed it was effective for learning (EFF3).

In order to gauge students' interest in Quick Quiz, they were asked if they would like it to be used in their other courses. 76.00% of students answered "yes", while 16.00% were unsure, and 8.00% did not want it to be used in their other courses (refer to Figure 7).

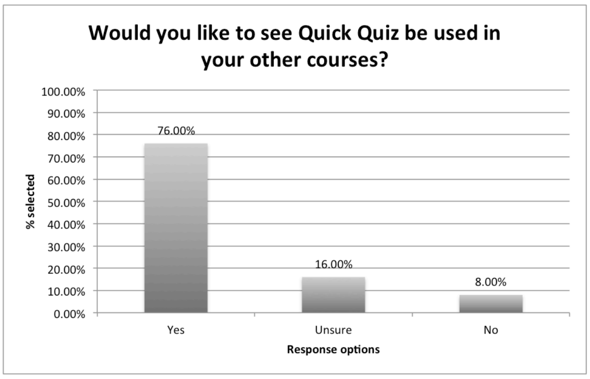


*Figure 7. Student interest in future use of Quick Quiz.*

Overall, the results are promising as all questions asked, except for the one about the use of graphs at the end of the quiz (ELE3 in Table 3), received above 75.00% agreement. It is worth mentioning that the results are not only positive because the majority of students are in favour of Quick Quiz; they are also promising because only a small number of students dislike Quick Quiz. For example, of the 24.00% of students who did not agree that Quick Quiz is effective for learning, 18.67% were unsure and only 5.33% did not find Quick Quiz effective for learning. This is similar for all of the questions asked. The percentage of students responding negatively were always less than those who were unsure, except in the case of the question about the leaderboards (ELE2; both "unsure" and "no" were 10.67%) and the question about Quick Quiz being helpful in general for learning (EFF2; 9.33% "unsure" and 12.00% "no"). As the majority of students like Quick Quiz and believe that it contributes positively to their learning and only a small amount of students do not like it, this indicates that with further refinement, it may be possible to gain positive feedback from the students who are unsure about Quick Quiz currently.

### 4.3 Discussion

The results of this work are encouraging, however, it is only a small part of our overall objective of addressing the declining motivation of students to learn. In this research project, we did not address this issue but we developed an initial working prototype and evaluated its impact on students. The results of this exploratory work were quite favourable but due to the small number of participants, it cannot be generalised and must be investigated further. The next step in the design science methodology is to put the tool to use in several classes and to evaluate its ability to improve students' motivation and, in turn, its impact on students' learning outcomes.

Of course, simply using the design artifact will not improve students' motivation to learn. It is not sustainable as the novelty aspect will fade with time. Thus, the design artifact must be embedded within one or more teaching methods or processes. That is, in this part of our research, we have developed an instantiation as our design artifact, however, the next step is to use design science to develop a method as a design artifact.

It is also important to use design science and gamification theories to develop more tools as it is difficult for a single tool to address all the necessary aspects of education. For example, in its current state, Quick Quiz is best suited to develop learning objectives on the lower level of Bloom's hierarchy, such as knowledge and comprehension, which form the foundation for more advance cognitive skills, such as synthesis and evaluation. It should be noted that we are not implying that all aspects of learning should be gamified, rather, we propose the development of a toolkit consisting of gamified learning activities that instructors can use as they deem appropriate.

Furthermore, evaluating improvement in student motivation is not a simple and straightforward task. Thus, as part of the design science methodology, it will be necessary to determine how to evaluate this in order to determine the effectiveness of our solution.

Thus, future work to address the improvement of learning using gamification includes using design science methodology to develop or search for technological tools (including improving our current design artifact, Quick Quiz), processes to use these tools, and evaluation of the impact of these tools. Although qualitative methods are useful for initial evaluations as they identify constructs, the focus of the evaluations should be empirical.

# 5 CONCLUSION

We have developed and evaluated a gamified quiz using the design science research methodology. The design artifact, Quick Quiz, used a number of game elements and it was found to be favourable with students who used it in their tutorials. Students reported that game elements such as progress bars improved the game experience, leaderboards motivated them, and result graphs helped them to learn. Overall, students found Quick Quiz to be effective for learning. Our contribution in this study is the successful instantiation of a gamified learning tool using the design science research approach.

Although the results are promising, they are related to only one tool in an initial prototype state. There are a number of issues that can be addressed to further improve the impact of Quick Quiz. Three such limitations are: (1) Quick Quiz is best suited to address low level learning objectives on Bloom's hierarchy, (2) Quick Quiz does not have any specific features for social interactions, and (3) there is no specific teaching method in which to use Quick Quiz. Each of these three issues has important implications for our long-term objective of improving student motivation for learning using technology and gamification techniques.

To address our long-term objective, other possible gamified tools should be investigated and developed. This includes further improvements in Quick Quiz. In addition to this, more research is required to determine how to embed these tools deeply into teaching methods to achieve learning objectives. For example, when intending to develop foundational cognitive skills in students, such as knowledge and comprehension, tools such as Quick Quiz are most appropriate. However, to develop more advanced cognitive skills, such as higher order thinking skills, different tools and approaches, such as *myVote* (Cheong et al., 2012), are better suited than Quick Quiz.

The exploratory work presented in this paper is an initial step in improving student learning motivation using technology and gamification techniques. The results are encouraging, as 76% of students find the approach favourable, but more work is required to achieve our long-term goal, such as investigating why the remaining 24% of students do not find this approach favourable. This will assist us in improving our approach and developing further tools and methods to improve learning outcomes in the future.

# 6 ACKNOWLEDGEMENTS

We would like to thank the students and academics for their involvement in this study. We would also like to acknowledge Daniel Lee, who assisted in the implementation of the mobile web client.

The research was conducted with ethics approval from the RMIT Business College Human Ethics Advisory Network under register number 1000389.

## References

Bogost, Ian. (2011). Persuasive Games: Exploitationware. Retrieved 10 August, 2012, from http://www.gamasutra.com/view/feature/6366/persuasive_games_exploitationware.php/

Cheong, Christopher, Bruno, Vince, & Cheong, France. (2012). Designing a Mobile-app-based Collaborative Learning System. *Journal of Information Technology Education: Innovations in Practice (JITE:IIP), 11*, 97-119.

Deci, Edward L., & Ryan, Richard M. (1991). *A motivational approach to self: Integration in personality.* Paper presented at the Nebraska symposium on motivation.

Deterding, Sebastian, Dixon, Dan, Khaled, Rilla, & Nacke, Lennart. (2011). *From Game Design Elements to Gamefulness: Defining Gamification.* Paper presented at the 15th MindTrek Conference, Tampere, Finland.

Hevner, A.R., March, S.T., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS quarterly, 28*(1), 75-105.

Kapp, Karl M. (2012). *The Gamification of Learning and Instruction : Game-Based Methods and Strategies for Training and Education*. San Francisco: Pfeiffer.

McGonigal, J. . (2011). *Reality Is Broken: Why Games Make Us Better and How They Can Change the World*. London: Penguin.

Nicholson, S. (2012). *A User-Centered Theoretical Framework for Meaningful Gamification.* Paper presented at the Games+Learning+Society 8.0, Madison, WI, USA.

Nunamaker, J.F., Jr., & Chen, M. (1990). *Systems development in information systems research.* Paper presented at the Proceedings of the Twenty-Third Annual Hawaii International Conference on System Sciences.

Orlikowski, W.J., & Iacono, C.S. (2001). Research commentary: Desperately seeking the "IT" in IT research -- A call to theorizing the IT artifact. *Information systems research, 12*(2), 121-134.

Reeves, B., & Read, J.L. (2009). *Total Engagement: How Games and Virtual Worlds Are Changing the Way People Work and Businesses Compete*: Harvard Business Press.

Robertson, Margaret. (2010). Can't play, won't play *Hide&Seek: Inventing new kinds of play* (Vol. 2013).

Simon, H.A. (1996). *The sciences of the artificial*: MIT press.

Weber, R. (2003). Editor's comment: still desperately seeking the IT artifact. *MIS quarterly, 27*(2), iii-xi.

Werbach, Kevin, & Hunter, Dan. (2012). *For the win*. Philadelphia: Wharton Digital Press.