A Case Study in the Gamification of a University-level Games Development Course

Siobhan O'Donovan
Department of Computer Science
University of Cape Town
siobhan.odonovan@hotmail.com

James Gain
Department of Computer Science
University of Cape Town
jgain@cs.uct.ac.za

Patrick Marais
Department of Computer Science
University of Cape Town
pmarais@cs.uct.ac.za

ABSTRACT

Gamification is the application of game mechanics and player incentives to non-game environments. When designed correctly, gamification has been found to increase engagement and encourage targeted behaviours among users. This paper presents the gamification of a university course in Computer Games Development using an online learning management tool, including how this might generalize to other courses.

Our goal with gamification was to improve lecture attendance, content understanding, problem solving skills and general engagement. The success of this intervention was measured using course marks, lecturer evaluations, lecture attendance, and a questionnaire; all with strongly positive results. However, this must be balanced against the costs, both monetary and time, required to successfully implement gamification.

Categories and Subject Descriptors

K.3.1: [**Computers and Education**]: Computer Uses in Education; H.5.2 [**Information Interfaces and Presentation**]: User Interfaces

Keywords:

Gamification, games design, active learning.

1. INTRODUCTION

The main objective of an education curriculum is to convey certain knowledge and skills from teacher to student. The design of such a curriculum should meet all learning objectives, while ensuring that students are engaged and given clear feedback [1].

SAICSIT '13, October 07 - 09 2013, East London, South Africa

http://dx.doi.org/10.1145/2513456.2513469

Unfortunately, the issue of student engagement is frequently neglected, particularly at the university level; Here we see an increase in disengagement, cheating, and learned helplessness, which are not conducive to the learning environment [2].

One approach to combating this worrying trend is the application of *gamification* to an educational context [1], with the aim of improving the overall engagement of students and providing an impetus to active learning.

Gamification is defined as the use of game mechanics in non-game contexts [3]. It applies reward-based games design elements to tasks, such as visiting a website or using a product, in order to motivate the target market to engage in these tasks more often and deeply. When correctly implemented, it may even inspire the target demographic to carry out tasks they would previously have found uninteresting or undesirable. Gamification has received a lot of interest recently, due to its success in medical, social, lifestyle, business, and more recently, educational contexts [1, 2].

In the case of education, a number of game-like attributes are already evident [2]. In higher education, students start as novices (freshmen). As they progress, they go on quests (lectures) to learn skills (coursework) and are then tested on these through challenges (tests and assignments) that determine whether they qualify for the final boss-battle (exams) in order to level up (pass the year) or lose the game (failure). The end goal of this game is to gain sufficient knowledge in the specific field in order to graduate with a degree (a badge of honour – the final prize at the very end of the game). Unfortunately, when viewed through the lens of games, this design supplies students with little motivation.

An effective game must be motivating, addictive and provide encouragement through very short-term goals, so that the player can fail and try again until they succeed. At university, if a student fails a single test, it is possible for them to fail the entire course. This puts immense pressure on students, decreasing motivation [1]. By improving the design of the "university game" to more closely mirror the traits of games, learning could be transformed into a more motivating experience for all types of students, not just the self-motivated achiever.

In order to judge the effectiveness of gamification in this context, we decided to apply it to an existing Computer Science course focusing on 2D games design and development offered at the University of Cape Town (UCT). This particular course was chosen for two reasons. First, its participants are avid gamers familiar with reward-based game elements and second, for pedagogical reflection purposes. We hoped that the gamification would prompt students to think about the game mechanics we employed to enhance teaching and how these principles could be used in their own games.

In the design of our gamification we sought to achieve a number of goals:

- Increase student engagement and motivation
- Improve lecture attendance and in-class participation
- Enhance content understanding and problem solving skills

To achieve this we decided to make use of an online management tool, Vula, as well as in-class activities. The class activities were designed to motivate students to attend lectures and increase exposure to course material. The online activities were intended to motivate students to review course material, and increase problem solving skills and creativity in assignments.

This paper is organized as follows: we begin by discussing existing work in gamification, with a focus on applications to the university setting. We then discuss the design and implementation of our gamification. This is followed by an evaluation of the effect on engagement, motivation and performance of the enrolled students. Next we discuss the improvements on our initial design before concluding and suggesting avenues for possible further research.

2. BACKGROUND

Gamification has been successfully applied in educational contexts, ranging from primary to tertiary education. Here, we briefly discuss the basic psychological theories behind the concept and analyse three implementations of gamification in the tertiary sector.

2.1 The psychology behind gamification

Gamification is applied to systems where specific user behaviour is desired. This requires that the game design techniques manipulate users' behaviour with a high degree of certainty. In order to understand how to do this effectively, we need to understand something of the psychology of human behaviour.

Fogg's Behaviour Model (FBM) provides a theoretical basis for human behaviour in this context [4]. He states that three factors influence any behaviour: motivation, ability and a trigger. For any behaviour to occur, a person must reach a certain level of motivation and ability [4] – the activation threshold (See Figure 1). Only once this threshold has been reached, will a trigger be effective and the desired behaviour successfully induced.

Good gamification design makes use of *learning theory* and *needs analysis* [5] to balance motivation using rewards, and ability using encouragement and prior practice, in order to increase the likelihood of performing the desired behaviour. Once the balance is right, the system will then trigger the user to carry out the behaviour. In the context of gamification, a trigger could be notifying the user that they can earn a new reward if they complete a desired task.

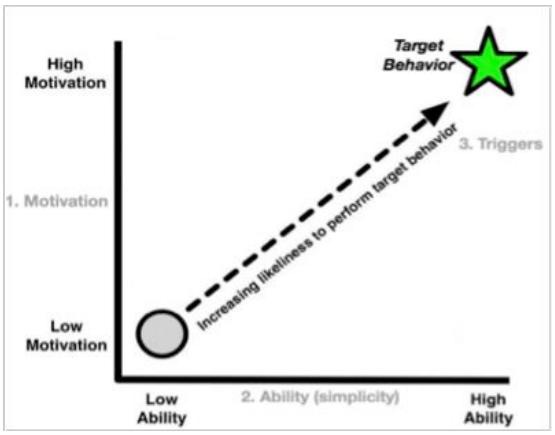

Figure 1: A graphical representation of Fogg's Behaviour Model [4]

This is a delicate system with many extraneous variables. The trigger design is key; if it comes at the wrong time it can leave the user feeling frustrated and demotivated [4].

2.2 Implementations in learning

There have been a few noteworthy implementations of gamification in education at a university level. One good example is the gamification of a undergraduate IT course at the University of Michigan [6, 7], with 200 participants. The author focused on the concepts of choice, community and quick feedback. Students could choose between academic and artistic assignments, take part in group "guild" learning activities and were given rapid, ongoing feedback. Students were given autonomy so that they would feel a greater sense of control over their academic performance. This was done so that students would become engaged with the material, as they were active participants in choosing what they were doing. Although, students reported that they remembered more from the gamified course than their other courses, there was little quantitative analysis provided.

Another key instance of gamification at a university level is a class on multiplayer-game design at Indiana University [8, 9]. The course provides an introduction to games design and online games, and was remodeled into a multiplayer game. Lecture time was spent on the usual course material, but it was shaped in such a way that presentations were now rebranded as quests, tests as boss battles, writing documents as "crafting" and marks were referred to as "experience points". Experience points, often shortened to

XP, are point rewards used in many role-playing games to measure the achievement of the players. It is therefore appropriate to rename marks gained as XP rewards. The class was also divided into "zones" in order to carry out group activities. The results were impressive, with the average grade increasing from a C to a B, over the previous iteration of the course. There was also a higher reported engagement. Our case study has produced similar positive results although the interventions take a different form.

Just Press Play [10] took a different stance, by creating a real game that is not course specific, but rather acts as a layer on top of the university experience. Implemented at the Rochester Institute of Technology, Just Press Play is designed to encourage general social and academic behaviours that lead to academic excellence, rather than to motivate carrying out specific academic tasks for a specific course. Students are immersed in an in-game story, and have to take part in quests to solve a mystery. These quests are mostly social tasks ranging from building academic relationships with faculty members and giving input on course syllabi, to taking part in a student flash mob or exploring hidden parts of campus. Upon completing a quest, students swipe an RFID keychain over a sensor. The confirmation is sent to a server, which keeps track of each student's game statistics. As they complete more quests, students gain rank and status among peers and unlock newer quests. Since *Just Press Play* employs a very different approach to gamification, it cannot be directly compared to ours. However, its success is evidence that gamification need not be course-specific in order to engage and motivate desirable behaviour among students at universities.

Two undergraduate courses in Game Design and Logic and Animation at Bond University, Australia were gamified [11]. The gamification included renaming grades for all assessments to "experience points", a weekly in-class team-based Jeopardy game, compulsory and non-compulsory activities and a leaderboard, which was integrated with an online resource management tool (Blackboard). Students agreed that the gamification encouraged them to engage more with the coursework. They also said that they were more engaged in analysing feedback for activities in order to improve and earn more experience points in the future. The fact that they could consistently monitor their grade as the course progressed was also regarded as very important.

In this paper we present another and different gamification system and provide a detailed analysis of its benefits and implications.

3. GAMIFICATION MECHANICS

Any good gamification design should have three basic properties. It should have a special **meaning** for the user, the ability to inspire the user to **master** the topic and it should be **autonomous,** by providing a feeling of free choice [12]. It should also focus on meaningful accomplishments, a sense of discovery, social/bonding interactions and incorporate visually pleasing elements [13].

For users to have a personal connection to the gamified product, they must feel that the product has a purpose for them specifically, i.e. the end goal must be one the users wish to achieve. The users must be able to clearly see and track their progress toward long and short term goals, in search of the final goal. This gives the product meaning.

To motivate the users to work toward these goals, gamification implements an accomplishment-based reward system. Points, stars and badges are often awarded to users for completing important tasks. Progress bars allow the users to keep track of their points and their proximity to the next achievement, be this rising to a new level or winning a badge. The prospect of winning a badge inspires users to work toward goals themselves: the badges act as self-affirmation symbols as well as allowing users to identify with a group that works toward the same goals [14]. Leaderboards allow the user to view an achievement compared to others in the same community and also create both competition and a sense of belonging to a similar minded group.

The reward system must be carefully designed so as to maximize user enjoyment. The progression from one level, badge or star to the next must not be overly easy. In essence, it must be an interesting challenge that is just out of comfortable reach. The challenge must also vary in nature and complexity [12]. If a user is faced with the same challenge, just at a higher difficulty level they might soon lose interest, but if it incorporates a new, unexpected twist, the intrinsic pleasure people get from solving new puzzles will be kept alive. This is one element that contributes to making a game addictive.

The product should also incorporate a simple, yet well thought-out story with matching graphics to intrigue the users. This will unify the rewards and goals into a single system. The familiar stories that allow gamers to "save the world!" can also apply to gamified products and will give the users a sense of purpose outside of the overall meaning the product has for them.

Finally, gaming is an unrestricted pass-time. If one wants to emulate the effectiveness of games, the users must be given the freedom to roam and do as they please. In gamification, the designer's main objective is to motivate the users. By giving each activity an external reward, the intrinsic pleasure (internal reward) a user feels when completing an activity may be devalued [12]. It is also the internal joy of succeeding at something challenging that makes a gamer want to continue [12]. If the gamified product drowns out internal accomplishment, users that play for this feeling might lose interest. Also, if users feel that they are being manipulated, they may notice that their freedom within the product is an illusion. Within gamification one must remember to give the user the freedom to choose – for instance when or how they carry out a gamified task.

4. PILOT STUDY

Prior to designing our gamification we undertook two surveys to provide contextual information: a survey to determine gamer personality types among students and a survey to determine reaction toward the proposed gamification.

When creating a traditional computer game, identifying the target gamer personality type is essential to the design. As gamification is based on this type of game design, it has also been incorporated into the creation of gamified products [15].

The most popular gamer personality test is the Bartle test. It has four categories: achiever, socialiser, explorer and killer [16]. Despite its popularity, the Bartle Model has some flaws: the player types are assumed to be mutually exclusive and the model employed is not empirically based and therefore cannot be validated [16]. Instead, we used the *Brainhex* [17, 18] survey, which extends the Bartle model to incorporate four further categories: seeker, survivor, daredevil and mastermind, while replacing killer with conqueror. It also incorporates certain so-called exceptions – specific game attributes that the gamer does or does not enjoy as part of their game play, such as fear or pressure. Furthermore, the *BrainHex* model accepts that gamer types are not mutually exclusive.

We also incorporated a proposed scenario to enable the participants to visualise the full scope of the proposed implementation. This was distributed to university and college students in Cape Town. The target group was selected for the following reasons: they were in an age group appropriate for the intended implementation; they had taken a traditional course, which they could compare to the proposed scenario; and, in the interests of later generalization, they represented students from a variety of faculties.

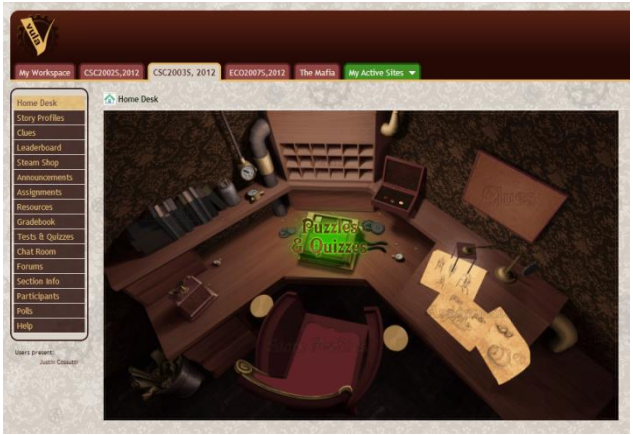

Figure 2: The edited Vula skin and home desk image used for site navigation.

The survey received 90 responses. Of these, 38.9% were female, while 61.1% were male. The *BrainHex* survey indicated that the top three classes were Mastermind, Conqueror and Seeker. This means that the main gamer type among students is a person who enjoys working on challenging problems and puzzles, strives to beat all competitors and loves discovering things. Of the 90 participants, 54 had a *BrainHex* exception. The top three categories were: no fear, no mercy and no pressure. This means that most of the participants enjoy being in control, dislike being afraid or under pressure and do not enjoy playing with other people [19].

From the scenario survey, the gamification techniques found to be the most potentially effective in an educational setting were: badges (appealing to masterminds), progress bars and leaderboards (appealing to conquerors), a storyline and a visual (appealing to the seekers). A system that combines these techniques would cater to the mastermind-conqueror-seeker gamers, which were the highest scoring personality types found in the students that completed the study.

5. GAMIFICATION DESIGN

This section describes how our design serves the goals of increased lecture attendance, class participation, content understanding, problem solving skills and general engagement. We begin by discussing the storyline, as this ties the other aspects together. We will then present the reward system and specific goals.

5.1 The Storyline and Visual Elements

The course had a *Steampunk* theme. Steampunk is a science fiction sub-genre set in an alternate past similar to the Victorian era, but with advanced technology. Students are introduced to a secret "Order of the Curmudgeons". This order is a club of mad scientists, each with their individual quirks and expertise. A device called the "Crowther Engine" (our equivalent of the Babbage engine) has gone missing and the students must solve the mystery of its theft. This is accomplished by earning clues by completing tasks (see section 5.2). Once the students unravel the final set of clues, they have solved the mystery.

This storyline was chosen because it inspires intrigue and a sense of mystery. This appeals to the seeker nature that prevalent amongst our survey participants. The science and mystery-solving nature of the storyline allowed us to incorporate lateral-thinking puzzle solving tasks, which appeals to masterminds and is one of the skills the course aims to foster.

The visual element of the course was heavily influenced by *steampunk* art. We edited the "skin" of the Vula page to immerse students in the game world when they accessed anything associated with the course, including resources not directly affiliated with the gamification.

The home page artwork, seen in Figure 2, is the desk of a mad scientist, used as the navigation "home" desk. From here, the students can access all the resources usually available in Vula, as

well as additional pages, such as the Leaderboard. To help students select the correct link, visual feedback is provided when the mouse is positioned over the various elements on the desk.. This is shown in Figure 2, where the player has selected "Puzzles and Quizzes". Other visuals will be introduced when we discuss the goal and reward systems.

5.2 Goals

The long-term goals of the second year Games Course are to teach development concepts and skills relevant to 2D games design. Gamification is intended to aid in meeting this long-term goal by:

- Improving the students' review of course material
- Increasing meaningful class participation,
- Fostering problem solving skills,
- Increase lecture attendance and
- Encouraging creativity in practical tasks.

Each of these sub-goals in our design was linked explicitly to a reward structure, through an experience point (XP) system.

The students were given short timed assessments, in the form of quizzes, once a week. The quizzes were based on lecture material taught in the previous week and promoted a review of course material after lectures. Students were awarded experience points (XP) for achieving various levels of success: 10 XP were given for 70-79%, 20XP for 80-89%, 30XP for 90-100%.

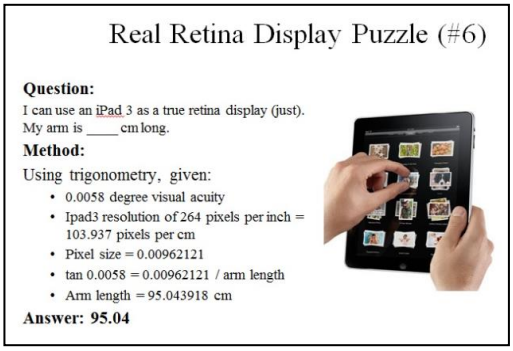

Figure 3: Example of a puzzle

Students were also assigned puzzles (e.g., Figure 3) in the form of lateral-thinking questions to complete every week. These were not timed, and while related to the course material, were more focused on testing creative problem-solving skills than course knowledge. Students received 40XP for solving a puzzle and an additional clue toward solving the game mystery, see Figure 4.

These quizzes and puzzles could be completed by the student at any time, so as to raise the autonomy of the gamification design.

Students were also given three attempts to solve each quiz. This was intended to promote the understanding that initial failure is an acceptable part of learning. As the puzzles were more complex, they allowed unlimited attempts.

Both the quizzes and puzzles had immediate feedback. This allowed the student to immediately see where they went wrong, and rewarded them instantly if correct with earned XP. This is a key aspect of gamification, in that it solidifies the connection between doing right and being rewarded for it.

Sporadic group challenges were organised throughout the semester to practice game development concepts learnt in class. During these, students worked together and the best work was rewarded with XP. This was done to inspire competition among students but also healthy collaboration.

Lecture attendance was recorded and students were rewarded with 10 XP per lecture. This was doubled for important tutorial days to motivate higher attendance rates. Class participation was awarded with "ad hoc" XP points depending on the quality of the discussion and the results of in-class exercises presented in class. This promoted active learning and also helped incentivize lecture attendance

Figure 4: A Clue on the Clues board. Hovering over the thumbnail (left) would show the full clue (right).

In the longer term, the regular assignments and tests in the course remained the same. These were marked in the conventional manner, but students were given incentives to show creativity in coding and design by the award of extra XP.

5.3 Rewards

The rewards we implemented were intended to motivate students to undertake activities in keeping with the sub-goals of our gamification. They were specifically designed for our target users based on the information we gathered from our two surveys.

5.3.1 Experience Points

As described earlier, students earn XP by completing quizzes and puzzles, attending lectures, participating in class exercises and for

creativity in assignments. These XP are used to determine the other rewards available to students. The number of steam points (see below), ranks and progress shown on progress bars are all determined by the amount of XP earned.

The value of these XP is measured by how much they mean to the student. As the rewards depend on them, students have a strong incentive to gain more XP. This means that even a relatively small XP increase can earn the student a reward, giving the XP a significant perceived value.

The final XP for each student was translated into a mark for the gamification assignment of the course. However, this weighed relatively little (2.9%) as a proportion of the total course result. The maximum XP value achievable was 1705.

5.3.2 Steam Points

Steam Points (SP) are our implementation of an in-game currency. Students were given 1 SP at the beginning of the game, and then gained 1 SP for every 200 XP earned. Students could then visit the Steam Shop page, to spend this in-game currency on:

- Quiz do-overs: These allow the buyer another three chances at a quiz.
- Puzzle hints: These gave hints to puzzles the buyer was having difficulty solving.
- Class reward: This was a group reward, where an accumulation of 50 SP would give the entire class a reward.
- Assignment extensions: Students could buy an extension for their assignments at 2 SP per day.

The first two were offered to help students struggling with the gamification itself, so that the gamification did not become demotivating to students who fell behind. The class reward was intended to inspire unity among students. The assignment extensions gave the gamification real-life impact.

5.3.3 Progress bars and badges

In other implementations of gamification, players usually earn badges to measure their achievement in certain skill areas required by the game, while progress bars indicate their overall progress.

The results from our surveys [20] showed that students are more motivated by progress bars than the badges denoting any progression in skill. However, because they received a high motivation score, we incorporated both. Instead of using badges to represent certain skills, we used them as a proxy for rank. We also felt that our assessment systems and rewards sufficiently emphasized the desired behaviour, without requiring a further complex badge-system.

Rank is determined by the overall number of XP, according to a non-linear progression chart (see Table 1). As a trigger to involvement, students had to earn relatively few points in the beginning of the semester to reach a new rank.

Table 1: Ranks and corresponding non-linear XP ranges for the first 5 ranks

Rank	Title	XP
1	Neophyte	0-49
2	Apprentice	50-149
3	Artificer	150-249
4	Techno-Apt	250-399
5	Inventor	400-549

5.3.4 Leaderboard

A leaderboard page, designed to look like a Victorian badge collection box (see Figure 5), displayed all the in-game statistics. The top 20 students, and the currently logged-in student's XP, collection of badges, progress to next rank and SP value are all portrayed here.

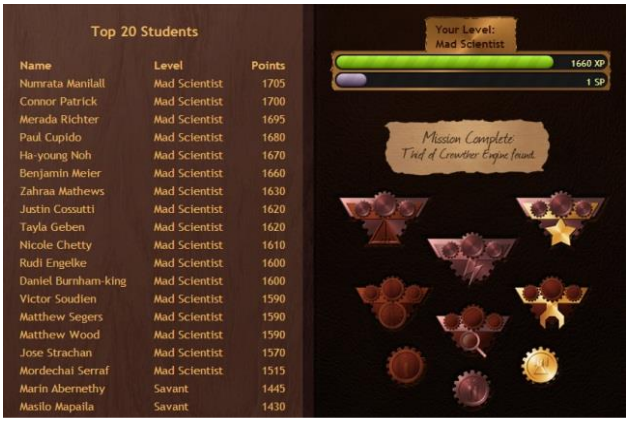

Figure 5: Leaderboard showing current student's rank, badges, and XP and SP progress.

We decided to include only the top 20 for two reasons. Firstly, we wanted to foster healthy competition for a spot on the leaderboard. This would appeal to the conqueror and mastermind personality types, as they would be driven to strategise to be near the top. Our second reason was that we did not want to shame the bottom half of the class.

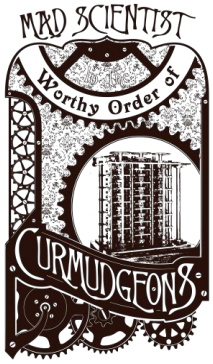

Figure 6: The game logo printed onto the T-Shirt prizes.

In order to bridge the divide between the virtual system and the real world, students were told that the top 10 on the leaderboard would win t-shirts with the game logo (as shown in Figure 6). The t-shirt prize and leaderboard are designed to particularly appeal to the conqueror players, who are motivated by winning.

5.4 Implementation

The University of Cape Town has an online portal facility called Vula, created through the Sakai framework, which is accessible to all students. Each course has a dedicated tab, which is only accessible to students enrolled in that course. Tabs display the course-specific academic resources and allow for assignment submissions, online tests, posting in forums and a variety of other tools for academic use.

The tab for any given course is integral to the management of course-related resources. Students need to check it almost daily for lecture note uploads, announcements from lecturers and relevant posts in chat rooms. For this reason, we decided that gamification of the course would require Vula as well as the in-lecture elements. This limited our implementation to the Vula Sakai environment, and we had to adapt our ideas to the existing infrastructure.

The technical implementation required that we modify the course's dedicated tab and was split into two parts. The involved changing the front-end appearance. We modified the CSS skin of the standard tab, gave it a home screen and used images appropriate to the *steampunk* theme. This was done to change the "look-and-feel" from the standard blue-white, immerse the student and make them feel that the game extended to the entire course.

The second part of the implementation focused on interfacing between the remote access-controlled Vula server, and a separate departmental server. Student data in XML format was extracted from the Vula server, and then manipulated and displayed using a combination of PHP, MySQL, JavaScript and HTML. We queried the Vula server every 20 seconds to ensure data displayed on the tab was up-to-date.

6 EVALUATION AND DISCUSSION

The overall effectiveness of the gamification was evaluated by comparing its benefits and costs. We determine benefits by analysing the course grades, lecture attendance, lecturer evaluations and a student questionnaire. Cost is the monetary and time investment required to build and maintain the system.

6.4 The Student Questionnaire

We distributed a questionnaire at the end of the course to determine if students perceived any improvement in understanding, engagement, and course marks in order to gauge the effectiveness of our gamification. We received 34 responses, which represented 77.72% of the class.

As shown in Figure 7, we asked students to rank perceived increase in understanding, engagement, overall course mark and whether the course was improved by the story and theme, on a Likert scale. Here, 1 represents "strongly disagree" and 5 represents "strongly agree". While all our results were positively skewed, being above neutral, students felt that the gamification improved their understanding and particularly their engagement most.

However, they were less certain whether it improved their overall mark for the course, probably because they had not yet written their final exam. This answer was anticipatory and may not have been an accurate representation.

Although still positive, the weakest result was whether students felt the gamification was improved by the story and theme. In the comment space provided a number of students mentioned that the storyline was not sufficiently integrated into the course as only one tutorial made use of it. This likely reduced its significance for some students.

The last few questions required students to rank the incentive elements, learning-based elements and steam products in order of preference.

(A) Improved Understanding: "The gamification improved my understanding of the course material"

1. Strongly Disagree	2. Disagree	3 Neutral	4. Agree	5. Strongly Agree	Mean	Std Dev
0	4	5	15	10	**3,91**	**0,97**

(B) Improved Engagement: "The gamification increased my engagement with the course"

1. Strongly Disagree	2. Disagree	3 Neutral	4. Agree	5. Strongly Agree	Mean	Std Dev
0	2	2	13	17	**4,32**	**0,84**

(C) Higher Mark: "I obtained a higher mark for this course because of the gamification"

1. Strongly Disagree	2. Disagree	3 Neutral	4. Agree	5. Strongly Agree	Mean	Std Dev
1	1	11	15	6	**3,71**	**0,91**

(D) Improved by Story and Theme: "The story and theme (Order of Curmudgeons) improved the gamification"

1. Strongly Disagree	2. Disagree	3 Neutral	4. Agree	5. Strongly Agree	Mean	Std Dev
1	2	11	16	4	**3,59**	**0,89**

(E) Incentives Order (1 - Best, 6 - Worst): "Order these gamification elements (from most to least effective) in motivating you during the course."

	Leader-board	Steam Points	Ranks	Progress Bars	End Prize	Badges
Mean	1,68	2,06	3,80	4,24	4,35	4,53
Std Dev	0,65	1,46	1,16	1,30	1,54	1,25

(F) Steam Rewards Order (1 - Best, 4 - Worst): "Order the steam point rewards from best to worst."

	Extensions	Puzzle Clue	Class Reward	Quiz Do-over
Mean	1,13	2,66	2,94	3,28
Std Dev	0,55	0,87	0,80	0,81

(G) Learning Order (1 - Best, 5 - Worst): "Order these gamification elements (from most to least effective) in contributing to your learning."

	Quizzes	Lecture Attendance	In-class Exercises	Puzzles	Game Story
Mean	1,81	2,19	2,52	3,69	4,73
Std Dev	0,91	1,28	0,96	0,71	0,58

Figure 7: Analysis of the student questionnaire

Of the incentive elements, the leaderboard was found to be the most motivating by far, with a notably low standard deviation of 0,65. This was followed by steam points and ranks, while the progress bars, end prize and badges were ranked lower. It is possible that the end prize was influenced by a "sore loser" effect, as only the top 10 would have found this a real incentive by the end of the course. Badges and progress bars were directly linked to the rank, and may therefore not have given any further incentive beyond visual enjoyment.

Extensions were the most popular steam shop reward on offer, with puzzle clues and the class reward trailing behind. The quiz do-over ranked last in popularity. Interestingly, these rewards were ranked in order of actual usage by students. Practical extensions were used the most with 74 practical extension requests bought, while the quiz do-over was only purchased once. Practical extensions were so highly valued because they gave the student a real and meaningful reward. This re-iterates the importance of meaning in a gamification design.

In terms of benefit to learning, students ranked the quizzes and lecture attendance as having the largest impact. Research into testing has found that doing tests and getting rapid feedback is more conducive to learning than studying the material in great depth [21]. It is therefore no surprise that students found this a significant benefit. It is interesting, however, to note the inclusion of lecture attendance, as the department traditionally has quite poor attendance for its courses. Puzzles and game story scored low, as these were not as obviously connected to the specific learning outcomes of the course.

Students also made several suggestions for improving the system. These included allowing students to use SP to weight assignments, extending the theme to the assignments, allowing a borrowing system for SP and including more teamwork activities. Students commented that there was a stronger sense of co-operation and class identity and that they would like gamification to be extended to other courses.

6.5 Course Grades

We compared the student grades for the course from 2011, which did not have gamification, to 2012, which did, and found a statistically significant improvement in student performance.

Using a t-test analysis, we compared 2011, which had a mean of 70.8% and a standard deviation of 10.3, to 2012, which had a mean of 74.9% and a standard deviation of 8.6. We chose a significance level of 5%, and our t-test p-value was 0.031, allowing us to exclude the null hypothesis and assert that the gamification had a significant positive impact on student grades.

However, there are some important caveats to this analysis: it was difficult to exclude extraneous variables in our study, and as such gamification was not the only change to the course. While the syllabus stayed the same, the lecturers did not, and there was one fewer lecturer in the course.

In an attempt to ameliorate this we tried to use the mainstream Computer Science course as a control. Here we found that the results of the games students improved from 2011 to 2012, but that this was not as significant (2011: mean = 64.2%; std dev. = 11.3. 2012: mean = 67.4%; std. dev. = 10.3. t-test p-value = 0.099). However, again extraneous variables intrude, as there was a major change to the syllabus from 2011 to 2012.

It is also worth noting that the gamification counted toward the final course grade, and that students had the ability to extend assignments, in effect potentially skewing the results.

6.6 Lecture Attendance

The reward scheme we implemented resulted in a very high lecture attendance, with a mean of 79.1% (see Figure 8). This is significantly higher than the mean for the other Computer Science courses in the department, which lie in the 30-60% band. This range is dependent on the lecturer, course material and style of delivery.

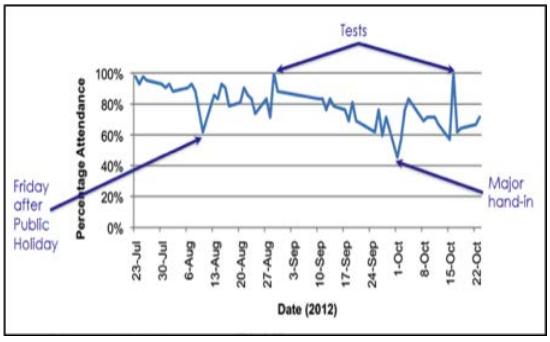

Figure 8: Graph showing lecture attendance for the course

In Figure 8, the spikes are the two class tests and the dips coincide with assignment deadlines and public holidays.

As mentioned in the system design, we awarded double XP for attendance at the weekly tutorial sessions. It is not possible to know whether this had any effect on the attendance, as the data we recorded is too erratic.

6.7 Lecturer Evaluation

The lecturers on the course were evaluated by students using the standard questionnaire supplied by UCT's Science Faculty, which assesses their overall effectiveness, knowledge, preparation, communication, clarity, pace, effort and approachability on a five point scale.

While the lecturers received higher scores in all categories than in previous years for this course, this was not statistically significant.

6.8 Time and Monetary Costs

Both the monetary and time costs of this system were substantial and need to be considered before deciding to embark on a similar gamification programme.

An artist was hired to create thematic content and a programmer was required to build the system that allowed for the gamification functionalities. Money was also invested in the prizes, namely the top 10 t-shirts and the cupcakes for the class reward. A breakdown of these costs is presented in Figure 9.

		Hours	Rate (Rands)	Total (Rands)
Lecturer	*Quizzes*	22	-	-
	Puzzles	16,5	-	-
	Clues	27,5	-	-
	Administration	10	-	-
Lecturer Subtotal		76	-	-
Artist	*Badges*	21,75	R40	R870
	Clue Thumbnails	8	R40	R320
	Home Page	62,5	R40	R2 500
	Site Design	19,5	R40	R780
	T-Shirt Design	15,5	R40	R620
Artist Subtotal		127,25		R5 090
Programmer	*Interfacing to Vula*	20	R40	R800
	Database Design	30	R40	R1 200
	Steampoints	30	R40	R1 200
Programming Subtotal				R3 200
Prizes	T-Shirts		R80	R1 440
TOTAL		**486,5**		**R9 730**

Blue italics indicates once off costs

Figure 9: Graph showing cost breakdown.

The time investment is primarily that of the lecturers and teaching assistant. This is crucial to the success of the system, as the setting of the puzzles and quizzes is very time consuming. We estimate that this required an additional 6 hours of work per week, on top of standard lecture preparation.

A significant portion of the reported cost is once off. The art, system code, puzzles and quizzes are reusable in future iterations of this course. However, the cost of the prizes and the maintenance of quizzes and puzzles is a yearly concern.

Complete re-use of puzzles and quizzes may lead to collusion with students from previous years. However, the risk of cheating is likely to be lower, as there is no gain for the students that are no longer enrolled in the course. To reduce this risk, we suggest including some new material in each iteration of the course.

It is also possible to reduce the initial and maintenance costs by dropping certain elements of the gamification, such as the storyline and puzzles, which were rated less highly.

6.9 Observations relevant to the analysis

Throughout the course our attention was drawn to interesting interaction behaviour we had not foreseen during design. We note that the presented results are very sensitive to small changes in the design of the system. For instance, quizzes were kept open all semester to give students a sense of autonomy. However, most students only completed them mere days before the deadline. This caused a dramatic reshuffling of the leaderboard at the end of the course, which we did not anticipate.

The students themselves colluded because of competition to stay in the top 20, especially the top 10, so as to win T-Shirts. The students were asked to not share puzzle and quiz solutions. However, they did in fact collaborate in an attempt to retain a top 10 place. There was also evidence of cheating during the quizzes. Students took screenshots during the first attempt, found the answers in their own time and got a higher mark than they would have under time constraints in the second and third attempts.

We were worried that gamification could cause a further divide between genders, due to its heavily competitive nature and our low proportion of Female students. This was not the case, with 5 of the 7 Female students placing in the top 10, and the top student being a woman. The female students also averaged 9.1 places higher in the gamification than they did in the final course ranking, suggesting that they embraced the gamification element and were not deterred.

Unfortunately, some students declined to take part in the gamification. Of the 44 students in the course, three took this approach and scored less than 25% on the gamification. Two of these also did poorly in their overall class result, with one being denied a Duly Performed certificate. This can therefore be seen as an early warning system for lecturers to identify students that are at risk of scoring poorly.

To allow for generalizability, we designed the gamification on top of a conventional university course, with lectures and tutorials occurring on a regular basis. Our entire implementation makes use of concepts that can be implemented manually. The quizzes and puzzles, as well as storyline and leaderboard could all be achieved without the use of an online portal if necessary. Also, the rewards systems are easy to implement and give the students a feeling of being in control of their result, which would be applicable in other course environments. In this way, we have designed this study to be reproducible in other courses.

We believe that the benefits outweighed the cost of the course, as the majority of the cost is once-off, and the effect the gamification had on the students was strongly positive.

7 CONCLUSION

Tertiary education generally lacks an emphasis on the engaging elements that help motivate active learning. We have critically examined the inclusion of gamification as part of the syllabus of a university course and evaluated its impact.

We found that our approach to gamification is effective in a university setting. The gamification techniques used in our design significantly improved students' understanding and particularly their engagement. Students' perceived improvement in overall mark was moderate, and while they were positive about the

inclusion of the storyline and theme, they were unsure if it improved the gamification. With regard to the actual techniques: leaderboards were found to be highly motivating, with Steam Points and ranks following, and progress bars, the end prize and badges found to be least motivating. The in-game currency reward policy was very well received, with extensions being highly popular. It was found that the quizzes and lecture attendance had the biggest benefit to learning, with the more abstract puzzles and game story less so. Finally, our gamification had a significant impact on course marks and lecture attendance.

This paper has discussed the positive and negative aspects of gamifying a university course. In future work, we would suggest the inclusion of the following:

- Greater integration of the storyline with the course material and assignments. Ours was superfluous to the course and therefore did not have sufficient meaning for the students.
- Implementing a "Guilds" feature that promotes teamwork and co-operation would help eliminate unwanted collusion, as this would be accounted for in group participation.
- XP should be given for constructive involvement in the online forum, strengthening class unity and support.

This study has shown that there is evidence that gamification improves student engagement and understanding. However, this outcome is sensitive to small changes in implementation and requires ongoing monetary and time investment to be successful.

8 ACKNOWLEDGEMENTS

Thanks are due to Andrew Juries, who provided artwork for the gamification. We also acknowledge the UCT Vice Chancellor's Fund and the National Research Foundation for financial support.

9 REFERENCES

[1] Wood, L. C. and Reiners, T. Gamification in logistics and supply chain education: Extending active learning. *IADIS Internet Technologies and Society*, Perth, Australia, 2012, 101-108.

[2] Lee, J. J. & Hammer, J. Gamification in Education: What, How, Why Bother? *Academic Exchange Quarterly*, 2011, 15(2).

[3] Deterding,C. S., Sicart, M., Nacke, L., O'Hara, K., Dixon, D. Gamification: Using Game Design Elements in Non-Game Contexts. In *CHI 2011 Workshop Gamification: Using Game Design Elements in Non-Game Contexts*, Vancouver, Canada, 2011, 2-5.

[4] Fogg, B. J. A Behaviour Model for Persuasive Design. 2009. Retrieved February 2013, from: http://bjfogg.com/fbm_files/page4_1.pdf

[5] Wu, M. Gamification 101: The Psychology of Motivation. 2011. Retrieved February 2013, from Lithosphere: http://lithosphere.lithium.com

[6] Professor Cliffe Lampe Talks about Gamification in Academia. 2012. Retrieved June 2013, from Slashdot: http://games.slashdot.org/story/12/12/10/1827251/professor-cliff-lampe-talks-about-gamification-in-academia-video

[7] The Gamification of College Lectures at the University of Michigan. 2013. Retrieved March 2013, from: http://www.gamification.co/2013/02/08/the-gamification-of-college-lectures-at-the-university-of-michigan/

[8] Syllabus – T366: Multiplayer Game Design. 2010. Retrieved June 2013, from Gaming the Classroom: http://gamingtheclassroom.wordpress.com/syllabus/

[9] Laster, J. 2010. Indiana U., a Class on Game Design Has Students Playing to Win. *The Chronicle of Higher Education*. Retrieved June 2013, from Wired Campus: http://chronicle.com/blogs/wiredcampus/at-indiana-u-a-class-on-game-design-has-students-playing-to-win/21981

[10] Brinkman, D. Just Press Play. Retrieved June 2013, from: http://research.microsoft.com/en-us/projects/justpressplay/

[11] de Byl, P. Can Digital Natives Level-Up in a Gamified Curriculum? In M. Brown, M. Hartnett & T. Stewart (Eds.), *Future challenges, sustainable futures*. Ascilite, Wellington, 2012, 256-266.

[12] Deterding, C. S. 2011. Meaningful Play: Getting Gamification Right.. [Online video]. Retrieved January 2012, from: www.youtube.com/watch?v=7ZGCPap7GkY

[13] Hoonhout, J. and Meerbeek, B. Brainstorm triggers: game characteristics as input in ideation. In *CHI 2011 Workshop Gamification: Using Game Design Elements in Non-Game Contexts*, Vancouver, Canada, 2011, 49-54.

[14] Antin, J and F., Churchill E. Badges in Social Media: A Social Psychological Perspective. In *CHI 2011 Workshop Gamification: Using Game Design Elements in Non-Game Contexts*, Vancouver, Canada, 2011. 10-13.

[15] Personality Types. Retrieved January 2012, from Gamification Wiki: gamification.org/wiki/Personality_Types.

[16] Dixon, D. Player Types and Gamification. . In *CHI 2011 Workshop Gamification: Using Game Design Elements in Non-Game Contexts*, Vancouver, Canada, 2011. 41-43.

[17] Bateman, C. 2009. BrainHex - What's your brain class? Retrieved January 2012, from: blog.brainhex.com/

[18] Bateman, C. 2010. Welcome to the BrainHex questionnaire! Retrieved January 2012, from International Hobo: survey.ihobo.com/BrainHex/

[19] Bateman, C. 2009. BrainHex: BrainHex Exceptions. Retrieved from January 2012, from: blog.brainhex.com/brain.html

[20] O'Donovan, S. Gamification of the Games Course. Technical report, 2012. University of Cape Town.

[21] McGonigal J. 2011. Game designer Jane McGonigal interviewed by Cameron Evans, U.S. Education CTO, Microsoft. [Online video]. Retrieved June 2013, from: www.youtube.com/watch?v=5-mc9Rrfs00