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A formative evaluation of a gamification app containing asynchronous multiplayer game elements

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Abstract: This paper evaluates the development of a videogame-like mobile app designed to enhance student experience using gamification principles. An approach is taken that attempts to avoid any reduction in intrinsic motivation and minimises subject specific content, while increasing the range of video game design principles beyond that normally found in educational gamification projects. Gamification that relies on points and leader boards to motivate can miss the essence of engaging video game design. The most popular video games use a wide range of game design principles to create a fun and motivating experience, something that is often missed in gamification. A non-educational 3D video game is used to motivate students to engage with the app, without being subject specific. However, making progress within the video game requires students to earn virtual credits by attending classes, engaging with class activities and handing in assessments. The game uses virtual avatars, currency and upgrades which motivate students to engage with the application while avoiding the need for real-world rewards. Asynchronous multiplayer allows students to work together within the game and share the experience as a group within class. This enables a form of competition that is less likely to demonstrate negative side effects, yet is still compulsive. An innovative game design was used that is based on recent 'one-button' mobile games. The design allows the app to attract and hold the student's interest without taking excessive amounts of time away from their studies, as it can be played in an interactive or non-interactive mode. In-app metrics, surveys and interviews were used to develop case studies of three of the students in the study. This gives an insight into the different motivations and styles of interaction that students exhibited with the app. By removing access to the embedded game part way through the experiment it was shown that the game provided a significant motivational element of the overall gamification app. Although the students did not report any negative impact on their intrinsic motivation or enjoyment of the class, cheating was detected as students attempted to maximise their progress within the embedded game.

Keywords: Game-Based Learning, motivation, mobile, gamification, design

1. Introduction

A mobile app, called UniCraft, was created to help HE students engage with their studies. It uses gamification principles and video game design methodology. Students can monitor their progress, claim virtual rewards for work done, play a multiplayer game and compare their virtual avatar to that of other students. This paper discusses how students used the application and the impact of an embedded 3D battle game used to incentivise students by allowing their avatars to compete in teams against an army of undead monsters. Although there were no real-world rewards, the battle game competition enhanced the compulsive element needed to help engage students with the app. The game was not educational and therefore its design was uncompromised by educational content, but this meant play time had to be minimised while still being compulsive.

2. Research questions

Is it possible to improve aspects of student experience by creating a gamification application that engages students: without real-world rewards, without undue extra workload on staff or expensive course specific material (RQ1)? Can video game design mechanics, virtual rewards and non-educational game content provide enough impetus to increase engagement (RQ2)? What impact does the app have on students and how do they use it (RQ3)?

3. Literature review

Players spend hours in video games acquiring skills, knowledge, working collaboratively, all voluntarily and often without real world reward (Royle, 2009). There have been attempts to transfer the motivational power of games into non-gaming activities for decades, especially education. An educational game attempts to teach the player learning outcomes of real-world significance within a 'fun' game framework. Educational games

tend to have common weaknesses: application to only one subject or topic (Egenfeldt-Nielsen, 2005), the educational content can feel tacked on (Habgood and Ainsworth, 2011), rarely both fun and containing appropriate knowledge/skill transfer to the real world (Van Eck, 2006). Gamification is a recent term given to the use of game design elements in non-game contexts (Deterding *et al.*, 2011). It can be broken down into three aims:

- Scaffolding the correct process to follow, with points and feedback to reward those that follow the defined process correctly
- Rewarding those that complete some task with greater efficiency and/or higher quality than their own previous attempts or in direct competition with their peers
- Making an activity more enjoyable without altering the activity

Player motivation often comes from intrinsic psychological reward (Gee, 2003), but gamification seeks to apply external motivation to undertake other non-gaming tasks. However, experiments in the field of psychology have shown negative outcomes related to extrinsic rewards, with reduced intrinsic motivation one of the most serious (Deci and Ryan, 2000). As an aspect of optimal learning, often associated with a state of flow (Shernoff and Csikszentmihalyi, 2009), a loss of intrinsic motivation would be an undesirable outcome. Gamification is often used in industrial applications to improve productivity (Duggan and Shoup, 2013). These initiatives can be compulsory, with financial rewards and punitive penalties. In education they might be linked to official assessment activities, but this can reduce creativity and is claimed to be more appropriate for rote learning applications (Dale, 2014). When gamification is perceived as oppressive there are often common issues: monetary or other valuable rewards, compulsory participation and prescriptive monitoring.

Gamification is accused of exploiting games design by reducing it to a raw behaviouristic manipulation of the user (Bogost, 2011). A game should have the fundamental quality of being inherently rewarding and intrinsically motivating (Habgood and Ainsworth, 2011), something gamification projects have often lacked. Although initially dominated by points and leader boards, more recently there have been examples of gamification projects that embraced a wider array of game design principles that have been hugely successful, for example, 'Ribbon hero' (Faulkner, 2011) and 'Zombies Run!' (Dredge, 2015). It would seem that it is possible for intrinsic and extrinsic motivational factors to work together to improve performance, but only when the extrinsic component is not perceived as controlling (Cerasoli, Nicklin and Ford, 2014). In experiments with image tagging, Meklar *et al* (2017) found intrinsic motivation was not reduced by the addition of gamification techniques such as points and leader boards, when implemented in a non-oppressive manner.

4. Design approach

In this study, a mobile app (see Figure 2) was designed to enhance student engagement. The gamification aspects have a minimal amount of course specific content (see Figure 4) and all rewards are virtualised and applied to the student's avatar to avoid reductions in intrinsic motivation (see Figure 1) which can result from gamification's potential to be seen as oppressive. Although these rewards have no real-world impact, there is evidence that players project their identity onto virtual avatars (Behm-Morawitz, 2013) providing a higher level of investment in a game.



Figure 2. UniCraft is a mobile app that applies gamification techniques in an educational context



Figure 1. A student avatar; body type, gender, hair, equipment and clothing are all customisable

The app's embedded multiplayer game (see Figure 3) allows players to use their virtual avatar to engage in a battle game. This gameplay is not compromised by the need to support any specific educational content. Students assign public nicknames to their avatars so their real identity remains anonymous to help reduce the possibility of competition induced stress.



Figure 3. A student battles the undead, catching hearts to recover health



Figure 4. A student logs in to claim an achievement for completing a piece of work and earns credits

A common video game theme was chosen, a light-hearted 3D fantasy setting (see Figure 5).



Figure 5. UniCraft battle game theme, implemented using Unity3D

As the game is not educational, it is designed for limited play time, using only one finger and with minimal time needed to learn to play. It can be played non-interactively, while the student is working or it can be played in an interactive mode where the student improves their performance by catching hearts (see Figure 3). On the student's smart device the game is played with two peers, player matched for equivalent rank, as a team together. The game can also be played on a PC with all student avatars taking part in a battle royal, which facilitates shared experience either on the class projector (see Figure 7) or on a large screen in a student common area (see Figure 6).

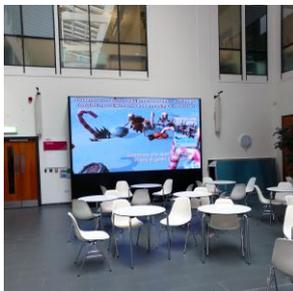


Figure 6. Battles were played out on a large screen TV in an area where students congregate at lunchtime



Figure 7. Battles were played out on the class projector at the start of lessons

4.1 Application overview

The diagram in Figure 8, gives an overview of the app and how the different user interface screens link together.

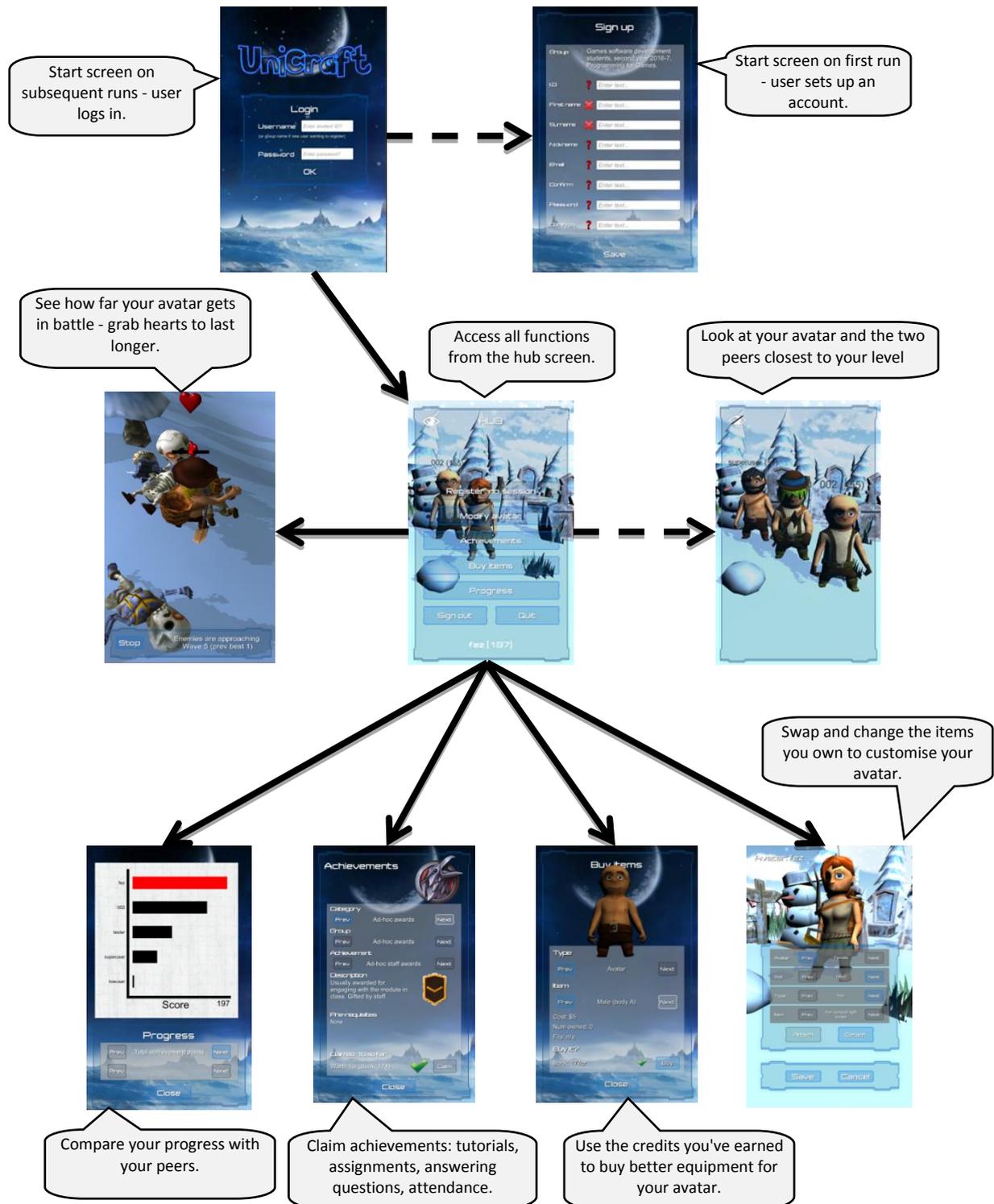


Figure 8. UniCraft user interface structure

4.2 Educational link

The video game motivates students to earn credits, the only way to do this is to claim badges (or achievements) using the app (Figure 4 and Figure 8).

To minimise the prescriptive nature of these achievements, a wide range of activities are included:

- Attending lectures and tutorials - pressing a button on the app automatically registers a student's attendance and this is rewarded with credit. A staff member must open and close a session for students to register.
- Handing in assessments - upon receiving the assessment a member of staff uses an administrative version of the software to manually award the student a matching achievement.
- Completing tutorials - students claim achievements themselves whenever a tutorial is completed. This is potentially vulnerable to cheating, but it would take too long for staff to authorise each one.
- Open ended engagement with class (e.g. answering a question, demonstrating some work a student did outside class, etc.) - a staff member manually awards this achievement as they see fit, allowing students to be rewarded for ad-hoc activities.

Students can use the app to gauge their progress with the subject. This happens abstractly by their avatar's performance in game, the warriors that survive longest belong to students making the most progress in the game and therefore in class. Progress can also be judged directly using the app (see Figure 8) using the bar charts which can drill down into individual achievements. For example, a student could compare their own progress through the different activities of 'tutorial 10' with their peers.

5. Research approach and methods

Two tutorial groups of 26 second year HE students taking a games programming course were selected for a longitudinal study spanning 12 weeks. The organisation of the study is shown in Table 1. For each group the ability to play battle games was available only during 3 out of the 6 weeks to isolate the effect of this specific gaming element.

Table 1. Organisation and schedule of study, A and B refer to two tutorial groups of student participants

	weeks in semester											
	1	2	3	4	5	6	7	8	9	10	11	12
survey	A+B			A+B						A+B		
interview	A						B					
lessons as normal	B	B	B	B	B	B	A	A	A	A	A	A
using the app	A	A	A	A	A	A	B	B	B	B	B	B
battle game is available	x	x	x	✓	✓	✓	✓	✓	✓	x	x	x

Surveys were conducted at the beginning, middle and end of the study in an attempt to monitor student engagement and satisfaction.

Table 2. Student survey questions

Survey questions		
1	How often do you play games on a smartphone?	1=never, 5=every day
2	Do you complete all assessed module work set by the lecturer? For example, tests, group projects, etc.	1=always, 5=never
3	Do you complete all non-assessed module work set by the lecturer? For example, tutorial tasks, optional homework, etc.	1=never, 5=always
4	Do you enjoy Programming for Games?	1=my favourite, 5=don't like it
5	Do you feel motivated by this module?	1=no problem, 5=have to force myself
6	Does this module provide opportunities for creative expression? For example, making your own games.	1=do what I'm told, 5=my own ideas
7	Do you know how much progress you are making in this module compared to other students?	1=I know, 5=I have no idea
8	Can you predict the mark you will probably get in this module?	1=no idea, 5=mark is clear
9	Is it important to you that you can gauge your progress?	1=makes no difference, 5=important to me
10	Do you think it's useful to encourage friendly competition between students?	1=yes good idea, 5=not useful

Follow up semi structured interviews were conducted, with in-app metrics used to identify any potentially interesting behaviour within the two groups and these measurements guided the interviews which were audio recorded and then transcribed.

In-app metrics were used to record student activity directly and store the data on a web server via standard http requests, see Figure 9.

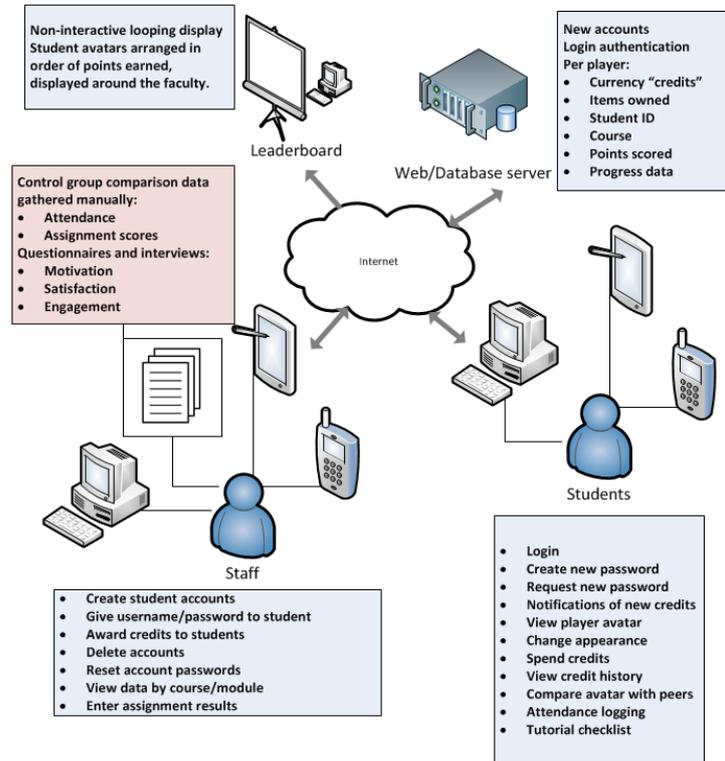


Figure 9. UniCraft system architecture

6. Results to date

When the battle game became active, app usage showed a statistically significant increase of 217% (one way ANOVA $F(1,44)=12.40$, $P=0.001$, $\eta^2=0.28$). Different students responded to different aspects of the app, however there were some consistent comments, for example, all students felt there should be fewer self-certified activities and more teacher-certified.

Survey results (see Table 3), didn't demonstrate any significant changes in attitude to class, as might have been expected if intrinsic motivation and satisfaction were reduced. During interviews and classes, most participants commented that they'd enjoyed using the app, a minority were uninterested, but no participants mentioned any negative feelings.

Table 3. Survey results repeated at the start, middle and end of the study

Survey questions			Start	Middle	End	One way ANOVA		
1	How often do you play games on a smartphone? (1=never, 5=everyday)	mean	2.83	2.85	2.69	$F(3,43)=0.04$	$P=0.99$	$\eta^2 = 0$
		S.D.	1.30	1.51	1.45			
2	Do you complete all assessed module work set by the lecturer? For example, tests, group projects, etc. (1=always, 5=never)	mean	1.17	1.54	1.81	$F(2,44)=2.06$	$P=0.14$	$\eta^2 = 0.09$
		S.D.	0.37	1.08	1.13			
3	Do you complete all non-assessed module work set by the lecturer? For example, tutorial tasks, optional homework, etc. (1=never, 5=always)	mean	3.11	3.31	3.00	$F(2,44)=0.45$	$P=0.64$	$\eta^2 = 0.02$
		S.D.	0.66	0.61	0.61			
4	Do you enjoy Programming for Games? (1=my favourite, 5=don't like it)	mean	1.72	2.00	1.88	$F(2,44)=0.45$	$P=0.64$	$\eta^2 = 0.02$
		S.D.	0.45	1.04	0.86			
5	Do you feel motivated by this module? (1=no problem, 5=have to force myself)	mean	2.39	2.23	2.38	$F(2,44)=0.15$	$P=0.86$	$\eta^2 = 0.01$
		S.D.	0.68	1.05	0.78			
6	Does this module provide opportunities for creative expression? For example, making your own games (1=do what I'm told, 5=my own ideas)	mean	3.22	3.46	3.50	$F(2,44)=0.38$	$P=0.69$	$\eta^2 = 0.02$
		S.D.	1.03	0.75	1.06			
7	Do you know how much progress you are making in this module compared to other students? (1=I know, 5=I have no idea)	mean	2.89	2.62	2.38	$F(2,44)=1.06$	$P=0.36$	$\eta^2 = 0.05$
		S.D.	1.15	0.92	0.86			
8	Can you predict what mark you will probably get in this module? (1=no idea, 5=mark is clear)	mean	3.33	3.31	3.44	$F(2,44)=0.07$	$P=0.94$	$\eta^2 = 0$
		S.D.	0.82	1.07	1.17			
9	Is it important to you that you can gauge your progress? (1=makes no difference, 5=important to me)	mean	4.00	3.92	4.00	$F(2,44)=0.02$	$P=0.98$	$\eta^2 = 0$
		S.D.	1.11	1.14	1.12			

Three contrasting student cases were selected for detailed analysis in order to provide a richer understanding of how they were using the app (users 28, 39 and 57).

Figure 10 shows each user's level of total app activity, which aligned with low, medium and high usage within the overall group.

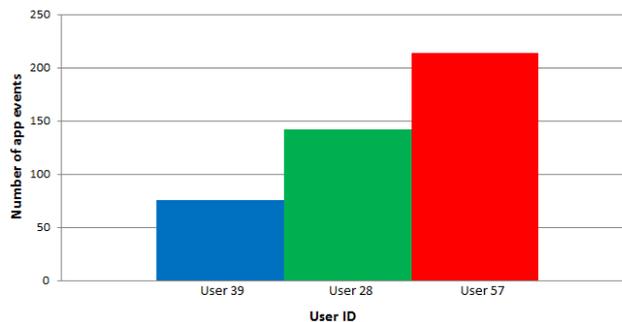


Figure 10. Total app events per user

There was also wide variation in usage during the day, as can be seen in Figure 11. The app was created for a lesson that ran 9am until 1pm, but some students used it well outside those times.

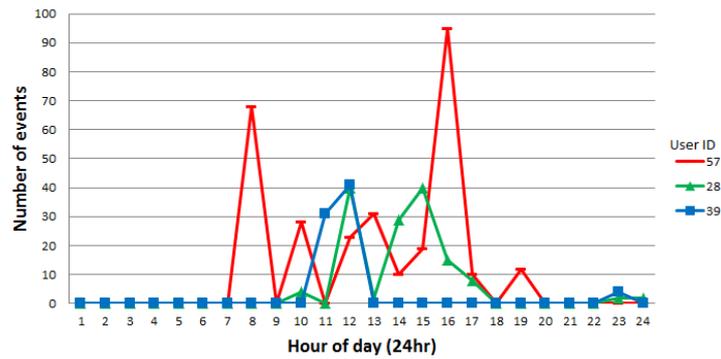


Figure 11. App usage patterns by hour of day per user

The lesson ran on Thursdays with most usage recorded on that day, but some students used the app on other days, see Figure 12.

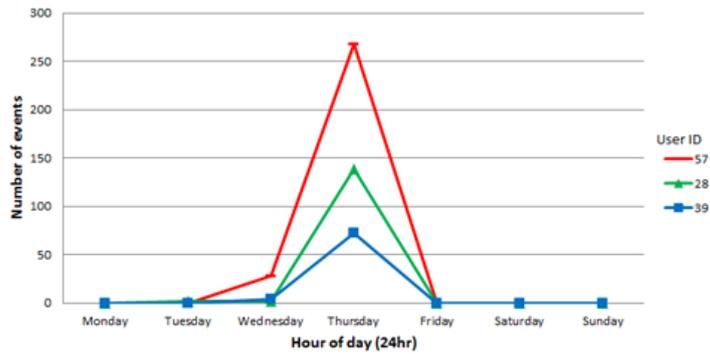


Figure 12. Usage patterns by day of week per user

Playing the app's embedded battle game motivated some students more than others, see Figure 13.

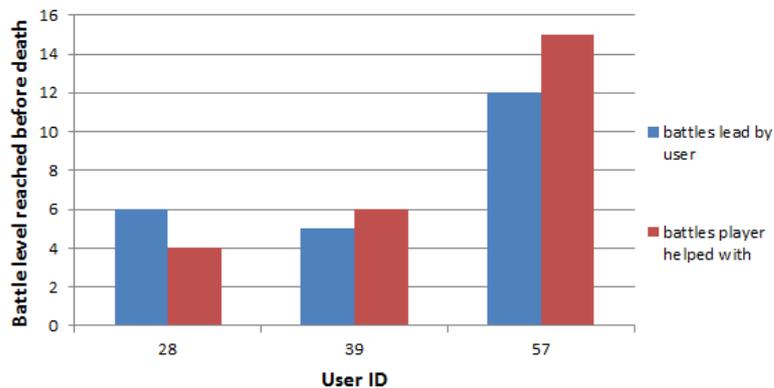


Figure 13. Highest level achieved in battle per user

Interviews allowed an exploration of these results.

User 39 was motivated by high scores, "chasing scores, the score board is motivating me". He was interested in how the game's systems worked, "it needs to be clearer...which weapon does what to the stats". The embedded battle game was attractive, "it [the battle game] definitely works". He would occasionally use the app at midnight, "that was when I was bored after doing some work, when I'm most productive". He was a very competitive player, "it wasn't competitive enough!" Commenting on the battle game part of the app, "the battle [game] doesn't require interaction, it can run on its own". Cheating was a concern, "it [multi choice Q&A] would reduce cheating". When asked about physical rewards, "physical rewards turn people off, it should be mental, a sense of accomplishment".

User 28 was motivated by peer competition. When asked when he used the app, "I saw a lot of people using it in a maths lesson that followed this, playing battles ... it's designed not to take up too much time, but I can imagine the lecturer being annoyed." Regarding motivation, "I didn't play battles myself, but I wanted to battle on the big screen." When asked about competition, "if you're dying all the time then obviously someone out there is putting in more time than me ... that's all the motivation you need ... It's not about competing it was about what we can do as a group".

User 57 said when asked if he cheated, "yes, I claimed everything straight away, tried to get as far as I could". Asked about battle games, "I didn't play battles myself, but I wanted to [see them] on the big screen". When asked about progress features, "it split the work up in a really good way, even though I was cheating, I did read them [achievement lists, Figure 4]."

7. Discussion and conclusion

This study allowed me to explore the practical issues of building a mobile gamification application and using online metrics. RQ1 referred to improving student experience and initial results are promising, a non-educational video game was a motivating factor in the student's use of the app, they did find it enhanced their enjoyment of the subject and there was no evidence found of reduced satisfaction. The only subject specific elements of the app were the tutorial achievements, which were simple text descriptions that could be reconfigured for any subject within a few hours.

RQ2 referred to the potential to improve engagement and by avoiding real-world rewards, using a more holistic approach common in game design, the app did appear to extrinsically motivate, without reducing satisfaction with this group of students. It was not clear if student's engagement with their studies had been improved, only that their engagement with the app was more than doubled by the activation of the embedded battle game. If these types of applications can have minimal course specific content and minimal impact on existing teaching practices, costs could be reduced when considering how to use video games in an education context, especially when compared to educational games.

RQ3 referred to the impact of this project on student behaviour and with this student group there were wide ranging differences in level of use of the app, the time of day it was used and the aspects of the app the students found appealing. This demonstrates the need for game based gamification projects to embrace a flexible design that supports a wide range of interaction styles and usage patterns.

Avoiding the oppressive potential of gamification is difficult, even without real-world rewards there must still be a motivating element to the process and competition provided that in this application. The battle game was perceived as competition purely 'for fun', with peers working together in teams against a computer controlled common foe. However, cheating was still an issue even though progress through the app had no impact on student grades. In the next version of the software all self-certification elements will be removed, but care will be taken to avoid an increase in teacher workload administering the system. This means many of the current achievements will need to be removed, they take too long to administer if all must be signed off by a teacher. Group multi-choice Q&A will be introduced, run by the teacher at the start and end of each session. This will have minimal impact on teaching staff flexibility, only requiring preparation of two questions per session, but it should ensure any credits earned are administered by staff to minimise the potential for cheating. The compulsive nature of the app meant some students continued using it during lessons on other subjects, the next version of the software should carry reminders to students that they shouldn't be using the app in lessons

where it is not relevant. Future experiments will attempt to access larger groups of students who are not studying a games related subject, to help assess if these findings are more generally reliable.

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