Glitch'16
An Investigation of the Use of Augmented Reality Gamification for Orientation in Urban Environments

Catriona Anne Wilkinson

KEYWORDS

Augmented Reality, Gamification, Scavenger Hunt, Augmented Reality Game, Motivation, Navigation, Interaction Design, User Experience

ABSTRACT

Mobile technology is still changing our experience of space and how we navigate an environment. This leads to increasing expectations for more intricate and engaging mobile facilitated experiences that allow people to explore their physical environment in a more captivating and intuitive way than ever before. The traditional map no longer contains the information that we require when entering a space; we need more rich and engaging information. Through the use of Augmented Reality there have been many attempts to familiarise people with the physical world with the aid of digital information.

This project explores how the emerging technology of Augmented Reality can be used in conjunction with gamification in order to provide engaging, information rich experiences that can help orientate the individual to new spaces by inviting them to view them in novel ways and from multiple perspectives. This project adopts a Design-Based Research Methodology to construct a 30-minute Augmented Reality scavenger hunt to transform passive visitors into active players exploring new environments through gamification. This project was refined through iterative play-testing in conjunction with the analysis of observational data and collected photography and questionnaires provided before and after the playtest experiences.

Through this investigation, it was found that that the use of gamification in conjunction with augmented reality allowed participants to immerse themselves in the

physical space in a more engaging way, as has become expected of the 21st century urban

environment.

TABLE OF CONTENTS

PRELIMINARY PAGES

CHAPTER 1: INTRODUCTION

CHAPTER 2: METHODOLOGY

CHAPTER 3: CONTEXTUAL REVIEW

.

CHAPTER 4: RESULTS AND DISCUSSION CHAPTER

CHAPTER 5: CONCLUSION

REFERENCES

APPENDIX: ETHICS

LIST OF FIGURES

GLOSSARY OF TERMINOLOGY

Alternate Reality Game: A game system that uses elements of the real world to anchor touchpoints of a fictional or alternate reality narrative.

Augmented Reality: Any application that provides a view of the real world with virtual information overlaid.

Gamification: The application of game elements to a traditionally non-gaming medium.

STATEMENT OF ORIGINAL AUTHORSHIP

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

Signature:

C. Wilkinson

(Catriona Wilkinson)

Date: 20/10/2016

ACKNOWLEDGEMENTS

I would firstly like to take this opportunity to thank my amazing supervisor, Dr. Deb Polson, who provided support and opportunities throughout my honours journey, so thank you Deb.

I would also like to thank my family, especially my parents for bearing with me through stressful times and talking me through any anxieties that may have arisen throughout the year. I could not thank my family without thanking my best friend, Claire Molkentin, who has provided an ear to talk to and has been especially helpful in abating anxiety as it has arisen, whether it be in person or over the phone, thank you Claire.

Finally, I would like to thank my QUT Creative Industries Honours cohort for empathizing with me through this journey as they have gone through all of the same uncertainties and hard times, and also being there to provide feedback on my many drafts.

INTRODUCTION

Introduction

Mobile devices such as phones and tablets have become a pervasive and ubiquitous reality in our lives. Users increasingly expect that their everyday experiences become more easily facilitated by smartphone technology. For example, when travelling to a new location, we expect our mobiles to not only show us a map of this location, but also tell us how to get there, the fastest route, alternative routes and different methods of transport that can be used. It is logical therefore, that we utilize the smartphone and its wide range of capabilities to its full potential when entering a new environment.

Background/Context

With the relatively new technology of Augmented Reality (AR) now available for handheld mobile devices, the potential for technologically facilitated engagement with the real world environment is virtually endless.

Despite this almost unlimited potential afforded by Augmented Reality, the current discourse mainly centres around the use of the technology in the field of education (Chauhan et al 2015), (Patrick 2011, 92), (Joan 2015, 11-12) while the existing commercial applications mainly focus on the use of AR to show the landmarks in the nearby area (Parker and Tomitsch 2014, 229). While the commercially available applications focus on orientating the user to the area, the potential to fully engage through gamification is lost, as the existing systems do not apply game principles to keep users immersed in the experience, as is the aim of gamification.

Research Question

This project is focused on the central question: How can Augmented Reality be used in conjunction with gamification in order to better engage people in the experience of navigating a new urban environment?

Project Design, Scope and Limitations

The results of this project indicates that through the implementation of augmented reality and gamification in the creation of an augmented reality game designed to guide players through a new space helps them become more aware of and engaged with the new environment, better orientating them to this new environment.

An Alternate Reality Game (ARG) has been developed and tested through iterative practice in order to introduce players to a new urban environment. Though this project does not utilize the common ARG concept of geolocation due to the fact that this game was developed for a multi-level building, location is still considered by way of introducing augmented map cards for each floor of the building.

Through the use of questionnaires, photography and observation, this project investigated how the use of Augmented Reality in conjunction with gamification can be used to create a more engaging experience of a new environment in order to familiarize a space to new visitors.

This work is comprised of a scavenger-hunt style Augmented Reality Game that was designed to introduce players to a new urban environment (The newly opened Creative Industries Precinct of Queensland University of Technology in Brisbane, Australia), this makes up one half of the work, while the other half of the work is comprised of this 7500-word exegesis.

Structure of the Honours Project

This first chapter introduces the topic and provides context into the background of the subjects of Augmented Reality and gamification. The second chapter provides an overview of the methods, methodologies and design of the project. The third chapter provides an in-depth contextual review of the existing research surrounding augmented reality and gamification. Chapter 4 presents the findings of this project and discusses the indications of this research as well as possibilities for further study. Finally, the fifth chapter provides a summary of the project overall and presents the key findings by way of conclusion.

METHODOLOGY

This project adopts a Design Based Research methodology, meaning that the project was built following the design processes of iteration, prototyping and playtesting as design experimentation in order to inform the outcomes of the user's experience and overall engagement. As Design Based Research focuses on the relation of theory to practice and the production of design artefacts, the outcomes of this project are as follows: a 7500-word exegesis provided as a framing document including documentation of three playtests (with a weight of 50% of the overall grade), a framework for a place-based augmented reality game system as a result of this design experimentation, and a web presentation documenting the final deployment of the design artefact and providing templates for this place-based augmented reality game system (these final two components making up 50% of the overall grade). This website can be found at https://glitch16arg.wordpress.com.

This project was planned with the intention of creating an augmented reality game system as a design artefact that would be produced as a result of a series of design experiments conducted to test and improve on theories surrounding augmented reality technology and gamification. The main theories focused on the major features of gamification, notably the cognitive, social and emotional aspects of a gamified experience (Dominiguez et al. 2013, 382-384), the current trends in augmented reality applications and how these can be used in conjunction with each other to produce a system that foster's what Kingsley and Grabner-Hagen (2015, 52) refer to as "21st century learning," or "multimodal" learning. These theories and trends will be discussed further in the "Contextual Review" chapter of this document.

In order to judge the effectiveness of the augmented reality gaming system produced, a number of methods were used. In order to gauge player engagement with the game, a questionnaire was given to participants with five pre-activity questions that were designed to determine how familiar players were with similar genre games, as well as five questions post-activity questions

focusing on how enjoyable and engaging the game was and how well the felt they could now navigate the space in which the game was deployed. The second method employed to interpret the success of this project was observational notes taken as players walked through the game as well as informal discussions with the players following the playthrough. The final method used to interpret the interaction of players with this game were photographs, with the more notable photographs displayed with descriptions on the project's documentation website.

The game itself was divided into three experimental playtests, with each informing elements of the next. Due to this setup, the discussion chapter of this document will be divided into three sections: one section for each playtest.

The first design experiment was for a minor project presented in-class to a group of honours students and critiques were given by way of discussion. The first game was judged on the its applicability as a site-specific installation based around Queensland's Gold Coast area as well as the possible levels of engagement of the target audience, how effective the game was at communicating information and finally the feasibility of setting the game up on a large scale. The first playtest comprised of a walkthrough of the design experiment where feedback was given by a group of fellow creative industries honours students. This feedback, as well as observations made during the development of the design experiment were used to inform the following two playtests.

The second design experiment saw the creation of a new project, titled Glitch'16. This project was built using elements of the project designed for the Gold Coast area, but explored the ideas of site specific design and the use of narrative through augmented reality further.

CONTEXTUAL REVIEW

Introduction

With the rise of mobile devices, we have come to expect that day-to-day living is enhanced with a set of experiences facilitated by this ubiquitous technology. Interaction between the real world and the digital world is an expectation of daily situations that is becoming ingrained in the collective psyche. With new developments in the digital field such as Augmented Reality (AR) this is becoming increasingly feasible and implementable. Using theories and techniques associated with user interface design and gamification, these new technologies can be seamlessly integrated into the everyday experience. This paper will explore the existing trends and research in the areas of AR and gamification in addition to exploring how these can be used together to create experiences that can be integrated into everyday life situations.

Augmented Reality: Current Usage

The emerging technology of augmented reality (AR) has developed exponentially over the past few decades and this paragraph defines AR and outlines the rise of the technology. AR is generally defined as the rendition of virtual object such as digital data or a 3D model over a real-world view. From Myron Krueger's Videoplace (Museum of Natural History, 1988) live video tracking in the late 80s to Yelp's restaurant locating application Monocle, the technology has already become ingrained in our everyday lives in ways we sometimes don't even notice. Until recently, AR has been mainly implemented within small-scale and rigid educational settings such as educational medical simulations with not much thought about how this can be translated to an everyday experience. However, in recent time this has changed as mobile technology has become more ubiquitous within society and developers have been able to make use of the affordances of these small, handheld computing devices. With technologies such as geolocation, cameras and internet connection developers have begun to produce intuitive, everyday augmented reality applications such as Wikitude and Yelp Monocle (Parker and Tomitsch 2014, 229).

Parker and Tomitsch (2014, 229) noted that the visual field is a highly important aspect of all of the augmented reality applications they examined. This is understandable as the concept of AR is based on the idea of layering new information over the visual field as some form of data visualization. The authors noted that most of the applications examined in this study presented some representation of the real world on the screen, whether as prefabricated images or through a live camera view and information is overlayed on this world view. Also noted in Parker and Tomitsch's study is the prevalence of geolocation in current AR applications. Along with the "fishbowl view" feature (Parker and Tomitsch 2014, 229), the authors also noted the prevalence of the on screen mini-map. The user's location is shown on screen and this is used in conjunction with the live world view to form a more powerful connection to the real world.

Both of these salient features utilize the many affordances of mobile phone technology in order to create a more immersive virtual environment that strengthens its connection to the real world. The live camera view of the real world creates a real-time temporal connection with the real world objects that anchor the on screen elements to the real world environment. In turn, this allows the AR system to draw attention to surroundings within the real environment, creating a more meaningful experience within the environment in which the use of the system is situated. For example, the use of an AR application like Yelp Monocle in a new city can lead to more meaningful navigation of the city by making users more aware of surrounding establishments in relation to their current location.

Augmented Reality: Affordances

This is important to acknowledge as this project is focusing on making navigation and exploration of the physical environment the main goal of the user's experience. In order to achieve this goal, augmented reality's ability to maintain elements of the physical environment in the overall visualisation of information were used with the purpose of creating awareness of elements in the user's surroundings. As well as this, AR's ability to anchor the data to specific points in a physical

environment in order to draw attention to these points and create a sense of familiarity with the place by acknowledging the user's surroundings. Robert Joan (2015, 11) notes the use of some augmented reality systems within historical precincts in order to bring the surroundings to life. This highlights augmented reality's ability to imbue further meaning to an object through the use of image tracking and three dimensional models.

Due to the many affordances of AR systems, there is much potential to use this technology to enhance many aspects of our everyday life. Chauhan et al (2015), Patrick (2011, 92) and Joan (2015, 11-12) note that augmented reality is currently being used to enhance teaching methods in educational settings. Although Wu et al. (2013) note that AR might once have been quite a costly experience to use or provide, the continuing development of augmented reality technology and content along with its widespread availability with the ubiquity of handheld mobile devices makes this technology an increasingly useful and viable tool in both the classroom and in more informal settings. Chauhan et al., Joan and Wu et al. highlight the fact that augmented reality affords the ability to examine and explore complex three dimensional systems in an intuitive way, utilizing the mobile devices' inbuilt camera and accelerometer to produce real-time three dimensional images on screen within the physical environment (Chauhan et al. 2015, 349)(Joan 2015, 8)(Wu et al. 2013, 41). Using movements of the user along with camera tracking to overlay a three dimensional image on the real world can immensely improve the capability of teachers to demonstrate spatial models and students' visualization of these concepts can be vastly improved with the ability to view these models within a real three dimensional space (Joan, 2015). While this can help to visualise otherwise complex and confusing systems, the use of three dimensional models can also add depth to specific space by augmenting users' memory of the experience in this place.

Gamification: Current Usage

Similar to augmented reality, gamification has been the subject of much research in recent years. Referring to the act of applying game mechanics to non-gaming experiences, gamification has

developed over the past decade as a means of creating more engaging and meaningful experiences from traditional activities especially in the field of education. Many studies have centred their focus on the use of gamified learning in the classroom in order to engage students better in their learning. Chauhan et al. (2015, 349) highlight the ability for both augmented reality and gamification to be used in situations where learning can be geared towards individuals. Calling this form of learning "21st century learning," Kingsley and Grabner-Hagen (2015, 52) posit that gamified learning can provide a better foundation for "multimodal" learning structures than traditional teaching methods in order to cater lessons to most or all individuals in a classroom rather than just those who benefit from traditional teaching methods. This form of "multimodal" teaching highlights a key aspect of gamification that sets it apart from traditional teaching: users can set their own pace with their learning and engagement.

Adrian Dominiguez et al. (2013, 382-384) make reference to the rules of engagement of gamification, namely the cognitive, social and emotional aspects of a gamified experience and how these aspects can inform the interactions of the user, whereas most authors focus solely on the cognitive aspects of gamification such as goals and incentives (Chauhan et al. 2015, 350) as the driving force of the success of gamified experiences. The cognitive area feeds back into the previously mentioned catered learning structure, referring to how the user engages with the content on a cognitive level. Gamification can be used to provide a number of pathways that users can take based on learning ability and preference in order to find the most appealing way to engage with the content. The emotional aspect refers to the ability to foster the desired emotions in users for a specific purpose. Chauhan et al. describe using this aspect to foster further engagement by creating positive emotion upon task completion. This is a common way of engaging users by asking them to invest emotionally in their own journey through the gamified learning experience. This emphasis on achievement leads into the third aspect highlighted by Chauhan et al., which is the social aspect. The social aspect is described as the user's ability to relate themselves to other individuals partaking in the activity. This can be done through leader boards or trophies and while this fosters competition,

some argue that this can lead to negative emotions due to the fact that the user is comparing themselves to pressures created by others (Rigby 2014, 124) and propose that focus should instead be put on the act of engaging with the system.

C. Scott Rigby (2014) postulates that the reason gamification is so successful is its ability to motivate. In his chapter on motivation, Rigby highlights a number of different aspects of gamification that can be manipulated to have a motivational effect on users. Similar to Chauhan et al., Rigby divides these motivational aspects into three key areas of "mastery," "autonomy," and "relatedness." These three terms fall very closely to the cognitive, emotional and social aspect previously discussed, as "mastery" refers to the individual's understanding and "mastery" of the overall content, "autonomy" refers to an individual's ability to make their own decisions and decide their own feelings towards an event and finally "relatedness" refers to how an individual is posed to compare themselves to others partaking in the activity. It is clear from the similarities between the two texts that understanding of content, positive emotion and the individual's position in relation to others are key concepts in creating a gamified experience that fosters long-term engagement.

Gamification: Affordances

It is clear that gamification affords many opportunities for meaningful engagement in not only a learning environment, but in everyday activities. Rigby posits that the fact that gamification can target our "basic psychological needs" (2014, 119-121) allows for the format to be more engaging than non-gamified activities. As an example, one could use the popular mobile application "Zombies Run"'s success to show that because this app focuses on getting fit for oneself rather than getting fit due to pressures from others and places emphasis on the importance of intrinsic values.

As highlighted above gamification can be used in an educational setting as a means for engaging users in a more meaningful way. This can be done by creating several streams through which users can work at their own pace in order to achieve common goals, however this does not always have to be for an educational matter. In fact, many gamified experiences focus on changing

other aspects of behaviour. Bohyun Kim's paper *Understanding Gamification* (2015) explores the wide range of existing gamified applications, who's goals range from completing chores and menial tasks to becoming thriftier and saving money. It is clear from these subjects that the gamification lends itself best to setting goals that users already wish to achieve, but making these more achievable through sustained engagement. This arcs back to Rigby's theory of placing focus on intrinsic values, or goals and values that originate from within the individual rather than from without.

Combining Augmented Reality and Gamification to Create Meaningful Experiences

From the affordances discussed previously of both augmented reality and gamification, it is clear that there is still much research to be done, especially in the area of using the AR technology in conjunction with gamification. This project eplored how these two concepts can be used together to create more meaningful engagements with content. In order to do this, an interactive augmented reality game was created that explored how this system can be used to orient individuals to a new urban space.

This project used the Design Based Research methodology in order to create a refined outcome through iterative practice. The project consists of an augmented reality application developed on the Vuforia platform in Unity3D Game Engine that interacts with checkpoints set up around throughout the Creative Industries Precinct 2 Z9 building, that was used to facilitate exploration of the space.

Participants were given consent forms, instructions on how to participate and questions to answer preceding and following the event as well as an augmented reality mobile application, a map card and a decoder seen in Figure 4, page 24. Stations were set up around the precinct that could be located using a hidden 3D map of the precinct that appeared when the map card was scanned. These checkpoints were locked with combination locks that could only be opened using a four-letter code

printed on the lid of the checkpoint box that needed to be decoded using the decoder. An example of these checkpoint boxes can be seen in Figure 1.

Figure 1 - A checkpoint box

Stations contained glyphs that when scanned with the AR app revealed a fictional narrative about a secret war that was being waged over the partner project, Museum of Colliding. Upon scanning all of these glyphs, participants would then decode them using a decoder given to them at the start of the activity and the code can then be used to access secret information about the corresponding interactive display, Museum of Colliding Dimensions. A logic map of the Glitch'16 game system can be seen in Figure 2.

GLITCH16 TOUCHPOINT LOGIC MAP
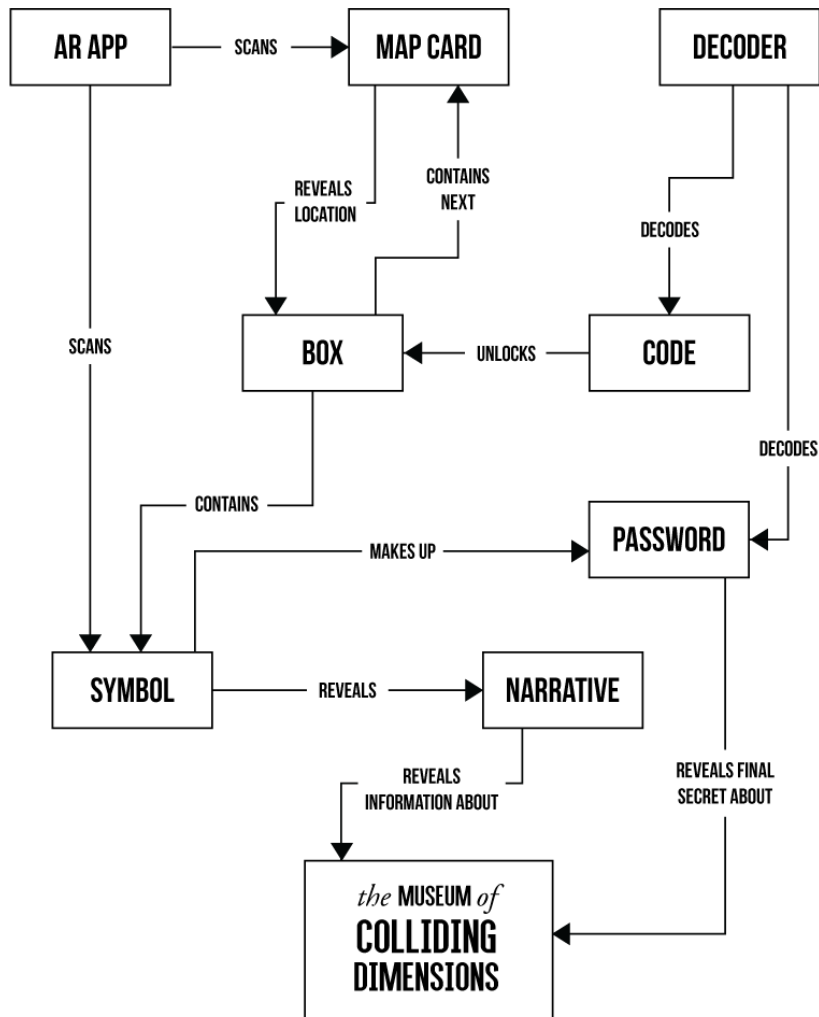
Figure 2 - Glitch'16 logic map

This project used the gamification feature of achievement awards in the form of a decoder and the successfulness of the project was analysed using the answers to a questionnaire in order to gauge the participants' engagement with the content and their understanding of the narrative presented. As well as this, observation and ethnography have been used as another way to gauge enjoyment and engagement of the experience. After undertaking this research, the project was analysed with regards to the major aspects of gamification theory as discussed earlier by Chauhan et al. (2015, 350) and Rigby (2014, 119-121).

19

This project addressed all three of the key aspects of gamification previously identified by allowing the users to feel a sense of "mastery" upon scanning a glyph, and upon deciphering the hidden code, while fostering a sense of autonomy by allowing users different difficulty levels with the alternate decoder feature included in the app, allowing players to set their own pace, and finally this project aimed to foster "relatedness" by allowing the participants in the project exclusive access to the secret code that will unlock the hidden interactive display, thereby setting them apart from other individuals who had not participated, serving as a sort of achievement award.

In order to align this project with the intrinsic values of the participants, the project was developed so that it aligned to the point of the day, which was to launch the Creative Industries Precinct 2 opening. This coincided with my augmented reality game which allowed users to explore the space in an engaging way and hopefully orientate them to the new main building by having them walk through it and examine the small nooks and crannies in order to find the checkpoints. This allowed users to explore the area in a casual way while also looking at parts of the building from a different perspective, creating a more meaningful exploration of the user's surroundings and anchoring information to certain spaces in order to trigger memory callback when the user walks edy these spaces.

By exploring the current trends and affordances of both augmented reality and gamification, this chapter has analysed the salient aspects of both in order to inform my practice. This project used both augmented reality technology through the creation of a mobile application as well as a gamification system in order to create an experience that fosters engagement through motivation of users. This project utilised the Design Based Research methodology to inform the practice in order to create a well-rounded work by using iterative practice during the creation process. The goal of the project was to produce a system that allows users to make their own way through a new environment whilst making themselves familiar with that environment by asking them to look at it from a different angle. This system allows users to engage with the space in a new and meaningful way that can inform future orientation projects.

DISCUSSION

Introduction

As mentioned in the Methodology section, in order to refine the outcomes of this project, a plan to create and iterate a new augmented reality game system was devised. This plan consisted of three playtesting phases, each being used to develop the game experience for the next playtest. The first playtest was developed alongside the contextual review phase of the project in order to be able to incorporate the salient elements of augmented reality and gamification into the development of the game system, whereas the final two playtests focused on refining the stronger components of the game system and further seamlessly integrating the elements present in the contextual review.

Each separate aspect of the game system is designed to be modular so that each piece can be edited separately in order to alter the game to be applicable to a new space, narrative or situation, effectively creating an open-source framework whereby new creators can download basic files and documentation and edit them to suit their own project or situation.

Playtest 1: Experimenting

This first playtest was developed to be deployed around the Gold Coast area of Queensland, Australia to promote the outdoors and facilitate local community engagement. Due to these criteria, the original game was developed with the target audience of family groups in mind and with a strong connection to place. Though the feature of an on screen mini-map highlighted in the contextual review as a salient feature of augmented reality apps would have been useful to implement in order to facilitate this place-based game dynamic, unfortunately the nature of the technology and the extent of the researcher's knowledge did not stretch that far. Instead, a mini-map was effectively faked by providing players with an image in a small booklet that when scanned would reveal a three-dimensional model of the surrounding area with game checkpoints indicated through three-dimensional bubbles superimposed on the map.

Though this in ability to implement geolocation limited the scope of the investigation of this project, the map system implemented instead afforded the ability to focus on a small locale that would generally be too small for geolocation services to display anyway, such as checkpoints located in very close proximity but on separate floors. For example, one checkpoint on the first floor of a building being in the same location as a checkpoint on the second floor of the building would be impossible to distinguish on a normal geolocation interface without the user needing to input their current floor. This concept will be discussed further in playtest 2 where a multi-floor space is used.

Aside from the need for an image tracker for the map, this small booklet was also used to facilitate the main "game" portion of this experiment, also containing questions that needed to be answered in order to achieve awards held within the boxes placed at each checkpoint. Each checkpoint featured an icon that needed to be scanned in order to reveal the answer to a question asked inside the booklet. This is where the "cognitive" aspect of Dominiguez et al.'s (2013, 382-384) gamification came in. In order to answer the questions inside the booklet, the users first needed to figure out how to use the augmented reality map provided and then also scan the icon on the checkpoint to reveal the answer to the corresponding question. An example of a checkpoint tracker image can be seen in Figure 3. This requires a level of mastery of the technology, as well as the ability to synthesise the information provided from both the map and the answers to each question.
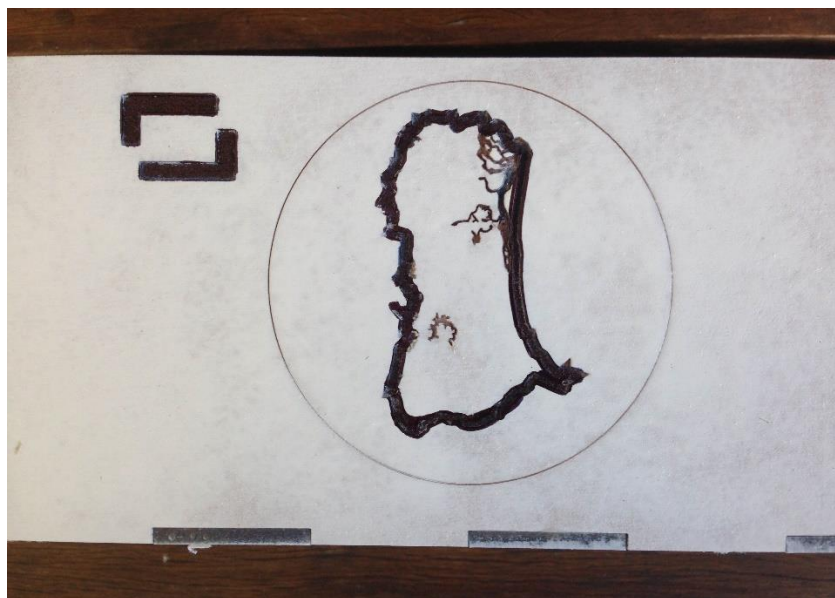

Figure 3 - A Playtest 1 checkpoint tracker image

As the players progress through the course and answer the questions they are rewarded with small coins with icons corresponding to those on the boxes to signify the completion of a question. These tokens act on not only the emotional aspect of gamification, but also the social factor as these coins act as indicators of progress through the course to other players and can be used to compare one player's progress to another, motivating players to compete with each other to complete the course. This plays into the emotional aspect of the coin, providing instant positive feedback to players upon completion of a question and motivating players to collect all of the coins.

Each of these separate elements was used in conjunction with one another in order to create a scavenger hunt that would maintain the players' attention and motivation from beginning to end. One aspect of gamifiction that is not considered throughout these experiments however is that of replay-ability or revisit-ability – that is the extent to which users are inclined to continuously come back and play the game. This is not really applicable in the context of this project however as the game is designed as a one-off event.

Playtest 2: Testing

The second playtest was developed over the course of approximately four months and was built from the elements of the first playtest that seemed to work, whereas other elements were changed and improved in order to better suit the context and situation in which it was set to be deployed. The second playtest utilised the map and box system of the first playtest, but more elements were added to the game to increase complexity, while also providing more aid to players through comprehensive instructions.

This playtest was the first iteration of the major project, which was deployed as part of the launch for the new Creative Industries Precinct of Queensland University of Technology at Kelvin Grove on August 28, 2016. The project was a tie-in with an interactive virtual reality, projection and sound installation called Museum of Colliding Dimensions (Polson, 2016) that was also deployed on

the August 28 and was designed to be a trail leading up to the installation that described a narrative surrounding the Museum of Colliding Dimensions.

This new project, titled Glitch'16 consisted of five boxes hidden throughout the main building of the Creative Industries Precinct that contained cards with a floorplan of another floor on them. When scanned by the Glitch'16 mobile application, these map cards would reveal the location of another box containing another map card for another floor. Each box was locked with a combination lock that could be unlocked using a code that was inscribed into the top of the box in a fictional alien language. This alien language could be decoded using a custom-made decoder given to players at the start of the game. Figure 4 shows what these decoders looked like.

Figure 4 - A decoder

Also contained in these boxes were symbols, which when scanned by the application would reveal a hidden narrative about the Museum of Colliding Dimensions. These symbols corresponded with letters of the alphabet, which could be discovered using the decoders. Upon completion of the game, players were asked to combine the letters contained within the boxes in order to reveal a word, which when spoken to the game master would reveal one final, crucial piece of information about the Museum of Colliding Dimensions.

This game system was developed with the use of the architectural floorplans from the newly constructed building as references for the map cards that were developed to be image trackers for the game application. The application was developed in the Unity3D game engine using the Vuforia Unity Development Kit, both of which are freely available at https://unity3d.com/ and https://developer.vuforia.com/ respectively. The maps were developed by printing a basic floorplan of each floor on a postcard-sized piece of card. The floorplan image of each floor was then uploaded to Vuforia's servers as a tracker image and the tracker images were then downloaded in database

form from the Vuforia site to be used in Unity3D. After importing the tracker images into Unity3D, three-dimensional models could then be superimposed on the images. To make the map readable for players, notable landmarks such as toilets, elevators and stairs were superimposed as three-dimensional models. In order to indicate the location of the checkpoint on each level, a red, morphing three-dimensional object was superimposed on the maps. At this point, the application was tested on the computer by using Unity3D's "play mode" and testing the tracker images by holding them up in front of the computer's webcam.

The symbols inside the checkpoint boxes were treated similarly to the floorplans, each being printed as a black and white sticker which was stuck on the inside of the lid of each box. However, before printing these stickers, the symbols were tested as tracker images and it was found that most of them did not have enough distinguishing features to be used effectively as tracker images. In order to rectify this problem, stylised images of the platonic solids – a recurring theme in both Glitch'16 and the Museum of Colliding Dimensions – was positioned around each symbol to give Vuforia's tracking software more points to track. This worked well and each symbol was able to be distinguished fairly well by the Vuforia system, though occasionally one tracker image would be mistaken for another and the three-dimensional models would be displayed accordingly. The three-dimensional models for these symbols were made by placing a grey plane over the tracker image and placing red text describing the narrative for each symbol over the grey plane. An example of this augmented reality feature in action can be seen in Figure 5.
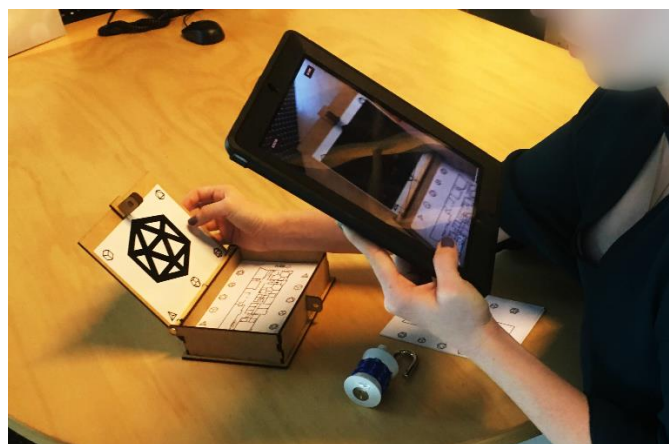

Figure 5 - A player scanning a glyph for the hidden message

This playtest was undertaken by a group of masters' students who were studying alternate reality gaming who were given a questionnaire used to gauge their familiarity with scavenger hunts and similar games. The players were then provided with the materials to play the game and observed as they played. Finally, the students were provided with a closing questionnaire that was used to gauge their perceived familiarity to the environment and their enjoyment and engagement of the experience.

From the responses to the initial questionnaire, the results indicate that though six of seven respondents had been to the Z9 building (the building in which the game is set) only two were confident in navigating it before playing the game. However, in the questionnaire following the game, six of seven respondents said that after completing the game they were confident in navigating the building. This indicates that the game was fairly successful in accomplishing its original aim to orientate players to the space, however due to the small sample size, more testing would need to be undertaken to confirm this, and this will be further addressed in the final playtest. Six out of seven respondents also answered that they would be willing to participate in a similar activity in a different space and while four of seven respondents agreed that they enjoyed the scavenger hunt, the remaining three of seven strongly agreed that they enjoyed it. Overall, this indicates that regardless of how well the game functioned as an orientation event, it was quite successful as a form of entertainment.

The participants' willingness to participate in future similar events indicate that though as mentioned previously the concept of replay or revisit-ability was out of the scope of this project, there is potential for it to be explored in the future as a means of expanding this game system to multiple situations or places with a regular or revisiting userbase. This potential adds credibility to the overall viability of the game system as a mean for entertainment, marketing and orientation.

Playtest 3: Deployment

The final playtest was conducted on August 28 at the launch of the Creative Industries Precinct 2 at the CreateX Festival (Queensland University of Tachnology 2016). This playtest was undertaken not long after the second playtest, with just a few minor adjustments made, and the same methods of observation and questionnaires used.

The main difference between this playtest and the previous playtest is that the feature of help and hints was added to the scanner application and that the playtest was open to a wider audience. The help and hints section of the application was added to aid players with the game as they played, as opposed to needing to return to the start area to seek the help of the game master. This section included hints such as what checkpoints looked like, how to open the locks on the checkpoint boxes and a reminder about the password that could be spelled out from the symbols inside the boxes. However, the major feature of this help and hints section was the inclusion of a "decode" section that showed each of the "alien alphabet" symbols directly decoded to its corresponding letter of the alphabet as seen in Figure 6.
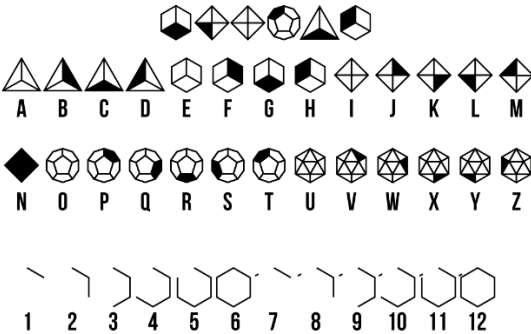

Figure 6 - Glitch font

The idea behind this help and hints section, and especially the "decode" section was to provide players with an alternative and easier way to decode the symbols. This was to foster what Kingsley and Grabner-Hagen (2015, 52) describe as "multimodal" learning, as discussed in the

contextual review chapter of this text. This would allow players to decipher the symbols according to their skill level, giving less skilled players an easier way to decode them.

Despite this though, upon talking with players after the playtest, it was found that these features were seldom if at all used. It seems that players would rather just get on with the game and try to figure out the application and game system themselves through experimentation and intuition rather than search for help and hints. This indicates that this game provided just the right amount of cognitive challenge for the players without being too challenging. However, the game still requires a lengthy explanation of game mechanics before the players can proceed, and perhaps some of this could be negated by simply directing users to the hints and instructions upon game commencement.

The results of the questionnaires for this playtest are fairly similar to those of the previous playtest, indicating that fourteen of fifteen players would be happy to participate in a similar game, with seven of fifteen strongly agreeing and five of fifteen agreeing that they enjoyed the experience, while the remaining three were neutral.

The questionnaire results also indicate that most of the players felt that the game at least somewhat familiarised the Z9 block environment with seven of fifteen indicating that they were familiar with the space prior to the game while twelve of fifteen feeling familiar with the space following the game.

These results indicate that there would be reason to undertake further research in the future in order to further explore how to familiarise spaces to users through gamified augmented reality. The results also indicate that further research into the use of gamified augmented reality to maintain engagement and enjoyment in an environment need to be undertaken in the future.

CONCLUSION

In summary, this project has explored the use of gamified augmented reality in order to familiarise users to a space. The project utilised the design based research methodology in order to develop and refine an augmented reality game designed to introduce players to a new environment and facilitate engagement with that environment. The development of this system involved a number of playtests, the first of which was an experiment to test many elements of the system before undertaking the development of the major project, Glitch'16. The second playtest centred around testing the Glitch'16 system in situ in order to gain an understanding of which elements were working and which needed refinement before the final deployment. The third playtest was the final deployment of the Glitch'16 game system on August 28, 2016 as part of the CreateX 2016 festival. This final playtest focused on how successful the game system was at introducing and orientating players to the space, as well as how successful it was as a form of entertainment.

This game system was developed with the aim of creating a framework for future augmented reality game events, and the documentation and fabrication files have been made available as a resource for other creators to use at their leisure as a base to create similar game systems in the future. This documentation website constitutes 50% of the overall grade of this honours project with this 7500 word exegesis constituting the remaining 50%.

Overall, the results of this project indicate that the game system developed was fairly successful in introducing and orientating users to the space, and was also successful as a form of entertainment by utilising the three major aspects of gamification in conjunction with the developing new technology of augmented reality. However, this could be further explored in future through continued development of the game system, which has been made available for researchers and game designers alike.

REFERENCES:

Chauhan, J., Taneja, S. & Goel, A. Enhancing MOOC with Augmented Reality, Adaptive Learning and Gamification. MOOCs, Innovation and Technology in Education (MITE), 2015 IEEE 3rd International Conference on, 1-2 Oct. 2015. 348-353.

CreateX Festival. 2016. Exhibited Brisbane: Queensland University of Technology, Kelvin Grove. Exhibition (viewed 28 August, 2016).

Google (Producer). (2007, May 7, 2016). Google Street View. [API] Retrieved from https://www.google.com.au/intl/en-GB/maps/streetview/

Myron Krueger - Videoplace, Responsive Environment, 1972-1990s, 1988. Video. Directed by HISTORY, M. O. N. Vernon: Museum of Natural History.

Kim, B. 2015. Understanding gamification. *Library Technology Reports,* 51**,** 1.

Kingsley, T. L. & Grabner-Hagen, M. M. 2015. Gamification. *Journal of Adolescent & Adult Literacy,* 59**,** 51-61.

Parker, C. & Tomitsch, M. 2014. Data Visualisation Trends in Mobile Augmented Reality Applications. *Proceedings of the 7th International Symposium on Visual Information Communication and Interaction.* Sydney NSW, Australia: ACM.

O'Shea, P. M. 2011. Augmented Reality in Education: Current Trends. *International Journal of Gaming and Computer-Mediated Simulations (IJGCMS),* 1**,** 91-93.

Polson, Debra. 2016. *Museum of Colliding Dimensions*. Exhibited Brisbane: CreateX Festival. Interactive lighting, projection and sound installation (viewed 28 August, 2016). http://fluiddimensions.tumblr.com/

Przybylski, A. K., Rigby, C. S. & Ryan, R. M. 2010. A motivational model of video game engagement. *Review of General Psychology,* 14**,** 154-166.

Rigby, C. S. 2014. GAMIFICATION AND MOTIVATION. *The Gameful World.* MIT Press.

Robert Joan, D. R. 2015. ENHANCING EDUCATION THROUGH MOBILE AUGMENTED REALITY. *Journal of Educational Technology,* 11**,** 8-14.

Whitton, N. & Moseley, A. 2014. Deconstructing Engagement: Rethinking Involvement in Learning. *Simulation & Gaming,* 45**,** 433-449.

Wu, H.-K., Lee, S. W.-Y., Chang, H.-Y. & Liang, J.-C. 2013. Current status, opportunities and challenges of augmented reality in education. *Computers & Education,* 62**,** 41-49.

APPENDIX: ETHICS

QUT Queensland University of Technology Brisbane Australia	**INFORMATION AND IMAGE RELEASE CONSENT FOR QUT RESEARCH PROJECT**

Glitch: An Investigation of the Use of Augmented Reality Gamification for Learning in an Everyday Setting

QUT Ethics Approval Number 1600000655

RESEARCH TEAM

Principal Researcher: Catriona Wilkinson, Honours student, QUT
Research Supervisor: Dr. Debra Polson, QUT
Creative Industries Faculty, Queensland University of Technology (QUT)

DESCRIPTION

This project is being undertaken as part of Honours for Catriona Wilkinson.

This is an interactive and visual design research project. The project, titled Glitch, will involve 10-20 treasure hunt stations being placed around the Creative Industries Precinct 2 site at QUT for you to find and interact with. The stations will contain small symbols which when scanned by a mobile device reveal a hidden narrative for you to follow. You will also be given a questionnaire to fill out with questions about the narrative to gauge your previous experience with this type of scavenger hunt and gaming as well as how effective this project has been in helping you navigate the environment. The answers from the question booklet will then be used to judge the effectiveness of the project. Photographs will be taken of you throughout this process in order to illustrate your engagement with the augmented reality scavenger hunt.

The purpose of this project is to understand the possible benefits of using game mechanics and game-type systems with augmented reality technology in order to navigate a new environment

You are invited to participate in this project because you are a student of QUT Creative Industries or you are an attendee of the QUT Creative Industries Precinct 2 Launch.

PARTICIPATION

Your participation will involve a photographically recorded scavenger hunt activity at QUT Creative Industries precinct or other agreed location that will take approximately 20 minutes of your time.

Your participation in this project is entirely voluntary. If you do agree to participate you can withdraw from the project without comment or penalty. If you withdraw within 3 weeks, on request any identifiable information already obtained from you will be destroyed. Your decision to participate or not participate will in no way impact upon your current or future relationship with QUT.

You can still take part to the hunt without participating in the research, but you have to be aware the research team is taking photos of the activity and so you might unintentionally be depicted in some of the images taken.

IMAGE RELEASE INFORMATION

A photographic image (including a video recording) which is sufficiently clear to enable you to be identified as an individual is personal information. QUT seeks to comply with the Information Privacy Principles as set out in the Information Privacy Act 2009. QUT shall, from time to time, endorse a privacy policy (see www.mopp.qut.edu.au) to ensure that personal information is used and disclosed only in ways which are consistent with privacy principles and will otherwise comply with QUT's privacy obligations under statute. In

general, personal information is not disclosed or published except where an individual's consent has been obtained.

- QUT is seeking your consent to use an image of you participating in a treasure hunt activity.
- Participation in this release is voluntary.
- Your decision to participate or to not participate will in no way impact upon your current or future relationship with Catriona Wilkinson or with QUT.

If you have any questions please ensure you have discussed them and are comfortable with the response before providing consent. You may choose to discuss participation with the following people:

- Catriona Wilkinson
- Family or friends.

What is the release about? We are using photography to observe behaviour in a mobile-based scavenger hunt situation.

Why do you want to include me? The study will follow the natural behaviours and reactions to people in an urban environment. Your participation will contribute to our understanding of how this can be observed.

What will you ask me to do? Your participation will involve a treasure hunt where you will walk to locations in the Z9 building and interact with a mobile device in order to scan symbols hidden throughout the environment.

Who will see the photos? The photos will be analysed by the researcher and also viewed by the research supervisor in order to judge the efficacy of this study. Non-identifiable photographs (photos with faces blurred) may then be included in the published study to demonstrate particular points.

Can I change my mind? You will have the opportunity to view the images as we plan to use them, and can decide to withdraw at that stage. However, once the study is written up, it will not be possible to withdraw.

EXPECTED BENEFITS

It is expected that this project will not directly benefit you. However, it may benefit future augmented reality and gamification research and the researcher's practice.

While the publication of this photography is not expected to provide tangible or intangible benefits to participants, the photography is not expected to be of detriment to participants either. The research team seeks to benefit from this photography by raising awareness of the research being undertaken by the research team.

RISKS

The research team has identified the following potential risks:

- Possible minor inconvenience for volunteering your time; in considering participating in the research you have to evaluate its time commitment and requirements.
- Potential discomfort in being seen in potentially unconventional situations and the possibility of being photographed in an embarrassing situation. You can still participate in the research and in the hunt without being photographed, although you have to be aware you might still be depicted in contextual photos not centred on you. In using and reporting photos, the identity of participants will anyway be hidden blurring faces and any other recognisable feature.
- Possible injuries connected to physical activity. The hunt is a game that requires physical movement. In joining the hunt you have to respect common health and safety practices as well as take responsibility for your own wellbeing.

PRIVACY AND CONFIDENTIALITY

The faces of all photo participants will be included in the photography. QUT understands that video participants may not wish to be named or identified in this photography. As a result, the names and faces of all photo participants will be excluded from this photography. QUT will only identify you in the video on the basis of your association with the researcher, i.e. participant in augmented reality gamification research program.

Any data collected as part of this project will be stored securely as per QUT's Management of research data policy.

CONSENT TO PARTICIPATE

You will be required to sign the attached consent form, acknowledging that you have read and understood the Participant Information and Image Release Consent for QUT Research Project.

QUESTIONS / FURTHER INFORMATION ABOUT THE PROJECT

If you have any questions or require further information, please contact one of the research team members below.

Dr. Debra Polson   Phone: 31385928   Email: d.polson@qut.edu.au
Catriona Wilkinson   Email: c5.wilkinson@qut.edu.au

CONCERNS / COMPLAINTS REGARDING THE CONDUCT OF THE PROJECT

QUT is committed to research integrity and the ethical conduct of research projects. However, if you do have any concerns or complaints about the ethical conduct of the project you may contact the QUT Research Ethics Unit on 07 3138 5123 or email ethicscontact@qut.edu.au. The QUT Research Ethics Unit is not connected with the research project and can facilitate a resolution to your concern in an impartial manner.

Thank you for helping with this research project. Please keep this sheet for your information.

QUT Queensland University of Technology Brisbane Australia	**CONSENT FOR QUT RESEARCH PROJECT**

Glitch: An Investigation of the Use of Augmented Reality Gamification for Learning in an Everyday Setting

QUT Ethics Approval Number 1600000655

RESEARCH TEAM CONTACTS

Dr. Debra Polson   Phone: 31385928   Email: d.polson@qut.edu.au
Catriona Wilkinson   Email: c5.wilkinson@qut.edu.au

If you agree to give consent regarding the use of your image, speech and/or dancing in the video recordings/images as part of Glitch 2016, please read and complete the consent below.

PLEASE RETURN THIS COMPLETED FORM TO Catriona Wilkinson
A COPY WILL BE PROVIDED FOR YOUR RECORDS

STATEMENT OF CONSENT

By signing below, you are indicating that you:

- Have read and understood the information document regarding this project.

- Have had any questions answered to my satisfaction.

- Understand if I have any additional questions I can contact the research team.

- Understand I am free to withdraw at any time without comment or penalty.

- Understand that I can contact the Research Ethics Unit on 3138 5123 or email ethicscontact@qut.edu.au if I have concerns about the ethical conduct of the project.

- Understand that non-identifiable data collected in this project may be used as comparative data in future projects.

- Understand that during the hunt I am totally responsible for my own wellbeing and in the case I get injured I will make no claim against QUT

- I understand that the anonymity afforded me, as a participant in this research project, will be rescinded if I appear in this video and/or photographic documentation.

- In the case I allow photographic images of me being taken during the hunt, I agree that I will make no claim against QUT for any payment or fee for appearing in promotional material or advertisements and release QUT from any other claims arising out of QUT's use of the images of me.

☐ Agree to participate in the scavenger hunt at my own risk and responsibility.

☐ Agree to participate in the project.

☐ I agree to QUT using, reproducing and disclosing photographic or video images of me as explained in this Participation Information and Image Release Consent for QUT Research Project form.

Name _____

Signature _____

Date _____

Glitch: An Investigation of the Use of Augmented Reality Gamification for Learning in an Everyday Setting

QUT Ethics Approval Number 1600000655

RESEARCH TEAM

Principal
Researcher: Catriona Wilkinson, Honours student, QUT

Research Supervisor: Dr. Debra Polson, QUT

                      Creative Industries, Queensland University of Technology (QUT)

DESCRIPTION

This project is being undertaken as part of Honours for Catriona Wilkinson.

This is an interactive and visual design research project. The project, titled Glitch, will involve 10-20 treasure hunt stations being placed around the Creative Industries Precinct 2 site at QUT for you to find and interact with. The stations will contain small symbols which when scanned by a mobile device reveal a hidden narrative for you to follow. You will also be given a questionnaire to fill out with questions about the narrative to gauge your previous experience with this type of scavenger hunt and gaming as well as how effective this project has been in helping you navigate the environment. The answers from the question booklet will then be used to judge the effectiveness of the project.

The purpose of this project is to understand the possible benefits of using game mechanics and game-type systems with augmented reality technology in order to navigate a new environment

You are invited to participate in this project because you have participated in a scavenger hunt in and around the Creative Industries Precinct 2 site.

PARTICIPATION

35

Participation will involve completing anonymous questionnaires with Likert scale answers (strongly agree – strongly disagree), multiple choice and short response answers that will take approximately 20 minutes of your time. The questionnaire is organized in two 5-questions-sections, one to be taken before the hunt, the other after. Questions will include:

I know what to expect from this interactive treasure hunt.

Strongly agree   agree   neutral   disagree   strongly disagree

I have participated in an interactive treasure hunt before.

- a. Yes
- b. No

Please state one reason you would come back to this space.

_____.

Your participation in this project is entirely voluntary. If you agree to participate you do not have to complete any question(s) you are uncomfortable answering. Your decision to participate or not participate will in no way impact upon your current or future relationship with QUT. If you do agree to participate you can withdraw from the project during your participation without comment or penalty. Any identifiable information already obtained from you will be destroyed, however as the questionnaire is anonymous once it has been submitted it will not be possible to withdraw.

EXPECTED BENEFITS
It is expected that this project will not directly benefit you. However, it may benefit future augmented reality and gamification research and the researcher's practice.

RISKS

There are minimal risks associated with your participation in this project. These include possible minor inconvenience for volunteering your time as well as possible trip and environmental hazards. We ask that you please exercise caution while participating in the scavenger hunt and use common sense when navigating the environment.

PRIVACY AND CONFIDENTIALITY
All comments and responses are anonymous and will be treated confidentially unless required by law. The names of individual persons are not required in any of the responses.

Any data collected as part of this project will be stored securely as per QUT's Management of research data policy.

Please note that non-identifiable data from this project may be used as comparative data in future projects or stored on an open access database for secondary analysis.

CONSENT TO PARTICIPATE

The return of the completed questionnaire is accepted as an indication of your consent to participate in this project.

QUESTIONS / FURTHER INFORMATION ABOUT THE PROJECT

If you have any questions or require further information, please contact one of the research team members below.

Catriona Wilkinson – Honours Student   Dr. Debra Polson – Lecturer, QUT

Email   c5.wilkinson@qut.edu.au   Phone   31385928

                                                                                   Email   d.polson@qut.edu.au

CONCERNS / COMPLAINTS REGARDING THE CONDUCT OF THE PROJECT

QUT is committed to research integrity and the ethical conduct of research projects. However, if you do have any concerns or complaints about the ethical conduct of the project you may contact the QUT Research Ethics Unit on 3138 5123 or email ethicscontact@qut.edu.au. The QUT Research Ethics Unit is not connected with the research project and can facilitate a resolution to your concern in an impartial manner.

Thank you for helping with this research project. Please keep this sheet for your information.

Name : _____

Questions prior to event:

1. I know what to expect from this interactive treasure hunt.
Strongly agree   agree   neutral   disagree   strongly disagree

2. I have participated in an interactive treasure hunt before.
a. Yes
b. No

3. Which outdoor games have you participated in before? (circle as many as you like)
Traditional Sports   Scavenger hunts   Orienteering   Wide games

4. Have you been to the Z9 block before?
    a. Yes
    b. No

5. Are you confident in navigating the Z9 Block?
    a. Yes
    b. No

Questions following event:

1. I can now confidently navigate Z9 Block?
    a. Yes
    b. No

2. Would you participate in a similar activity in a different space?
c. Yes
d. No

3. Please state one reason you would come back to this space.
_____.

4. I enjoyed this interactive treasure hunt.
Strongly agree   agree   neutral   disagree   strongly disagree

5. Did you interact with any other Glitch'16 players?
1. Yes
2. No