Batman
BSc (Hons) Computer Games (Design)
Matric No: S090xxxx

Honours Project Final Report

An Investigation into the Effectiveness of Co-Designed Learning Games versus Traditional Teaching Games

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"Except where explicitly stated all work in this document is my own"

Signed: _____ **Date:** _____

NOTE FOR STUDENTS STUDYING THIS AS AN EXEMPLAR: IN THE ORIGINAL REPORT, THIS STUDENT MISTAKENLY NAMED THE PRIMARY SCHOOL USED. THIS SHOULD NOT BE DONE. HE ALSO USED PUPILS FIRST NAMES WHEN REFERRING TO INDIVIDUALS IN HIS RAW DATA (APPENDIX C). AGAIN HE SHOULD NOT HAVE DONE THIS. IT SHOULD SIMPLY BE SCHOOL X AND PUPIL A, B, C ETC.)

ABSTRACT

Research has demonstrated that traditional one teacher many pupil passive teaching methods are generally less engaging compared to other techniques such as the more active e-learning. Learning through computer games has proven to be an effective learning method because the pupils are generally more engaged with the learning process than they would normally be if they were being lectured or simply reading the material which they are to learn. Little research has been done into discovering how much more efficient the process of learning while playing is when the pupils are involved in the design process of the learning game as opposed to not being involved in the process.

This project attempts to understand the differences in effectiveness in games created through a Co-Design process and games which did not go through a process like this, through the conductance of multiple participatory design sessions with children of primary school age – who helped to shape the design of a learning game based around the topic of recycling.

With the game designed and implemented, it was compared to a game of a similar level of fidelity through the usage of evaluation methods designed to investigate how engaged a player is with a certain game and by comparing the test results of a player before and after playing an educational game on that particular subject.

The project found that there is evidence to suggest that the Co-Designed creation will more frequently-out-perform in engagingness, even among participants who were not originally involved within the designing process when compared to a non-Co-Designed game and with the game created within the course of the project being at least partially successful in serving as an educational tool – meaning that it is likely that Co-Designed games function better as teaching tools based on how more engaging they are whilst still providing an educational message.

ACKNOWLEDGEMENTS

I would like to take this opportunity to first thank my supervisor Julie Campbell for her guidance and support throughout the project, and for accepting me and allowing my pursuit of a semi-self-selected project topic after me being assigned her supervisee. I would also like to express my gratitude to her, for her own personal knowledge of the subject matter and the guidance she was able to provide due to her own experiences with participatory design.

I would also like to thank Richard Foley for his work as co-ordinator and for the extension he granted to me at the Proposal stage of the Project after my late arrival back to Scotland, and for his informative feedback provided during the marking of the Proposal.

Additionally, I would like to thank all of the staff and students at Glasgow Caledonian University who supported me throughout the years, with added thanks to David Farrell whose work on e-Bug and other projects had influence on my overall project.

Finally I would like to thank my family, who supported my decision to attend university and have generally been quite supportive throughout my time despite sometimes thinking that all I did was play games all day.

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

1. INTRODUCTION

This section of this report will serve as an introduction to the project as a whole and some of the background issues concerning the project. The background section will provide information concerning serious games and gaming, with a particular focus on learning games; however it will also provide information on more project-specific areas such as co-design and the need to modernise parts of the educational system.

1.1. PROJECT BACKGROUND

1.1.1. TRADITIONAL TEACHING METHODS

The traditional (didactic) teaching method commonly used in primary schools involves one teacher effectively lecturing and testing their pupils, unfortunately this method of teaching is becoming less effective due to the reduction in attention span in young people caused by modern technology, with 71% of American school teachers believing that student's home entertainment usage, including social networking and video games, has had a negative impact on the attention span of pupils and their learning (Prucell *et al.*, 2012; Common Sense Media, 2012). Handwriting and spelling standards have been falling (Harrison, 2010) and it has been argued that this is as a result of automatic spell checkers, keyboards, and the abbreviations used whilst text messaging (Watt, 2010) - the development of these skills requires a lot of one-on-one attention which is increasingly difficult using didactic teaching methods in today's large classes.

This fall in standards indicates that the didactic teaching methods are becoming less effective as more and more pupils become more engaged with modern technology and require not only more attention to accommodate falling standards, but also require teaching methods that can keep them more engaged than current methods can. This form of didactic teaching has remained relatively unchanged since the introduction of public education with today's pupils learning in very similar ways as their parents and grandparents did before them (Esteve, 2000). The concept of active learning – which requires more interaction from pupils – has become more popular in recent years (Bonwell, 2002), and is an attempt to improve the standards of teaching by shying away from the passive nature of didactic methods. Studies in psychology indicate that active learning experiences are generally more effective in allowing the learner to retain information than passive experiences (Bernstein, 2007). While this has led to a small improvement in educational standards and has a nigh-universal uptake in the United States (K12 Academics, 2012), and Scotland (Education Scotland / Foghlam Alba, 2012); along with some uptake within England, Wales, and Northern Ireland (Johnson *et al.*, 2007), it has not conclusively made a large improvement to educational standards or dealt with all of the problems related to the now more limited attention spans of pupils (Prucell *et al.*, 2012).

1.1.2. ALTERNATIVE TEACHING METHODS

Prensky (2001), suggested that all learning environments must be made more active and less passive, with the 'teach-test' educational methods becoming increasingly more difficult to attain success with the increase in digital media – suggesting that teaching needs to move more into the digital realm where children can learn at their own pace in an environment that they are possibly more comfortable in as opposed to lectures. Since these type of games have had many practical purposes including usage within training and education (Durlach & Lesgold, 2012) this application is quite reasonable and has been explored as a teaching tool. Game-based learning (or 'edu-tainment') has been found not to increase the performance of pupils, but it has been found to result in pupils that are more engaged and motivated about learning whilst keeping the same level of standards and pupil performance as didactic teaching methods (Kuo, 2007). In addition to the increase in engagement during lessons, game-based learning also increases the intrinsic motivation for pupils to learn more about the subjects related to the game which is likely to have long term advantages with regards to future learning (Ryan and Deci, 2000), although as the techniques are new no research has been done to confirm that pupils who use learning-based games are more motivated to learn for the sake of learning in later life. A distinct advantage of game-based learning over traditional learning is that the held perception of games being enjoyable results in a higher likelihood of the game being used repeatedly (Ritterfeld *et al.*, 2009) meaning that if the pupils have access to the games then they are likely to choose to play them even when it is not required of them.

The use of digital games for learning has become slightly more common in recent years and has been implemented on numerous occasions in Scotland within the Curriculum for Excellence as surveyed by Razak *et al*. (2012), a survey which revealed that around 74% of primary school teachers in the Glasgow City Council had used computer games in some way to aid their teaching. Despite the figures revealed for the usage in Glasgow, the numbers showed that the figure was not as consistently high in the Renfrewshire region which only reported usage by 39% of teachers, implying that the use of games in teaching was unusually high in Glasgow and that the uptake of computer games based learning was not as widespread outside of Glasgow. Furthermore the survey reveals that despite the penetration of game-based learning in schools, access to game making tools in the classroom was very low, with only 5% of primary school teachers in Glasgow using them in teaching, and 11% in Renfrewshire – indicating that teachers are not taking advantage of the benefits that come when pupils are involved in the creation side of a game.

There are two different types of games currently used in education (and a third method that remains mostly unimplemented) (Van Eck, 2006), and this is an issue that can have a dramatic effect on how useful the game is for educational purposes. The first type of game sometimes used in an attempt to integrate games into education are pre-existing commercial games (also known as COTS – commercial off the shelf (Sandford *et al.*, 2006) that aren't specifically designed to be learning games but offer educational information within them. The use of commercial non-learning games have had mixed results, Squire (2006) utilised the war tactics game '*Civilization III*' in an attempt to teach pupils about

history and geography (since the game allowed players to play using a map of the world and in-game time advanced the 'year of play'), however he discovered that this type of game had such a steep learning curve that pupils had to spend more time learning how to play than could possibly be spent learning about history. On the other hand using this type of software can be cheaper than using specialised software which can require a license for use in schools, but it also requires teachers to fully engage with the software to extract the educational elements (Sandford *et al.*, 2006; Podolefsky, 2012). In the majority of cases the educational content of these games is not substantial enough to serve as a useful teaching tool.

1.1.3. SERIOUS GAMES

The other type of game used for educational purposes is the more specialised specifically designed learning-game such as *Logical Journey of the Zoombinis* (1996) and *Where in the World is Carmen Sandiego?* (1998) which were quite successful in their time and often sold to schools and libraries. During the 1980s in the United States of America, learning games were embraced warmly, with *The Oregon Trail* (1971) in particular appearing in a very large percentage of computer-equipped classrooms (Bigelow, 1997). These type of learning games became more and more unpopular as Internet-access spread since the parents buying the software realised that children would be able to play games online for free (Gibbs, 2006), since the home market was such an important part of the industry the number of learning games being produced dramatically fell and became more unpopular meaning that most learning games available for purchase were designed for outdated hardware and operating systems, leading to an even greater decline in the proliferation of learning game software. Despite the falling number of learning-based games available on the market, these games normally have a higher educational value than commercially developed non-learning games since the latter normally only contain educational content for immersion purposes with no real intention of delivering an educational purpose.

Figure 1 - The Oregon Trail (1971), an early serious game encouraging learning about history through a reenactment.

Games for purposes similar to this are generally referred to as 'serious games'(Bergeron, 2006), although this description is not generally limited to games used for education and can include other 'serious' or 'professional' issues such as use within medicine (Hannig *et al.*, 2012;), exercise and fitness (Garcia Pañello, 2012), and e-commerce (Cummins, 2002)

1.1.4. GAME DESIGN

A large part of what makes a successful game (learning-based or otherwise) is knowledge of the target audience (Salen and Zimmerman, 2003), and there is a correlation between the amount of consideration of the stakeholders of a game project and the fun and

engagement gained from the final product. Generally speaking when developing games for children, many developers fail to consider the target audience fully or rely on the information provided by parents for their research rather than directly asking the children (Druin, 1996), which is sometimes due to the problems that arise when attempting to gather information from children in the same ways that information is often gathered from adults, for instance focus groups cannot be used with children since they are likely to copy each other's answers. Difficulties in information gathering from children with regards to software design often results in developers choosing to use 'personas' to construct designs which they think match what children want based on their already existing knowledge and assumptions of what children like (Blomkvist, 2002). This implies that many of the learning games currently available to children will not have considered the stakeholders to a reasonable extent, and as a result of this, the learning games may not be reaching their full potential with regards to how engaging children find them to play and consequently how effective they are at delivering a fun learning experience that works as an alternative to didactic methods.

Druin (2002) suggests that partnering with children in the design process of a piece of technology, is a very effective way in learning exactly what the children want from the technology. A game created using this sort of method would likely result in something much more engaging than a reliance on personas or focus groups in the design research stages of the development of the project. Druin's method involved co-design, which is a user-centred design approach typically involving a designer and a non-designer-stakeholder (Sanders *et al.*, 2010), in her work Druin implemented the co-designed aspects of the development within the early stages of the project – something considered unusual since normally the co-designed aspects of a project involving it happen at the later stages of the design cycle resulting in some of the needs of the users' needs being missed by the developers. Co-design, being a form of user-centred design often results in an end-product that is closer to the original project requirements than projects that do not adhere to any form of user-centred design.

The work done by All *et al.* (2012) suggests that co-designing games with children can be a rewarding experience in terms of the generation of ideas but can often result in unworkable or unusable ideas (as would be expected when working with children), and warns of the danger of allowing design sessions to become to unstructured citing that involving children in the design process often results in the theme or main idea being lost to other ideas. The end result of All's project was a realisation that although the target audience enjoyed and engaged with the end product, there was a great need for regulation regarding the design of the final product because of the initial lack of boundaries involved in the co-design sessions. With the additional assistance of the regulation of the game's design on the part of the game designer responsible for developing the game, a game perceived as being more engaging than other serious games that the co-designers had played was created.

From past experiments we know that game-based learning is an effective tool in classrooms where didactic teaching is failing some pupils and as a supplement to traditional teaching methods (Van Eck, 2006; Saridaki *et al.*, 2011; Razak *et al.*, 2012) but that in many cases these types of games are designed for children based on specifications given by adults (Blomkvist, 2002). Games designed specifically for their target audience are more engaging

(Salen and Zimmerman, 2003; 2005) with co-design being one of the most effective ways of creating a product that fully meets the needs of the target audiences (All *et al.*, 2012) and it is the engaging quality of the learning games as opposed to the traditional methods of didactic teaching methods that makes learning games an effective teaching tool (Kuo, 2007).

1.2. Project Outline And Research Question

The aim of this project is to develop a web-based learning game with the intention of teaching children about recycling, using co-design primarily in the analysis of what is to be delivered and the design and evaluation of the game, in order to investigate if the game created from this process is suitable for teaching about the subject. This will be investigated by comparing testing children who play the end product on what they have learned and comparing the results of these tests with children who have been taught about the subject using a traditional learning game covering the same subject in order to deliver the same content.

The project will involve initial research into suitable tools for creating a web-based learning game, alongside research into obtaining participants for the research at a local school or church. As soon as is possible, a group of participants will be involved in the co-design process involving semi-formal group interviews and questionnaires in order to evaluate what the children want from a learning or non-learning game. Once this information is collected, a prototype will be developed using the tools identified by the previously completed research, with a smaller group of participants being available in the case of any 'emergency' gaps in the design of the game. Once this prototype has been created, it will be returned to a group of participants (involving both pupils who participated in the design and those who did not), who will have the opportunity to play the prototype in-class (or possibly at home), this will be followed by a short basic quiz on the subject taught within the game. At the same time, a short session of another game teaching the same subject which did not make use of the co-design method will be delivered to a separate group of participants, and they will be given the same test. After the testing is completed, the results of the two groups will be compared.

1.2.1. Research Question

The research question for the project is as follows:

To what extent is a learning-based computer game, for children of senior Primary School age and co-designed by the target audience, a suitable tool for teaching about a subject when compared to a traditional teaching game?

Based on the research question, the hypothesis is that the players who played the game which made use of the co-design methods outlined within this project will obtain higher results when compared to children who learned the same thing from a non-co-designed game.

1.3. REPORT STRUCTURE

This report will follow a specific structure in order to present the entire process of the project. The project background above, including the outline and objectives – serve as some additional information about the project area and what the project will attempt to find out in the form of the research question presented.

A literature review has also been produced to research into the characteristics and principles of Co-Design including some background into the fields of user-centred and player-centred design. The literature review will also focus upon the roles of the individuals associated with the Co-Design process and the techniques used within these sessions. The literature review will also look into the problems traditionally associated with learning games, since learning games themselves haven't taken off in the way researchers had expected them, and some of the possible explanations for that will be discussed.

Following the literature review, is the problem and systems anaylsis section of the report which covers the justification of the methodology used within the project and the lifecycle used to support this methodology. An analysis of the requirements of the game is then detailed extensively within the context of the Co-Design sessions held in order to establish this information, and the educational content required within the game is also established based on this knowledge alongside the identified functional requirements.

A briefer section covering the implementation and design of the project based on the works gathered through the Co-Design session follows, looking at each key mechanic within the game alongside the other decisions made in terms of the implementation of the game such as the genre and aesthetics.

This is followed by the evaluation of the game in relation to the research question. Followed by a discussion and the conclusions of the project.

2. LITERATURE REVIEW

This section of the report aims to address some of the areas addressed in the background section of the report, whilst also addressing the objectives mentioned in the previous section of the report. This Literature Review will look at some of the technical details surrounding the main objective of this project, and provide a base of knowledge to assist with understanding and undertaking the primary research of the project.

Section 1.2 identified some of the objectives to be met through the secondary research of this project, and this Literature Report should serve to provide a framework of knowledge upon which to complete the primary research. The objectives identified in the previous section were:

- Identify the characteristics of Co-Design
- Identify the problems associated with traditional learning games
- Identify appropriate platform for game development
- Identify a suitable subject for the evaluation purposes

2.1. INVESTIGATING THE CHARACTERISTICS OF CO-DESIGN

Although co-design in games is often seen as being something quite new, it has been in use within the creation of other types of media for almost half a century; 'participatory design' has been used mostly in processes outside of the software creation industry – instead often being used during the industrialisation of workplaces in the latter half of the 20th Century (Sanders and Stappers, 2008). However it has gradually moved into the realm of application development and computing systems.

2.1.1. PRINCIPLES OF CO-DESIGN

Co-Design, also known as participatory design (Sanders *et al.*, 2010), is a design practice which involves different non-designers coming together with designers in order to participate in the design process. These non-designers are typically the potential users of the system or stakeholders; however this process can also involve non-designers who are still involved with the development of the application without being a member of the typical design team. A good range of diversity is extremely beneficial to any project, and the inclusion of non-designers, aside from helping to identify what these non-designers want from the application, can help to provide different ideas and opinions that would otherwise not be included within the design process (Ehn, 1988).

According to Heirschim (1989), the participation of the user within the design process has a large number of benefits. Firstly, the quality of the design itself increases upon that of the design achieved through other simpler methods such as user-centred design or where participation was limited to non-face-to-face contact with the users. The commitment to the project on the part of the developers is also seen as being increased through the implementation of Co-Design due to the reliance of the users in having the product completed to their specifications – especially if the developers were present at the Co-Design session; in essence they do not want to let them down. Work satisfaction on the part of the developers is also increased in a similar way since they are said to feel more valued in doing something

that they know will be used by the target audience rather than just relying on research, since the audience have assured them themselves. In relation to this project, the efficiency of the training the product is designed to deliver is increased; meaning that if Heirschim is correct, the hypothesis of a co-designed game being more suited for teaching than a non-co-designed alternative is also correct. The participants are also said to gain a boost in productivity and feel the value of the participation event for themselves.

Sanders and Simons (2009) state that one of the key reasons why Co-Design is such a useful tool is that people are generally quite different creatively and they cite four different types of creativity to demonstrate this; 'doing' which is the accomplishment of something through productive activity, 'adapting' which is changing something to make it one's own, 'making' which is using one's hands and mind to build something new with some sort of guidance to provide structure and, 'creating' which is the need for expressing oneself. As already stated, different people are different creatively, so having a diverse mix of people can improve the design of any product.

Overall co-design is an incredibly beneficial tool which allows for interactivity with the potential users that other designing methods do not. In doing so, co-design is perhaps one of the best methods of design.

2.1.2. User-Centred and Player-Centred Design

Although co-design is a specific manner of designing a game, it relies heavily on the principles of user-centred and player-centred design (from henceforth referred to as UCD/PCD), bearing great similarities to the methodologies. UCD/PCD has been encouraged within the design of software and other things (Norman, 1988) and is a philosophy of design which focusses on fulfilling the needs of the user as opposed to the technological or functional needs – these needs are of course still examined, however the user's takes priority.

In order to allow for the sometimes chaotic involvement of UCD/PCD, the approach has to be taken from an early stage in order to prevent costs from escalating in professional projects, in smaller-scale projects such as this one, early-deployment cuts down on development time by reducing the need for large changes later in the project lifecycle which take longer to implement due to the amount of material that needs to be changed (Salvendy, 2006).

An international standard has been established for what is called 'Ergonomics of human-system interaction' (International Standards Office, 2010), a more recent version of ISO 13407: 1999, which lists that there are four UCD activities which must take place during the development process of an application making use of UCD/PCD:

1. Understand and specify the context of use
2. Specify the user and organisational requirements
3. Produce design solutions
4. Evaluate designs against requirements

A diagram was also produced in order to better illustrate the process, since these activities are dependent on one another:

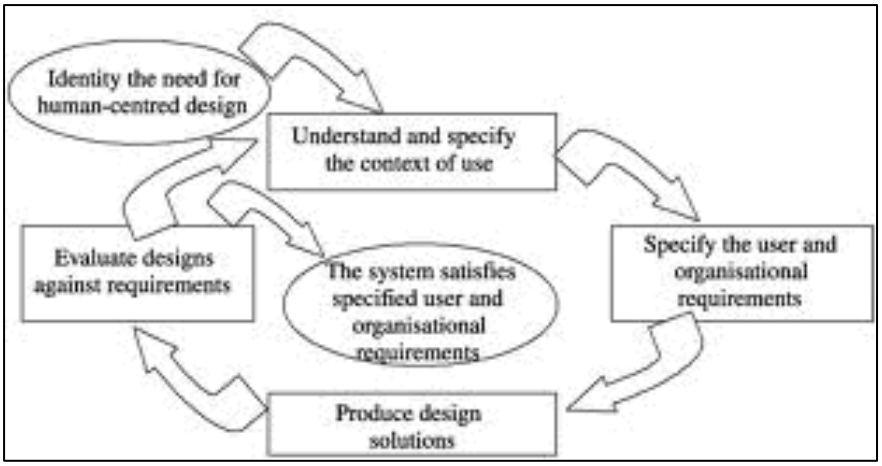


Figure 2- Demonstrating that the separate required parts of the UCD process are dependent on one another (International Standards Office, 2010)

The UCD/PCD standard is an iterative process, and the diagram above illustrates the need to identify the context of use before continuing with the design process, since this can make quite a lot of difference to the end product (Raskin, 2000). An educational game designed for use in the classroom can be quite different from one designed for use in the home, since quite often classroom-games will need to be able to be enjoyed in short bursts and without sound effects in order to prevent the disruption of a class. This first stage must be considered even before considering the individual needs of the user since the user's needs be restricted will differ depending on the environment that the application is used within, as demonstrated by the previous example. After defining the needs related to the working environment, the needs of the user must be fully considered before attempting to produce design solutions in order to remain user-centred (Viitaniemi, 2010). Since UCD is an iterative process it should continue until the design documentation is suitably consistent with the requirements originally set out for the application.

In general the design process for an application using UCD/PCD is overall quite similar to the entire waterfall process used in the development of a full application (Adkisson, 2002).

2.1.3. USER-CENTRED AND PLAYER-CENTRED DESIGN VERSUS CO-DESIGN

Despite the obvious similarities between UCD/PCD and co-design, both featuring a heavy say from the users of the application, the way in which games are designed adhering to these principles is quite different. Although co-design involves a distinct and absolute relationship with the user in the creation process, it still relies on the second-hand information from the user (Dix *et al.*, 2004). Information gathered from the user in a UCD/PCD application normally comes from the results of a focus group, interview, or survey, with both the user and the designer maintaining their strict roles. Alternatively the information which is relied upon for a UCD/PCD game may come from fictional personas (Sharp *et al.*, 2002) generated to reflect what the designers believe the user to be, but without actually involving

an actual potential user within the process, which can lead to skewed or unreliable results and bad choices in design.

On the other hand, within a co-design environment, the user has a direct say in the design of the game and is involved much more heavily in the design of the game. Games created using co-design methods are generally designed within a much shorter space of time in order to accommodate for the needs of those involved (All *et al.*, 2012).

A traditionally UCD/PCD application will take its development's design from the designer-produced design document; this document will have been produced after having received the insight from the potential users and stakeholders or their personas, and after receiving researched information from the researchers of the team. Conversely, a co-designed application is much less sequential (although the UCD/PCD process will involve a degree of iteration) instead relying upon collaboration with all members present in order to establish the design of the game (Mumford, 1989), see below:

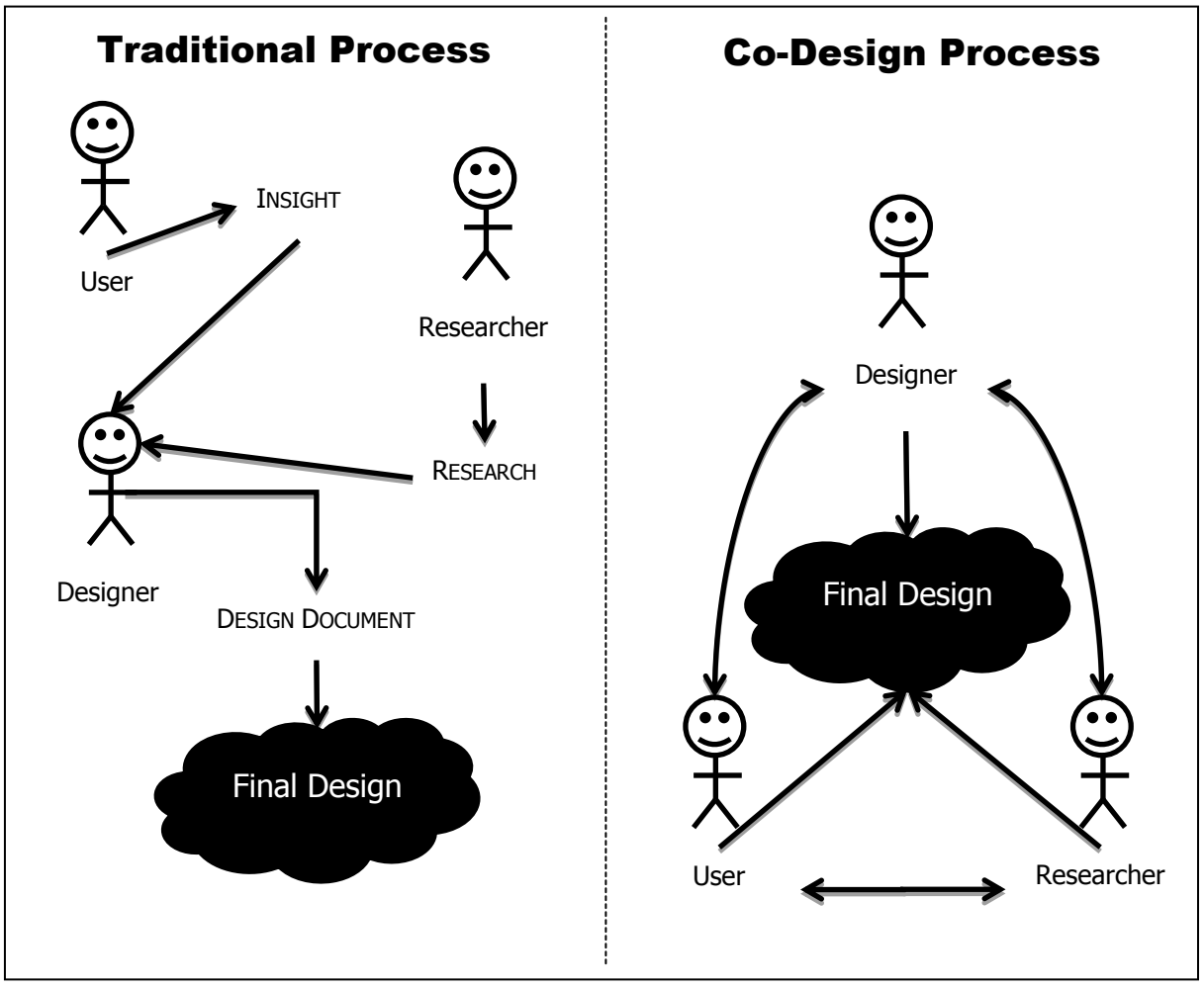


Figure 3 - The roles of Users, Researchers, and Designers; within an educational game. Traditional process versus a co-design process (Sanders and Stappers, 2008)

In simple terms, the main difference between UCD/PCD and Co-Design is the level of interaction and representation granted to the users of the final product within the design of the product (Marzano, 2003). Lindsay (2003) developed a pyramid detailing the different levels of user involvement within the design of a product, as seen in the opposite Figure:

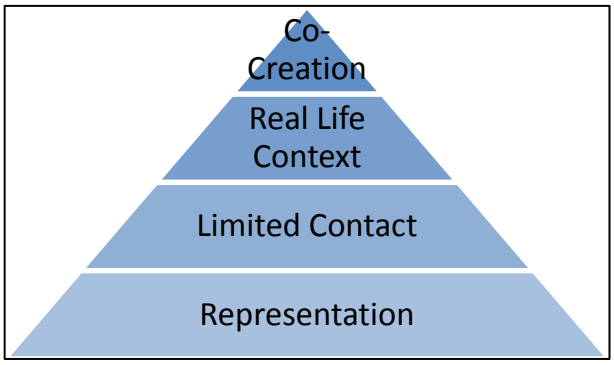


Figure 4- The four levels of user involvement with the design of a product (Lindsay, 2003)

UCD/PCD is said to take place when any of the three lower tiers of the pyramid are used within the development process concerning the involvement of the users. The bottom tier 'Representation', involves the use of Personas (see Carroll, 1995) filling in for the actual users, however as previously stated this can cause many problems (Sharp *et al.*, 2002), this technique has become less popular since there is always the chance that the designer will eventually employ the 'I-methodology' (Lindsay, 2003) leading to them designing for themselves if any of their personal traits happen to overlap with the traits of the intended target audience. The second tier from the bottom 'Limited Contact' involves one way communication in the gathering of information from the potential users, normally by making use of common evaluation techniques such as questionnaires, focus-groups, and telephone interviews (see Isbister *et al.*, 2006), more commonly used within small-scale UCD/PCD applications in order to quickly gather information about the user's needs. The second tier from the top 'Real Life Context' is the final point of UCD/PCD and normally the most informative of all of the lower tiers of interaction, this tier involves regular back-and-forth between the development team and the target audiences and can also involve shadowing in order to better understand the environment in which the application will be used in (Lindsay, 2003). The top tier, 'Co-Creation' is Co-Design - treating the potential users of the application as equal, less experienced, designers in the development process.

In developments making use of Co-Design, sessions must be run in order to generate the information needed for the design, and ultimately the design itself. Since there is likely to be limitations on the number of Co-Design sessions implemented during the course of this project, it is likely that although Co-Design will be responsible for the majority of the design decisions, some aspects of User-Centred Design will need to be used in order to cover up any gaps in the design that are not significant enough to warrant an additional session.

2.1.4. The Roles within a Co-Design Session

Since the running of a Co-Design session is one of the more important aspects of the project, it is vitally important that the session be run in an appropriate manner using proven techniques to make the most of the session. Sanders and Stappers (2008) identified three major participants of both UCD/PCD and of Co-Design: Researchers, Designers, and Users.

Therefore each of these three roles shall be looked at. In the case of this project, the Researcher and Designer are the same person, whilst there are many more than users than just one.

2.1.4.1. The Role of the Researcher

The role of the typical researcher within the Co-Design process is to serve as a facilitator (Sanders and Stappers, 2008). In a participatory environment a facilitator's job is too support all members of the session in their participation (Kaner, 2007), much in the same way as a facilitator participates within a focus group. A common problem within focus groups is that more vocal members of the group will usually drown out the words and ideas of less vocal members of the group (Sharp *et al.*, 2002), and a facilitator should be responsible for ensuring that this does not happen since the loudest ideas are not necessarily the best ideas. In addition to ensuring everyone has their say, the researcher is also responsible for serving as a 'translator' for the different types of user group present at the session, so in this case it could be translating various terms to non-gamers if they are brought up by gamers – although the use of any serious gaming terminology is unlikely to be brought up within the session.

In situations where Researchers are fortunate enough to have skills in other fields which may add to the Co-Design process then they are able to bring in these skills for the benefit of the session (Postma and Stappers, 2006). Ideally, all Researchers serving as facilitators should be able to provide support for under-developed ideas, but also allow for other members of the session to develop upon these ideas.

2.1.4.2. The Role of the Designer

The role of the designer within any Co-Design process is to remain as a font of expert knowledge and to help constrain some ideas which may be impossible. Quite often with these types of sessions, users may lack any kind of knowledge of what is achievable which can lead to an under-developed or over-developed idea and subsequently a boring or impossible design (Sanders and Stappers, 2008).

The expert knowledge of the designer must be put to use throughout the session, in taking lead in situations where the users are unwilling or unable to do so. They should be able to offer their own suggestions based on their pre-conceptions of the user-group in a similar way as to if they had completed the design using personas and user-centred design (Sharp *et al.*, 2002) in order to keep the design process going. They should also be responsible in finding gaps within the design of the users, and making efforts to plug those gaps at the time, or to later develop suitable plugs on their own, if development is already underway.

Designers should be familiar with the technology to be used in the development of the project, and use this knowledge to the advantage of the session by explaining what is available to users and what can be done with it.

2.1.4.3. The Role of the User

Within a co-design session, the user is the most important member of the team since they are the target audience of the design. With guidance from the researcher and designer,

they should be responsible for the overall design of the game, including things such as aesthetics and mechanics.

Sleeswijk Visser *et al.* (2005) suggests that the users that participate in a co-design session can be used as experts of their experiences to deliver what it is they perceive to be needed within the application. This can be on two levels, the level of an 'expert user', who has plenty of experience with the type of application (so in this case, someone who regularly plays games, or even better web-games), or a 'regular user' who may have only limited access to the application type.

2.1.5. PARTICIPATORY TECHNIQUES

The techniques used within a Co-Design are essential for insuring that the Co-Design session remains as efficient as possible. Due to time constraints it is unlikely that there will be more than a single Co-Design session and therefore the techniques deployed must be researched and refined before attempting to carry out the session so as not to waste the opportunity to establish the design document. Entering the session without sufficient research could lead to the use of inefficient techniques which do not gather enough information within the allotted time.

Sanders *et al.* (2010) delivered a framework of techniques and tools to be used within Co-Design sessions, and the techniques and tools used within this delivered session will likely reflect that. The tools used by Sanders, Brandt, and Binder, have been used in a real context and have been found to work successfully.

2.1.5.1. Group discussion

Group discussion is normally first method implemented within the co-design session, since it is likely that the participants (being children) will be excited about the opportunity to help in the development of the game. In cases where participants do not already know each other it is always a good idea to begin these sessions with an ice-breaking session to allow for the participants to learn each other's names before diving into the session, normally this will also include the use of nametags (this will not be necessary in this situation since the users will all most likely know each other, being in the same class).

Lee (2008) suggests that this type of discussion should begin with a brief section talking about the pre-conceptions of what the users believe to be the definition of what is being designed and go from there. It is likely that the participants will have ideas that they want to develop on very quickly in the process of co-design, so it is important to allow them to voice their opinions whilst still fresh in the minds (especially in cases of forgetful children) (All *et al.*, 2012).

2.1.5.2. Use of two dimensional collages and three dimensional objects

A suggested way to allow children to unleash their creativity is through the use of collages to demonstrate their ideas. By creating their own aspects to the overall design, a final collage could be created to give information at a glance regarding the design of the game. This would also appeal to all the creative types discussed in Section 2.1.1. by Heirschim (1989).

2.1.5.4. Storyboarding

Storyboarding is often used in professional settings outside of co-design and could provide a good framework for the development of ideas. If children within a session were asked to create a storyboard of how they would create a game regarding the chosen subject, the ideas can be discussed and combined at a later stage of the session within another brainstorming and group discussion.

2.1.6. CONCLUSION

In conclusion co-design is a specific manner of designing a game, relying heavily on the principles of user-centred and player-centred design but distinguishing itself from this type of design. Within co-design sessions, there are specific roles for the members of the session and specific techniques to carry out the session adequetly.

2.2. INVESTIGATING THE PROBLEMS ASSOCIATED WITH TRADITIONAL LEARNING GAMES

Unfortunately there has been no significant research into the problems associated with traditional learning games. This may be because of the general decline in availability of learning games, and the still reluctant educators being unwilling to experiment with games as a learning device (Gee, 2007). Within classroom-based learning games, there are two parties involved in the process: pupils (users), and teachers (facilitators).

One of the problems associated with serious games is the belief that they do not need to conform to some of the more recognised traits of 'normal' games (Göbel and Gutjahr, 2011). This can have negative effects on the user, since as established by (Prensky, 2001), the point of having the learning in game form is to increase the amount of engagement with the subject. This engagement with the user can be lost for quite a few reasons including:

2.2.1. OVER-RELIANCE ON TEXT

Generally, children are not expected to read as much for leisure as they once were, which has led to a lot of children being less enthusiastic about actually doing so, by just associating reading with something that they might do in school (Ortlieb, 2010). With the introduction of instant gratification through television and film, children prefer entertainment that requires relatively little effort on their part if the activity is not seen as being 'engaging'. Games that provide too much text for children to read are likely to find that the text is simply 'skipped' if it is possible to do so and as a result parts of the games message or educational content may be lost on the users (Farrell *et al.*, 2011).

The e-Bug games created in conjunction with Farrell *et al.*'s (2011) papers and posters (2008) featured a lot of text in order to get the message of the games across. This was partly due to the direct involvement with scientific professionals concerning the educational matters found within the game, however there were often occasions in game where the player's only interaction was clicking to continue with the speech being given by an on-screen character which would be several paragraphs long (See Figure 5).

Figure 5 – e-Bug Detective Game, featuring an over-reliance on text-based information (e-Bug, 2008)

Feedback gathered from the evaluation of e-Bug (Farrell *et al.*, 2008) included suggestions from teachers that the games should include voice acting in order to support children who did not have strong reading abilities, and were unable to fully participate with the game. Note that this was not feedback on the senior game which is pictured above, but on the junior game, which although featuring a fair amount of text, uses it much less liberally than the senior game uses it.

Learning games that suffer from this are also common on the Nobel Prize website (2013), in particular cases such as the game teaching about the Red Cross/Crescent, which require players to read about the Geneva Convention III before being able to fully participate. Since there are no usage statistics on the web page, there is no way of absolutely knowing how this has affected players playing the game, however previous works indicate that it has an adverse effect such as the works of Brom *et al.* (2011).

2.2.2. LACKING IN 'FUN'

A common mistake made by the developers of serious games is their hold over a captive audience. In training situations where users are required to play the games in order to

be credited as such in a course such as 'Forklift Driving', users are not given the choice to play the game and have to do so.

The active learning experience (Bernstein, 2007) is usually much more successful when the participant is having fun (Michael and Chen, 2005; Guillen-Nieto and Aleson-Carbonell, 2012). If a learning game is not designed to have fun elements then it is likely to be no better at engaging the pupils than the didactic teaching methods which have been failing schools.

2.2.3. Bloom's Learning Taxonomy

Bloom (1956) developed a taxonomy on learning which is often used when evaluating the educational content of learning games.

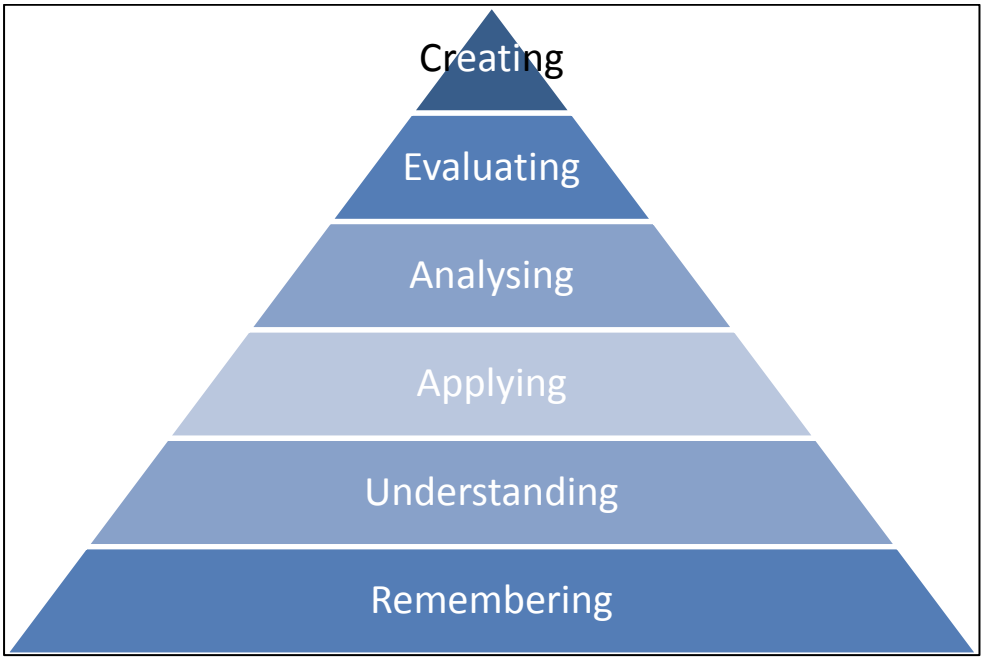


Figure 6 - A pyramid representation of Bloom's (1956) Taxonomy, revised by Anderson and Krathwohl (2001)

Today Bloom's taxonomy has evolved and been revised to reduce the confusion related to the original terms used within Bloom's work. Anderson and Krathwohl (2001) changed the terms used within the taxonomy in order to aid in the process of understanding them, and to change the nouns used in Bloom's work to verbs which can be related to within real-life situations.

2.2.3.2. Current Implementation: The 'Skill and Drill' Approach

A large proportion of traditional learning games are successful in maintaining at the very least temporary education to the users. Normally this is done by using the 'Skill and Drill' approach to learning games which is an incredibly common feature of learning games. These games normally do not take the time to introduce a new concept but rather treat the entire game and its gameplay as a formal examination, normally requiring pre-existing information to be attained by the user – but sometimes including some iterative teaching

techniques in order to get a message across to the player. Examples of such games include most of the mathematics games developed in the 1990s, such as the previously mentioned *Logical Journey of the Zoombinis* (1996) and *Where in the World is Carmen Sandiego?* (1998). The main problem of such an implementation is that it only briefly touches upon the base layer of the taxonomy without exploring the upper levels.

For instance, in a game featuring multiplication drills, the player needs to at least already have the knowledge of the multiplication tables – although this can just be a simple memory trick with no real understanding behind it. The player will then normally be rewarded for repeating the same actions again and again without changing any part of the game or really learning anything new, or learning why they are doing what they are doing or anything like that.

2.2.3.3. Improving Implementation

In order to improve upon the current implementation of learning within games, Bloom's taxonomy must be penetrated even further than the typical learning game manages to portray in their educational aspects. In order for game-based learning to be effective there has to be more focus than simply the 'Remembering' and 'Understanding' aspects of the taxonomy. Learning is understood to increase dramatically upon each new rung stepped upon within the taxonomy, so even having a game that allows the player to take the knowledge gathered from it and apply it within their own lives means that the learning process has been more successful than the typical standard.

2.2.4. INTERNATIONALISATION

As with all computer and videogames, a learning game has the potential to be internationalised and distributed across the world. This is because in general it is far cheaper to translate and update references within an existing game than create a new game from scratch. Localisation is common within big budget games but also common within commissioned educational games since they often reach across initiatives such as the EU to deliver the content to multiple different countries and cultures.

In order to allow for the easiest transition to the localisation process, the GUI of the application must be considered at all times to allow for the easy access to text that must be translated and to avoid small boxed spaces for text to be displayed in since common words and phrases can be greatly extended in length upon their translation to another language such as Russian or German.

2.2.5. CONCLUSION

In order to prevent the game following into the common traps of non-co-designed games, the game produced from the co-design session should work hard to avert and prevent this from happening.

2.3. Investigating an Appropriate Game Platform

A large proportion of the project depends upon the creation of a game based on the information gathered from the co-design session. Serious games, both educational and non-educational, have been developed on many different platforms in recent years. However in order to accommodate for the very short amount of time allotted for the development of the game, not to mention the inherent hardware and software limitations likely to be imposed upon the evaluation stages of the project, the platform with which to develop the game for must be carefully considered from several perspectives.

2.3.1. Time Limitations

The entirety of the project has a limited time in which to complete the projects goals. A strict deadline dated to the beginning of April exists, by which point all work associated with the project must be completed. To accommodate for this, the amount of development time to complete the game can only take up a smaller proportion of the time available in order to allow for evaluation and design time.

To allow for the time restrictions, any platform used in the development of the game should ideally be simple to use and efficient. Preferably, the platform should make use of either a solution which requires little knowledge of programming, or uses a programming language which the designer is familiar with.

2.3.2. Hardware and Software Limitations

A major part of this 'develop and test' process is the evaluation of the game for suitability which occurs at the end of the project. Ideally as many school pupils as is possible would participate within this process within the shortest amount of time, assuming that permission from the school is granted for the purposes of the experiment.

At the time of writing, the available hardware within the school has not been identified; however deployment of technology across the Inverclyde Council area has remained fairly consistent, with the hardware available in primary schools being the same as that in secondary schools. When last closely examined – four years ago – the technology available within the schools was more than capable of playing web-based games without any trouble.

The software installed in the hardware to be used for evaluation has the potential to cause more problems than even older hardware. Like many schools around the world, and sometimes enforced by legislation (McClure and Jaeger, 2009), Inverclyde Council has protective software which prevents the installation of new software or plugins which could cause problems with some browser-based game platforms. In addition to the software preventing the installation of new software, there is strict censorship and limitations on the websites that can be visited from within the Inverclyde Council network – meaning that if the game were to be deployed to a web games portal, there would probably be no way to access it from within the network. This is an advantage that the BBC has with web-based learning games (BBC, 2013), since the BBC website is generally not restricted on school networks.

2.3.3. Possible Platforms

In the 1990s, the only platform available for children to play educational games was normally a computer at school or the local library – in rare cases children also had access to a computer at home. Nowadays however, thanks to the reduction in price of technology, technological developments in handheld and mobile computing, and the great increases in digital literacy; children have access to a number of platforms from which they can consume digital media including educational games (Hanson, 2011; Gilete, 2011; Malik et al., 2011; PR Newswire, 2012).

A large number of children now not only have access to an Internet-connected computer but also to smartphones, tablets, and handheld games consoles. However development for portable platforms can quite often be more difficult than development for desktop computers.

2.3.3.1. iOS application

The original specification connected to this project suggested the usage of an iPad or iPhone in the development of the final game. The main problem with developing for the iOS platform is primarily down to a restriction in the hardware used to create the actual game rather than any restrictions surrounding the platform itself. In order to design and develop an iOS game, hardware running a recent version of OSX is required. In addition to the initial costs of the hardware required to actually develop the game, there is an additional fee and subscription required if the project were ever to be deployed commercially, which would likely render the game unprofitable if it was to be sold on the iOS appstore.

Aside from the inherent issues with hardware and software incompatibility, additional project time would need to be allocated in order to accommodate for a lack of knowledge regarding the platform, making an iOS application rather unfeasible for the project.

2.3.3.2. Flash

The use of Adobe (formerly Macromedia) Flash (2013) for the creation of games is commonly used in situations where development time is quite limited and is often used for prototyping project ideas and such. Flash was, for a long time, one of the only tools readily available to independent developers who intended to deploy their games to the Internet, and is the most common file type on games-portal websites such as Miniclip (2013) and Not Doppler (2013), making it the most used web-based game platform.

Recent devices have dropped support for Flash and it is currently incompatible with most operating systems outside of Windows, OSX, and Chrome; with some compatibility with Android and Linux devices. Since the introduction of HTML5, the use of Flash has been declining (International Business Times, 2011) in favour of web applications which compatible with a greater number of devices. Flash development is still relatively popular among those developers who have used the software extensively .

2.3.3.3. Unity3D

One of the more recent tools adopted by independent web-based games developers is Unity (2013). One of the greatest appeals of Unity is its powerful built-in graphical capabilities, although its portability is highly advantageous as well. Elements of

programming used within Unity3D may be C-Sharp, Java, or Boo; making the platform quite open to developers who have knowledge of any of these .NET languages.

As already mentioned, the portability of Unity is perhaps one of its strongest features. With the correct licencing purchased, the engine is capable of deploying Windows or Mac based applications, web-based applications, web-streamed applications, Android based applications, and applications capable of running on iOS. Unity is also making moves into Linux and Flash territory, although since the application already deploys its own web based applications this is just to benefit any potential players who may not wish to download the plugin required for web applications.

Another major advantage of Unity is the relative simplicity of adding networking capabilities to the games which are created with the platform. The basic networking of Unity has been criticised many times, however alternative methods are available in order polish the existing capabilities and to make them more than capable of connecting many users at the same time, including the capabilities of building an MMO if the correct hardware is employed.

Since multiplayer games have become the most popular type of games in recent years (as demonstrated by Kotaku/Google, 2012), the Co-Design session could reveal the need for a multiplayer game to be created on some level, and although this could potentially dramatically increase the amount of development time required for implementation, testing, and evaluation; of all of the platforms available, Unity is perhaps the strongest in dealing with this type of requirement.

2.3.3.4. RPG Maker XP

One of the more unknown game development platforms is the increasingly more popular RPG Maker software created by the Japanese company Enterbrain (2012). A major benefit of using RPG Maker is that the software can be used for basic highly-graphical 2D games without the need for large amounts of programming skill, and assuming the right scripts can be sourced from the Internet there is sometimes no need to partake in any programming at all.

Despite the relative ease of use of RPG Maker as a tool for creating games, the games created by the engine have a tendency to require text-heavy games to make up for an inherent lack of mechanics built into the base engine for immediate implementation. The programming language used by RPG Maker, RGSS (Ruby Game Scripting System) is not commonly used outside of the communities which employ RPG Maker as their main source of game development which causes many issues with implementation and testing. The title of the engine is also rather revealing as being refined mostly for the development of turn-based RPGS on computers running Windows XP, although the games are capable of running in later versions of Windows, they are not capable or running on Apple operating systems or on Linux without an emulator or a Virtual Machine running. The games produced using the software are also completely incompatible with mobile and tablet devices excluding those running on Windows 8.

In this situation, RPG Maker XP would not be an appropriate tool for the development of the game since there is also no web-based delivery system for games designed using the application.

2.3.3.5. Game Maker

Game Maker (YoYo Games, 2013b) is another tool which is frequently cited as being easy to use and very efficient, whilst also being a relatively powerful tool. Like Unity, Game Maker is incredibly portable with options to export applications created with the software to Windows, OSX, Android, and Android.

Something that Game Maker has what Unity does not have is the ability to export the game directly to HTML5 format. This is an incredibly powerful feature as it allows games created with the application to be run in any compatible browser without the need to download third-party plugins, which would mean that limitations over software installation could be overcome in cases where the game is deployed on the web with the intention of being played within schools. Unfortunately the exportation to HTML5 is something that YoYo Games recognises the value of, as a specific license costing $199.98 (YoYo Games, 2013a) is required to export to HTML5.

One of the potentially major disadvantages of Game Maker is that makes use of its own unique scripting language which only shares features with other more mainstream languages. The use of variables is somewhat limited within Game Maker, restricted to strings and real numbers, which causes problems at the development stage.

2.3.3.6. Scratch

Scratch (Massachusetts Institute of Technology 2013) is the same tool that was used by All *et al.* (2012) in her own Co-Design experiments with games. This application has more practical use in cases where multiple design sessions can be carried out as it will allow for pupils to actually participate in the design and implementation of the project due to its easy-to-learn nature.

Scratch is a very basic tool and is not suited for anything more advanced than what could be produced using Flash, and indeed runs using the Flash web plugin. Games created must be shared to the Scratch website unless a workaround is employed which can be complicated, and standalone applications are equally as complicated to create using the software. Any games shared to the Internet are actually compiled in real-time, meaning that if the Scratch service ever becomes unavailable, and the correct precautions have not been taken, the games will cease to work.

In essence, Scratch is good for directly involving children with the entirety of the development process but is unfortunately not suitable for a project such as this simply because it is too limiting and would most likely not produce a game suitable for employing game-based-learning techniques within it.

2.3.4. COMPETITION

The main outlet for Games-Based-Learning in today's market is on the Internet, relying on web-based games rather than those delivered through optical media. Websites such

as the BBC (2013) and Nobel Prize (2013) feature examples of learning games and the primary distribution of these games is Flash.

This serves the sites well in some regard since the installation of Flash is now almost universal on platforms which support it. However with the proliferation of handheld devices being used to connect to the Internet, Flash is becoming a much less viable platform for delivering this type of content.

There are some websites now offering a syllabus of serious games to schools, these are sometimes application-based but based on the understanding of hardware/software restrictions as detailed in Chapter 2.3.2. Global Conflicts (2013) offers a series of serious games in social studies, focussing on difficult issues such as the Palestinian-Israeli conflict, and various other issues in places such as the Middle East and Latin America. Global Conflicts differs mainly from other serious games provided online since it does not rely on Flash, instead relying upon the Unity Web Player.

Releasing educational games on optical media has become unpopular, for instance the 'Educational PC Games' section of Play.com (2013) provides only games that are many years old, including games from as early as 1999.

2.3.5. MOST VIABLE PLATFORM

The two largest factors within the production of any application are practicality and cost. In order to develop a learning game based on the design documentation developed from the Co-Design session, the platform chosen to be used must be capable of meeting the design requirements. Since the project is on such a small scale and there is no budget to accommodate for any expenses associated with the project, the issues with distribution are also incredibly important.

Commercial-off-the-shelf learning games have become almost non-existent in recent years, and parents and teachers can sometimes be less than eager to download software for educational purposes, partially due to their lack of status as a 'digital native' (Prensky, 2001). In following the current trends of learning games being released for web-distribution, it seems that the most viable method of distribution should be web-based.

2.3.5.1. For Development Purposes

Of the six suggested platforms, only Unity3D makes use of a .NET programming language (Java and C#), with Game Maker implementing its own unique language, Flash relying on ActionScript, and RPG Maker on RGSS. Scratch does not make use of any programming languages which makes it quite limited.

In terms of complexity, all of the suggested platforms remain relatively uncomplicated to implement with. It is entirely possible to develop a prototype in limited time with any of them.

Other than omitting Scratch for lacking a programming language and allowing complicated scripting to be involved, developmentally there is no clear advantage between the different platforms other than the size of the community implementing the platform, and thus the additional support available to the game developer. Flash has a large following and hence a large base of support, it is an established tool within the web-based game industry and there are many people who are familiar with it, and many websites devoted to using it. RPG Maker also has a large community, but the introductions to the programming language are complicated and tiresome due to the languages origins in Japan, often leaving comments in Japanese. Since Unity uses .NET languages, it is expected that there will be a lot of support for the scripting side of development within Unity, and the dedicated website to Unity also has a large community willing to lend their support.

As mentioned before support for Flash is falling, so this may have effects on the technical support offered to a developer. For this reason, and for .NET being such a commonly used thing, using Unity would be the most logical choice for the project in terms of development since the scripting languages are well established and often used for large scale projects, whereas Flash is generally limited to animation, websites, and small games. It is true that the end result of this project will also be a small game, but the support offered for Unity and its scripting languages is likely to be far more common and professional than any support offered for a ‘dying’ platform.

2.3.5.2. For Cost and Distribution Purposes

Despite the project not being delivered to a professional level, future and current implementation may depend on the costs associated with the platform. The table below demonstrates the different formats available to the considered platforms, and the cost of distributing to these formats. The Unity costs feature the 'standard' / 'professional' costs, whilst the basic application form for Game Maker displays the format 'using limited resources' / 'no limit to resources'.

Table 1 – A price comparison of the possible development platforms (Unity 2013; Enterbrain 2012; YoYo Games, 2013; Massachusetts Institute of Technology, 2013)

Platform	Distribution Types	Cost for Distribution (USD)
iOS	iOS app	??? (irrelevant)
Flash	Web, Flash files	(+) 0.00
Unity3D	Application	0.00 / 1500.00
	Web, Unity files	0.00 / 1500.00
	Web, Flash files	400.00 / 3000.00
	Android	400.00 / 3000.00
	iOS app	400.00 / 3000.00
	All of the above	1200.00 / 6000.00
RPG Maker XP	Application	(+) 0.00
Game Maker	Application	0.00 / 49.99
	MIPS-based Android	0.00
	Android	298.98
	HTML5	198.98
	iOS app	298.98
	Windows Phone 8	298.98
	All of the above	499.99
Scratch	Web, 'Flash' files	0.00

Items marked with a (+) do not consider the original price of the development software

As you can see from the above table Web deployment is only possible for four of the suggested platforms. As discussed in the section covering Game Maker, the only method of web-distribution capable within Game Maker requires licensing fees of at least $298.99; which completely excludes the possibility of the application at this stage being developed within Game Maker.

Distribution wise this leaves only three possible platforms to develop and distribute from:

- Flash
- Unity 3D
- Scratch

2.3.6. CONCLUSION

Realistically of the three proposed platforms on which to develop the final product of the co-design session, only Unity 3D is reliable enough to work based on the decline of Flash and the possibility that Flash applications may be banned within the testing environment.

Unity 3D also provides the most powerful engine of all of the suggested engines, being capable of three-dimensional graphics without the need for additional plugins to the software. The target audience of the game have grown up used to three-dimensional games and have also grown accustomed to multiplayer functionality, which are both offered by Unity. It also has the potential to integrate into Facebook, although this is unlikely to be usable within primary schools due to networking filters.

Had there not been such a rapid decline in the use of Flash, Flash would have likely have been the used platform for the prototype. There are tools that can convert Flash's SWF files into applications that run without the need of the Flash plugin, so this would have been less of a concern. Having considered all of the facts though, Unity 3D still seems like the strongest choice for the game's platform.

2.4. INVESTIGATING A SUITABLE SUBJECT FOR EVALUATION PURPOSES

The subject to be used within the educational game is mostly irrelevant since the experiment involved within the project is focussing mainly on whether or not children absorb the learning outcomes of the games, rather than functioning as a legitimate outlet for teaching children about a certain subject. Due to the relative unimportance of the subject, only a brief amount of research has been undertaken in deciding upon the subject to be taught within the game.

The decision regarding the subject must be simple enough that the subject does not require extensive research in order to implement, and straight-forwardly compared to other non-co-designed learning games. Basic reading, writing, and arithmetic, would provide to be ideal subjects for these purposes since there are no disputable facts within educating about them other than the methods used to deliver the information. Keeping it a basic level may skew the results so it may be necessary to introduce a new concept to the participants, however further research will need to be completed in order to evaluate this fully. In this case recycling has been chosen due to the relative no complexity of it.

The complexity of the subject should be relatively low, so that the pupils have time to understand the basic concept within a relatively short period of time before applying it.

It is again important to consider Bloom's Taxonomy since some subjects are unable to be taught through a game beyond the first level of the pyramid. However in this case, recycling is an activity that can be applied to everyday life assuming the correct message is taken away from the game.

3. PROBLEM AND SYSTEMS ANALYSIS

The overall aim of the project is the development of a learning game created through participatory design and to evaluate whether this approach is an effective way in which to do so.

3.1. JUSTIFICATION OF METHODOLOGY

The primary methodology of the project is a 'Develop and Test' methodology. This methodology was chosen as opposed to an 'Experimental' methodology because although the actual aim of the project could be seen as being an 'experiment' (since the evaluation techniques involves testing a method against another type of method), and 'Experimental' approach normally focuses upon using pre-created resources in its evaluation (Dawson, 2005). On the other hand a 'Develop and Test' approach involves the creation of a new piece of software in a new domain using a new method, appropriate in this situation since Co-Design in educational games has not been used extensively.

Further possibilities for methodology included 'Case Study' and 'Survey Based' approaches, however these methodologies were not considered due to both a lack of accreditation granted by the British Computer Society (2013) and the lack of any true practical element.

3.2. LIFECYCLE

The lifecycle of the project was based on an HCI-Oriented Design Lifecycle developed by the University of Birmingham (2009). Originally a Waterfall lifecycle had been planned but the problem with that lifecycle was that it did not make the required allowances for any sort of User-Centred-Design based techniques and relied entirely on the knowledge of the developer. The lifecycle proposed by the University of Birmingham was as follows:

1. Obtain User ideas about the proposed system
2. Decide general design approach
3. Complete initial requirements specification
4. Design
5. Prototype

This lifecycle mapped perfectly onto the type of lifecycle required for the completion of a Co-Design game, since the very first stage within the lifecycle involved involving the user. Since Co-Design relies on all or most of the application's design being drawn from the user's input, the first step within the lifecycle was thoroughly investigated and a significant investment of time went into obtaining the ideas from the user base.

The second step of the lifecycle looks at the hardware/software to be used in the development of the project, a step that had already been completed by the Literature Review section of the project.

Obtaining specific user requirements is almost impossible within a Co-Design environment since the ideas are to come from the participants themselves rather than the developer. Instead of focussing upon the concrete functional requirements of the project, the functional requirements were more generic and based upon the needs of any Co-Designed

Learning game, with some specificity relating to the theme of the game and the educational content to be delivered.

The prototyping process was simplified somewhat due to the inclusion of Unity within the development process; a lot of the internal engine-related programming did not need to be completed. However a lot of the things that would otherwise be covered by programming were instead handled internally within Unity's interface, and the physics had

3.3. REQUIREMENTS ANALYSIS

The requirements analysis section of this report deals with the investigation that was carried out in order to discover the requirements of the project. Since the project is the creation of a Co-Designed game, the main requirement was quite obviously the delivery of a game that could be used to teach about the chosen problem area. However the mechanics, aesthetics, and genre – alongside the other functional requirements were to be designated by the results of the efforts into participatory design. It is very important to note that the requirements analysis done in the form of the participatory design sessions also contributed largely to the design aspect of the project rather than just being a part of the analysis of the problem.

Due to the nature of this project, the design stage of the design and implementation was arguably a lot more important than the actual implementation section of the development. Since the main part of participatory design places the future users right at the heart of any design process (see Chapter 2.1 for more information) that will be carried out it is virtually impossible to enter the implementation process before having done an extensive amount of design work. During the course of this project, the pupils of XX. XXXXX's Primary School, XXXXXX, were enlisted in participatory design sessions in order to establish multiple pieces of information related to the design of the ultimately co-designed game:

- The most favoured game genre of the users – this collection of this information was vital to the process, since if there were any distinct patterns in the preferred genre it would be beneficial to the project and remove the ambiguity of which type of game genre to aspire to develop towards.
- Whether or not the platform established to be most suitable in Chapter 2.3 was in fact suitable for the users – since a PC-based environment was chosen this was unlikely to be an issue in the modern age, but there was the possibility that there would be individuals who were not in the possession of a computer of any kind.
- The general aesthetic of the game – since children do not generally understand the more complicated factors behind a game other than what they can actually see, the aesthetic of the game is one of the most important factors within the game. Unfortunately there is no real 'budget' for a game of the aesthetic integrity that the players will likely expect, due to the modern graphical standards of consoles. This may be eased a bit by

the generally high exposure to smartphone games experienced by children too young to own their own expensive games console (Hanson, 2011; Cunningham *et al.*, 2011).

- The general gameplay mechanics of the game – ideally with the children involved in the participatory design being responsible for dictating the majority of these mechanics if not all of the mechanics involved within the game to ensure that the game was truly an example of Co-Design created with children rather than just being a game created for children based on the minimum amount of opinion from children or the reliance on HCI techniques which exclude the actual target audience from the design process.

The information collected was chosen so that it would not be too difficult to explain to children what kind of information was requested of them. Several of these pieces of information were not gathered in a 'conventional manner' and thus some of the information may not be completely accurate. The reason for the 'shying away' from outright asking the children 'What is your favourite game genre?' was simply because this involved the use of 'technical terms' which the children may not be familiar with, and the introduction of these terms could have some influence over the opinions given by children; for instance explaining the term 'genre' as being what type of game it is, and listing a few examples, might influence the children to choose a genre based only on the ones listed as an example.

3.3.1. PREPARATION FOR THE CONDUCTION OF A PARTICIPATORY DESIGN SESSIONS

The preparation of the Participatory Design sessions were perhaps the largest aspect of the entire process since there were two major aspects to the entire thing; both the gathering of resources and knowledge on how to conduct the actual session, and the sourcing of a suitable group of users to conduct the session with.

The Literature Review featured previously within this report played a significant role in the development of the technique to be deployed within the participatory design sessions. The techniques used within the final participatory design sessions were all based on previous attempts of participatory design used in various other projects, and these techniques were refined and cherry-picked into something that would be appropriate for the creation of an educational game.

Games are quite a visual medium, whereas not all versions of participatory design focus upon the visual aspects of the design process. There were some established participatory design techniques that could not easily be used within this process due to a lack of appropriateness for the setting or the worry that the employment of the technique would not produce any valid or usable information from which to create the game.

Sourcing the users was an aspect not directly covered within the Literature Review and also took a large amount of time as it was important to have a very good understanding of the techniques and the direct method to be employed before contacting any plausible source of participants – since it was incredibly likely that the point of contact would need additional information before allowing an experiment to be conducted using children that are under the

POC's care. In addition to the requirement of the relevant reference materials having been already developed, sources could not be sought before the ethical and legal side of the project had been given approval. This meant that ethical approval from the university had to be obtained before any practical element of the experiment could occur, and more importantly disclosure from Disclosure Scotland had to be obtained before any work involving children could be carried out.

Local primary schools were the first considered venues for the participatory design sessions, since they seemed to be the most obvious concentration of children and the safest environment to hold a participatory design session within – also parents would be much more likely to agree to have their children participate if they knew it was to take place in a school. A list of the local primary schools in Inverclyde was compiled alongside the appropriate telephone numbers required to get in contact with the schools, however this list went unneeded since the first school contacted kindly agreed to participate and allow use of their facilities, whilst also being kind enough to create consent forms and issue them to children prior to the implementation of the session. Other venues considered were local churches and community centre, but thankfully these were not required.

3.3.2. CONDUCTING THE PARTICIPATORY DESIGN SESSIONS

With the appropriate materials and research gathered prior to the instigation of the sessions, the sessions were held within the identified and successfully recruited venue of XX. XXXXXX's Primary School.

3.3.2.1. The Venue

A room functioning as both the school library and an unused classroom served as the actual venue for the sessions. This was done in order to ensure that the participants within the session would not be distracted by other things and so that they could concentrate on the session. For similar reasons it was suggested by Naranjo-Bock (2012) that children would be able to concentrate better on their own creations if they were not distracted by their peers, and for this reason it was decided within the first Co-Design session that the children should not be left sitting next to their friends – since the initial part of the session involved an individual piece of work which was hoped to be diverse, in other words if children were sitting next to their friends then they would be more likely to copy ideas from one another at a point where it was hoped they would generate their own ideas. For this reason, the children were asked to sit around the work area with alternating genders in each chair, i.e. boy-girl-boy-girl.

Group work was an important aspect of the overall co-design session so the room in which the participatory design session was held was specially laid out in order to accommodate for the type of layout that would normally accommodate a focus group whilst also allowing for the participants to work on their own. Several desks were pushed together to form a larger single table that would allow for group discussion during the session when appropriate.

Contrary to initial expectations about the venue, there was access to a computer in the room functioning as the venue for the Co-Design session. In fact not only was there access to

a computer, but the computer itself was an interactive white board which would have allowed for a much greater usage of multimedia elements within the Co-Design session and even the use of example games to stimulate the participants imagination and perhaps generate better results. An important part of managing to obtain the school for the use of Co-Design was that the process tends to work better if the participants already feel at ease within their environment, meaning that if they are in a place that is already familiar to them then they are more likely to fully participate to the best of their abilities. Other locations considered included the local church hall, which would not have been as effective as a familiar environment and would not be as likely to have provided participants of the correct age group.

3.3.2.2. The Sourced Participants

Originally it was only expected that a single group of participants would be sourced for the purposes of the project, however due to the accommodating nature of the school and its headmistress, three design sessions were able to be held with a total of 28 participants as opposed to the originally planned 10 participants being involved with the co-design process. This had the majorly beneficial effect of generating more information which could be used after the Co-Design segment of the project in the development and design of the game to be created.

When initially making contact with the school, the ideal participant age/primary was specified before any advancement was made on recruiting children within the school to participate within the Co-Design sessions. However whilst initially discussing the plans to only include children in the upper levels of primary school (Primary 6 and Primary 7, meaning an age range of 9-11), it was suggested by the Headmistress that the age range be expanded upon slightly in order to accommodate for the forgetful nature of children since each child had to complete a consent form and return it to the school before being allowed to participate in the project, and because of this consent forms were sent out to children from Primary 4 age to Primary 7 age.

In total there were three sessions carried out during the day and each of these sessions had a different makeup of pupil ages. The first session held in the morning was comprised of 10 pupils, of which all but one was in Primary 6 with a single Primary 7 pupil being included within the session. The second session held in the morning was made up of 9 pupils, with all of them being in Primary 7. The final session of the day, which was held in the afternoon after the children had had their lunch was made up of a mix of Primary 4 to Primary 6 pupils, meaning that there was the inclusion of some children who were outside of the target audience range within the Co-Design sessions, although they made up a minority of the participants of the session.

An ideal Co-Design process would have involved an even or near-even balance between the ages and genders of those involved within the process, with also some considerations for different ability level and disability, in order to provide the same sort of diversity that would be fitting for representing the target audience on a smaller scale than the actual entirety of the target audience. During the actual sessions, it was noted that there were

in fact children of multiple ability levels participating within the sessions and at least one child with disability. In terms of racial diversity, there was no representation of minority pupils – although this was to be expected since the area in which the school is in is predominantly (>98%) white, and the school itself was a Roman Catholic school placed next to a Non-denominational school, meaning that there would less likely be pupils from racial backgrounds which are typically non-Christian such as children from an Asian background.

It was hoped that there would be an equal number of female and male participants within the sessions however this was not the case. Approximately 60% of the participants were male, and 40% female; however the reason for this distribution of gender is unknown. The Headmistress herself chose the children who would be participating within the sessions, and she gave no indication as to how many consent forms had been returned by the pupils – so it is not known whether or not there was simply more interest from boys wishing to participate than girls wishing to participate – or whether or not it was just a case of random selection leading to more boys being involved than girls. Despite the overall makeup of the participants leaning towards a male majority, this was because of the final session which had a distinct minority of girls. The first session conducted had an even number of boys and girls, the second session had one more boy than girl, and the final session had a large majority of boys – with only 2 girls being included in the group of 9 participants.

As per the suggestion of the supervisor of the project, a letter (see Appendix A) was issued to each of the participants (to give to their parents/guardians) after the completion of the session seeking permission for the information gathered from the session from the individual to be used. Since there were logistical issues in having the letters be returnable to the school, an opt-out approach was taken instead allowing parents to send an email if they did not wish their child's information to be used.

3.3.2.3. The Implementation

On the day of the session, a room was set aside as described in the above section, and the Headmistress provided an introduction before each session explaining a little bit about what would be involved within the session, what the session was to be used for, and who would be conducting the session. Each session was conducted slightly differently since it was found that certain techniques used within the sessions were not as effective as they would have been expected to be.

3.3.2.3.1. Introductions, Icebreaking, and Questionnaires

Just before the beginning of the first session it was noted that there had been an administrative error in obtaining the correct number of materials to be used within the session – this was not one of the considered risks at the proposal stage since it seemed to be a very unlikely and not-too-damaging possibility, however a number of factors led to the early-session questionnaire (see Appendix B) not having enough printed copies to go around. Despite the fact that the questionnaire was not printed off with a sufficient number of copies, the answers to the questionnaire were still collected using plain A4 paper as an alternative collection source, but since this had not been anticipated the A4 paper also ran out – meaning that the participants of the final session were left to fill their answers on the back of the same

papers used to create the storyboards. Although this was a slight hindrance in the collection of information and the analysis of said information, the results were digitised to make analysis easier – and ultimately the information was still gathered. At the same time there was a fear that due to the fact that there were only going to be around 10 participants within the Co-Design process, that the number of resources gathered to be used within the participatory design sessions would be insufficient, and as already mentioned the A4 paper that was to be used as a backup for the storyboarding materials which then ran out, there was also the fear that there would not be enough of the Data-Protection letters discussed earlier (Appendix A), however this was not a problem after all.

After the introduction to the pupils, labels were provided to every child for them to write their name on, to serve as both an ice-breaking session where the children were each given the opportunity to say their names and an interesting fact about themselves. Although the children would obviously already know each other, it also gave the opportunity to get to know who was conducting the session and to help to settle the participants in, since they would have just come from a lesson in a more formal environment before joining the session.

After taking care of the icebreaking portion of the session, the questionnaire (Appendix B) that had originally been devised was attempted without the appropriate original materials, to a degree of success due to the aforementioned administrative error. In order to get accurate results it was intended that this section of the session be completed by the participants in absolute silence in order to prevent neighbours from simply 'copying' each other, which is why the children were requested to sit beside children of the opposite gender – this was done based on research into using focus groups with children (as already discussed in Chapter 2) which showed that children just copy answers if they cannot immediately come up with one on their own or if they perceive a neighbour's answer to be 'better' than their own answer, or out of simple embarrassment if they happened to have been playing a game considered 'uncool' by their peers. Even though this part of the session was intended to be completed in silence, this was not followed through with, due to the number of participants – however the negative effects of focus groups were not observed within this environment for unknown reasons, although every child had similar results there did not seem to be any active collusion going on in the choosing of answers. The results of this questionnaire were important, since they gave insight into the type of games that the children themselves actually enjoy playing, rather than focussing upon what they were capable of designing well. The information gathered from the questionnaire section of the participatory design session is discussed later in this chapter with regards to the information collected regarding the game genre and availability of gaming platforms.

Figure 7 - One of the internationally recognised recycling logos

Before launching into the main aspect of the participatory design section, it was important to introduce the educational content intended to be

portrayed as soon as possible to encourage thinking about the various aspects of recycling. The way in which the topic was introduced was simply by showing an image of one of the standard internationally recognised recycling logos (see accompanying figure) and allowing the children to talk about what the symbol meant, and what they knew about the subject as a whole. A short discussion was held within each participatory group, with some sessions showing more enthusiasm for the topic than others – for instance the enthusiasm was high for Primary 7 pupils and the session containing Primary 4-6 pupils, but for some reason this enthusiasm was not shared by the session made up mostly by pupils in Primary 6. The pupils were encouraged to detail as much as they knew about recycling but most of what was discussed concerned the local recycling scheme of Inverclyde Council, as discussed in more detail in a later part of this chapter. The discussion on the details of recycling then led carefully on to the main point of the participatory design session.

3.3.2.3.2. Storyboarding

Upon concluding the questionnaire questions on paper rather than the originally intended forms, the most important section of the participatory design session began with each pupil being issued a sheet of A3 paper and being invited to imagine a screenshot in a game focussed on teaching about recycling. As an additional note, the pupils were reminded that anything that they designed was intended for a target audience of the same age and that for that reason anything they designed had to be appropriate – a statement that was amusingly met with some begrudging sighs from the mostly 10-year-old pupils. The children had access to colouring supplies and pencils provided by the school and were given a limited amount of time to draw out an idea for a game individually. It was not expected that the individual ideas would generate any outstanding types of design but it was hoped that the initial individual storyboarding would allow for the creativity of the children to be realised before involving group work in the creation of a design.

Upon the creation of a first initial storyboarded image by each pupil, there was some brief discussion about each of the designs produced and some discussion about how clear these ideas were to the other pupils in the room. Pupils were given sticky notes to describe what they had designed focussing upon what may not have been obvious just by relying upon the picture and through the recommendations of their peers, any positive feedback given by their peers was also stuck onto the storyboards using sticky notes. This section of the session was timed rigidly and the participants were given reminders as to how much time they had left to complete the individual storyboard in order to ensure that what they were designing was understandable in later analysis. There was some additional guidance given to the pupils regarding how they should manage their time during the entire exercise and this information was given during each additional storyboarding activity completed by the pupils, with advice to set some time forward for planning (and discussion in the later group storyboarding sessions) before drawing their concepts out. However, the individual storyboarding activity mostly served as a warming up technique before asking the children to participate in a group storyboarding session.

During the period of time between this individual creation session and the next part of the overall participatory design session, a specially created storyboard was shown to the pupils to demonstrate a more professionally quickly-created storyboard (see accompanying Figure on the next page). This was not in any way supposed to influence their core ideas, but to show them the various aspects of a storyboard which can make the image easier to understand for other people. One of the main things featured within this demonstration storyboard and not featured within the majority of the participants' early storyboards is a form of interface to help to demonstrate what is happening within the game. Within this basic storyboard, the aim of the game is simply to throw the rubbish into the correct bin as quickly as possible, with future items being displayed along the bottom of the screen so the player can anticipate which bin to throw the rubbish into next. This type of detail was not achieved within the earliest storyboards created by the children, as the only additional material other than what they perceived to be the main aspects of the game were usually pictures of Xbox360 controllers, the name of the game, or a short statement saying 'this game is free' or 'don't drop litter'. This image was only shown during the first and the second session as the third session had to be completed in a shorter period of time and the introduction of younger pupils had had some impact on the pacing of the session as a whole.

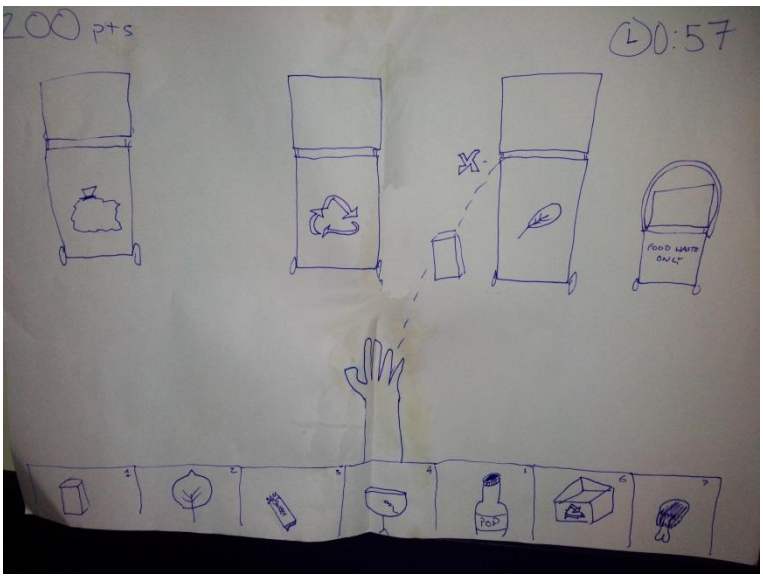


Figure 8 - A basic storyboard used as demonstration

After this, a group storyboarding exercise was carried out, with group sizes being determined by the number of total participants within the session; within the 10 person session (the first session) there were two people per group, and within the 9 person sessions there were three people per group. It was expected that the best information to be collected during these participatory design sessions would be gathered within these small groups – but it was later found that the method in which this was implemented was not the most efficient for doing so, as the recommendations of Naranjo-Bock (2012) which were consulted before and after the design sessions actually spoke in favour of having group co-design sessions between friend pairs rather than involving children who may not have interacted as much.

3.3.2.3.3. Additional Storyboarding Activity

Naranjo-Bock's theory on involving friend pairs rather than unaffiliated children was demonstrated within the course of the session during an additional storyboarding activity carried out only within the second design session (the session involving only Primary 7

children), because this session was expected to have the concentration required to participate in a second group storyboard. The second storyboard was not in the original plan for the design sessions but was implemented due to the realisation that the mixed-sex groups were experiencing quite a bit of conflict when deciding upon what to actually design and that some groups were not managing to get anything on paper at all due to arguing about certain aspects of their original concepts or even the concepts itself. Upon seeing the disagreements caused by the group storyboarding, the children participating within the design session were divided up by gender; with boys being sent to one side of the room, and girls being sent to the other side (giving a team of 5 boys and a team of 4 girls). The quality of the storyboard produced using this method was considerably higher than previous attempts – despite the allocation of the same amount of time. Everything from mechanics to aesthetics were clearer and there was virtually no in-fighting during the same-sex storyboarding session (excluding a disagreement among the girls about who would get to draw out the concept).

The completion of all of these activities within the session took around an hour each time, excluding the second session – because of the inclusion of the second group storyboarding activity – which lasted slightly longer. Thanks to holding multiple design sessions being held some more general information about holding participatory design sessions themselves was gathered, including the realisation that any type of session that lasts longer than an hour will normally lead to a great loss in concentration with children. Even though the only session that really lasted longer than an hour was the second design session which included the eldest pupils and led to some of the most cohesive and high-quality storyboards, it was around this time when pupils began to be distracted by things inside of the room such as past projects stuck on the wall. Luckily this was able to be taken into account before launching the final session, as the younger pupils participating in the final session would likely have suffered an even larger drop in focus and concentration.

3.3.3. EVALUATING THE MATERIALS GATHERED THROUGH THE PARTICIPATORY DESIGN SESSIONS

The actual evaluation of the questionnaire and analysis of the results generated through this segment of the participatory design session is looked at in more detail later on in this report, as the results of the questionnaire were vital in determining the actual genre of the game and the confirmation of the game's platform of deployment.

The storyboards gathered from the session[*] were the most vital components in establishing the game design and it was important to take some time to analyse the storyboards to work out which concepts from them would be workable into a game designed to teach about recycling. Determining what concepts could be implemented was the most important part of implementing the participatory design session, and it was hoped that most if

[*] Due to poor weather conditions on the day of the participatory design session, some of the materials gathered, particularly the storyboards were slightly water-damaged by the rain and this led to some colours running on the storyboards – however the damage done to the storyboards was not significant enough to render them unusable.

not all of the games concepts, aesthetics, and mechanics; would be gathered from the materials gathered during the storyboarding.

Part of the Co-Design process had involved a brief evaluation of each storyboard instigated by the peers of the participant(s) that created that particular storyboard, which involved the use of sticky notes and other participants detailing what their favourite aspect of each storyboard was and how well they thought the message came across. Negative criticism of other participants storyboards was strongly discouraged since the children involved within the project were quite young and likely to become upset if their ideas were overly criticised – and having an upset child participating within the design session would likely lead to some of the results being ruined or possibly lead to the cancellation of the rest of the session. Generally speaking the children were more likely to give praise to storyboards which they perceived as being similar to their favourite genre (see Chapter 4.1); boys were much more praising of games involving shooting or action of some kind[*], whereas girls were more reserved with the praise they issued.

In so far as evaluation occurred using the storyboards after the session, the first part of the process involved dividing up the storyboards into two piles: 'interpretable' and 'non-interpretable'. Despite the sticky notes being employed by the children to attempt to explain what was going on within the storyboard, there were some storyboards were the ideas weren't fully realised and in these cases sadly it was unlikely that any of the mechanics or aesthetics would be heavily influenced by these storyboards – and because of this the 'non-interpretable' storyboards were not looked at in great detail, but only much more briefly consulted; though some storyboards were sparse enough that there was no real analysis to do.

The storyboard analysis was divided up into the same sessions as the participatory design was completed since this made the periods of analysis shorter and allowed for evaluation of the sessions themselves and for criticism of how each design session went and whether or not this had an impact on the quality of the storyboards that were produced and the general theme of any storyboards produced.

3.3.3.1. Evaluating Storyboards

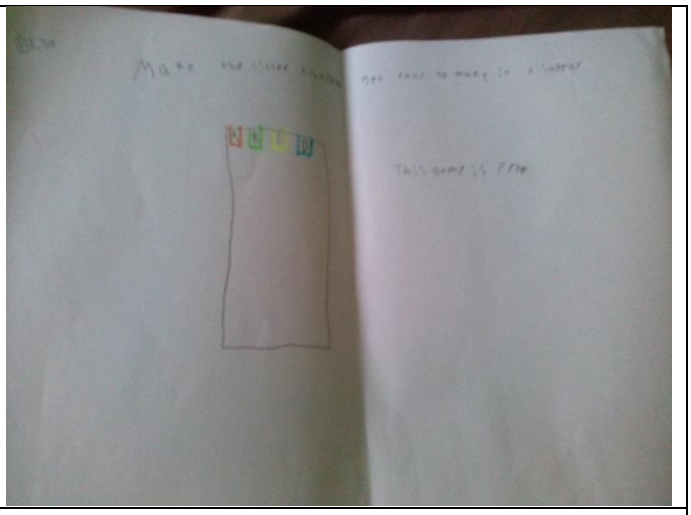
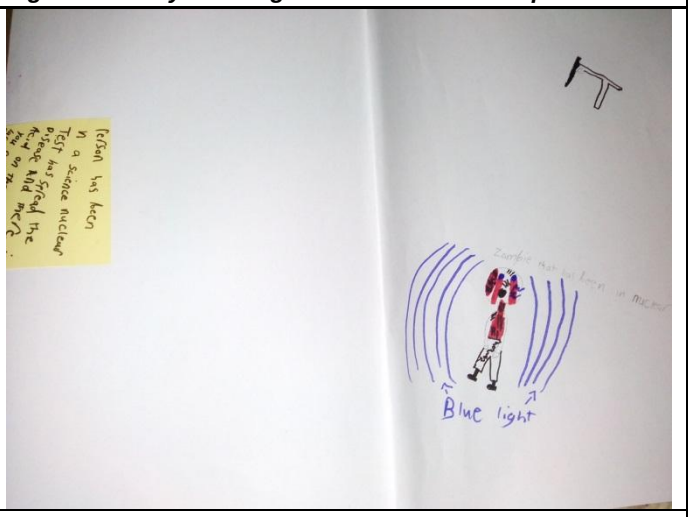
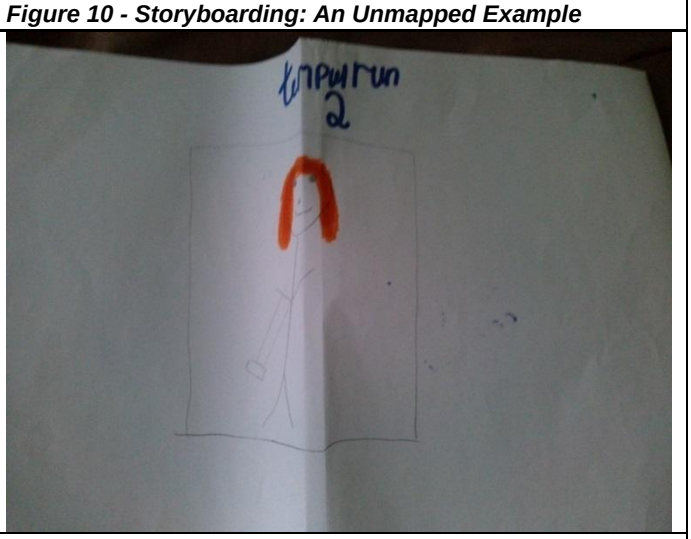
In terms of what was interpretable without having the original designer to directly describe it after using sticky notes to do just that, only around 60% of the storyboards produced during the first design session were interpretable through a combination of notes taken during the day, the sticky notes produced by the designer themselves, and the sticky notes created by the additional participants on the day of the design session. Unfortunately even though 60% were salvageable, 40% could not be interpreted after the co-design session. There were also a few interpreted storyboards which could not be used for a variety of reasons, established by doing a miniature 'heuristic evaluation' and ensuring that the storyboards had no problems such as:

[*] An unfortunately high number of shooting-based games designed during the first designing session led to a more comprehensive explanation about the need to design a game that is appropriate for children of the same age as the participants themselves.

- A lack of detail – where even the sticky notes provided at the storyboarding portion of the participatory design session coupled with the actual storyboard were not enough to establish how the game is supposed to look or play.
- A lack of mapping to context – since the game to be created from the participatory design sessions is to be an educational game, it was important that the designs at least reflected this.
- Plagiarism – some storyboards ended up resembling existing games far too closely or just copied them, even keeping the same name or just designing a 'sequel'

Examples of such problems are shown overleaf:

Table 2 - Some of the Unusable Storyboards from the first Participatory Design Session

A lack of detail *This storyboard, even with the notes produced during the storyboarding session by both the participants and the designer himself, lacked in any real detail which could be used within a real game. It was described as being similar to 'Tetris' but there was no actual detail into how this works.*	 ***Figure 9 - Storyboarding: An Undetailed Example***
A lack of mapping to the 'Recycling Concept' *It was stressed throughout the participatory design process that the main point of the game was as an educational tool. However this storyboard, along with some others, seemed to have the game concept created before just 'tacking on' the actual message of the game. There wasn't a single mention of recycling or even refuse within the storyboard. It also breached 'appropriateness' rules.*	 ***Figure 10 - Storyboarding: An Unmapped Example***
Plagiarism *This storyboard not only featured Plagiarism but no real designing of mechanics or concept. It is very likely that the designer of this storyboard was not really all that interested in participating within the session, or perhaps expected to participate with something different in description to the actual session.*	 ***Figure 11 - Storyboarding: A Plagiarised Example***

Interpretation problems were not limited to the first design session, however within the second session involving the older pupils there was a small proportion of unusable storyboards with only 30% of the storyboards produced being non-interpretable. This may have been because the pupils involved within the session were older but it is more likely that the reason for this occurring is because a longer period of time was spent explaining what the children were supposed to be doing, but this did not prevent an instance or two of plagiarism and a few unrealised ideas. Some of the ideas deemed non-interpretable were a result of the use of mixed-sex group storyboarding in which the members of the three person group were unable to meet a compromise; this happened only in groups where there were two boys and one girl within the group – with the girl of the group being unwilling to agree with the boys' ideas. This type of reaction had been anticipated but unfortunately there was no planned contingency for groups of this makeup – and the group storyboarding efforts within the second session would have yielded less usable material had it not been for the inclusion of the additional storyboarding activity executed within the session.

The third design session was incredibly successful in obtaining storyboards which could be interpreted and this seems to serve as evidence that the technique developed over the three sessions became more successful. Thanks to encouragement, the children were much more liberal with the usage of sticky notes to explain what was going on, and what features they liked, etc.; which led to around 90% of the storyboards being 'interpretable' and only 10% being 'non-interpretable'. The third session did however suffer from a lot of unusable and spoilt storyboards, likely due to the fact that there were a number of younger pupils involved within the process who did not understand the meaning of plagiarism. In anticipation of the amount of plagiarism that was likely to occur, the children were asked to give their game a name – and if it could be described using the name of another popular game (such as Subway Surfers 2 or FIFA 2014[*]) then it was not an idea that could be used. Unfortunately despite these warnings and suggestions, a small number of storyboards featuring plagiarism were produced and unable to be used.

[*] Amusingly, this led to a conversation in which a boy asked whether 'FIFA '99' would be allowed since he believed there had not been a game named that, not realising that the annual series had in fact begun in 1994 (at least 7 years before he was born) – whilst missing the point that including 'FIFA' would be a larger problem than using ''99'

As already stated there was an oversaturation of gun-related games designed during the first session, something that is discussed in the next Chapter upon the decisions related to the choice of game genre. A collection of these storyboards from the first session are below:

Figure 12 – Storyboard samples from the first design session resulted in an overwhelming number of games featuring guns.

A quick period of evaluation directly after the creation of these storyboards led to a change in technique to the rest of the design sessions as mentioned previously in this chapter. The overabundance of games featuring guns in a situation where guns don't actually make any sense in the context of the games and their focus on recycling, was which led to additional warnings and discussion on the content of the game with regards to what is and is not appropriate for a game including children. In order to get the children to think about this in a little more detail, they were asked to indicate on their questionnaire answers whether or not any game mentioned within these answers was appropriate for their age group according to its PEGI (2013) rating which led to 0 First-Person-Shooter games being storyboarded within the second session. Due to the nature of the third session, the request about PEGI ratings was not added to the session – since it was thought that perhaps some of the Primary 4 children involved within the session would not completely understand what was being spoken about, which seems to have led to the inclusion of First-Person-Shooters within the third session.

3.3.3.2. Evaluation of Specific Storyboards

As stated earlier within this Chapter, the additional group storyboarding activity completed by the pupils participating within the second design session resulted in what was perceived to be higher quality storyboards featuring more interesting unique ideas than were perhaps portrayed within other storyboards. Throughout the entire process there were storyboards created which had concepts which could be taken and used within the final designed game but even though all of the main concepts and gameplay mechanics coming directly from the storyboarding activity – the largest portions of this come from the additional group storyboarding involving the single-sex teams.

The higher quality of these storyboards and the information provided on how the game works led to a more rigorous evaluation and analysis of the storyboards.

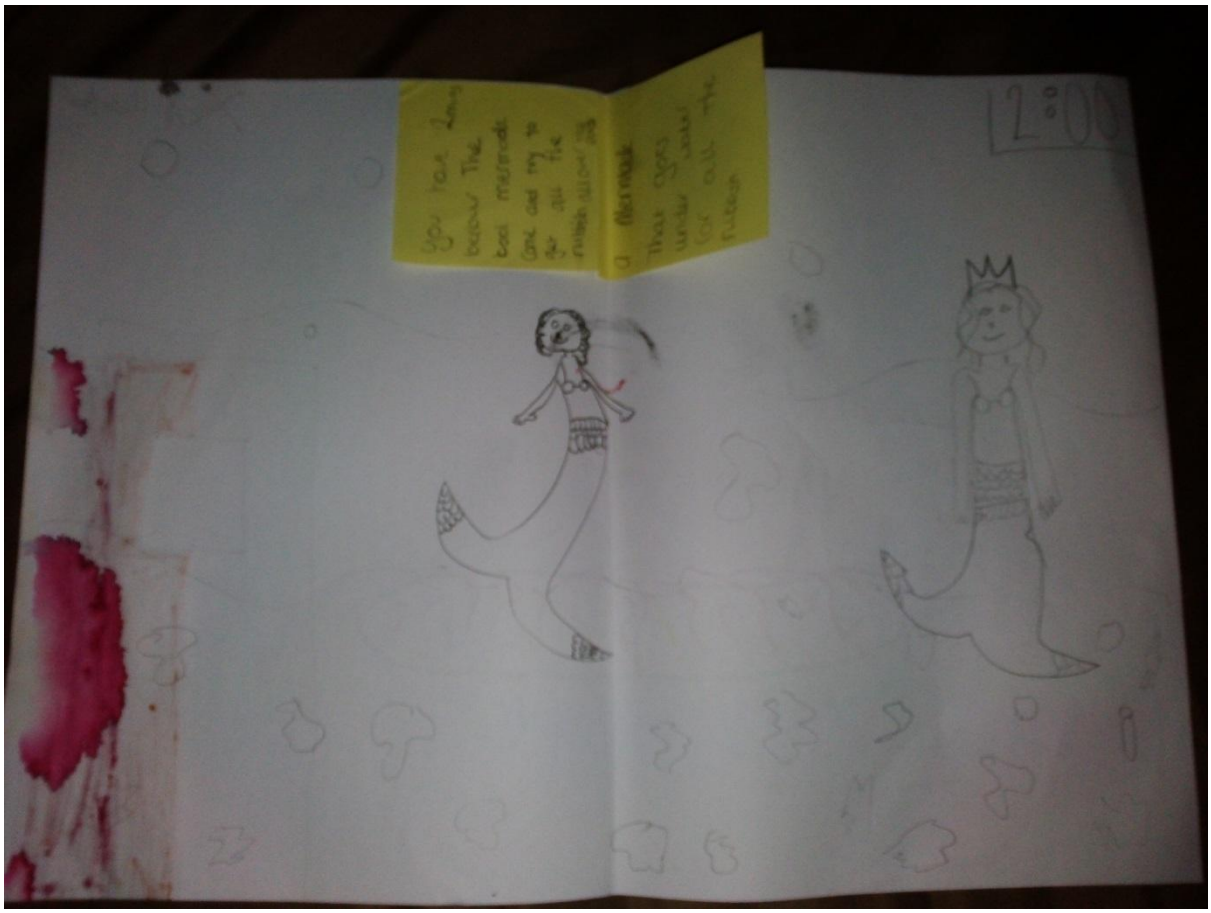


Figure 13 - The storyboard produced by the girls during the additional storyboarding task in the second design session

As described in the caption, the Figure above demonstrates one of the storyboards produced during the additional group storyboarding task allocated only during the second design session. This particular storyboard was created by 4 girls working together after first completing their own individual storyboard and an additional group storyboard featuring teams of 3 pupils featuring both sexes. Although other storyboarding sessions had featured heavy suggesting that before putting pen to paper the children take time to plan out what they

are going to draw – this was mandatory in this case because the groups were larger and if the time allocated to the storyboarding allowed for it there would likely be in-fighting if there was no organised planning time.

The objective of the game portrayed by the girls' storyboard was less about recycling and more about environmentalism, where the player played as a mermaid trying to clear refuse that had been dumped into the sea – a task which has to be done within the confines of a time limit or else another 'evil' mermaid would come and mess up the efforts completed by the player. Not only did this storyboard feature some sort of story behind it but it also included interpretable game mechanics which could be easily employed within a real game – and a general idea of what the user interface would resemble should the game be implemented.

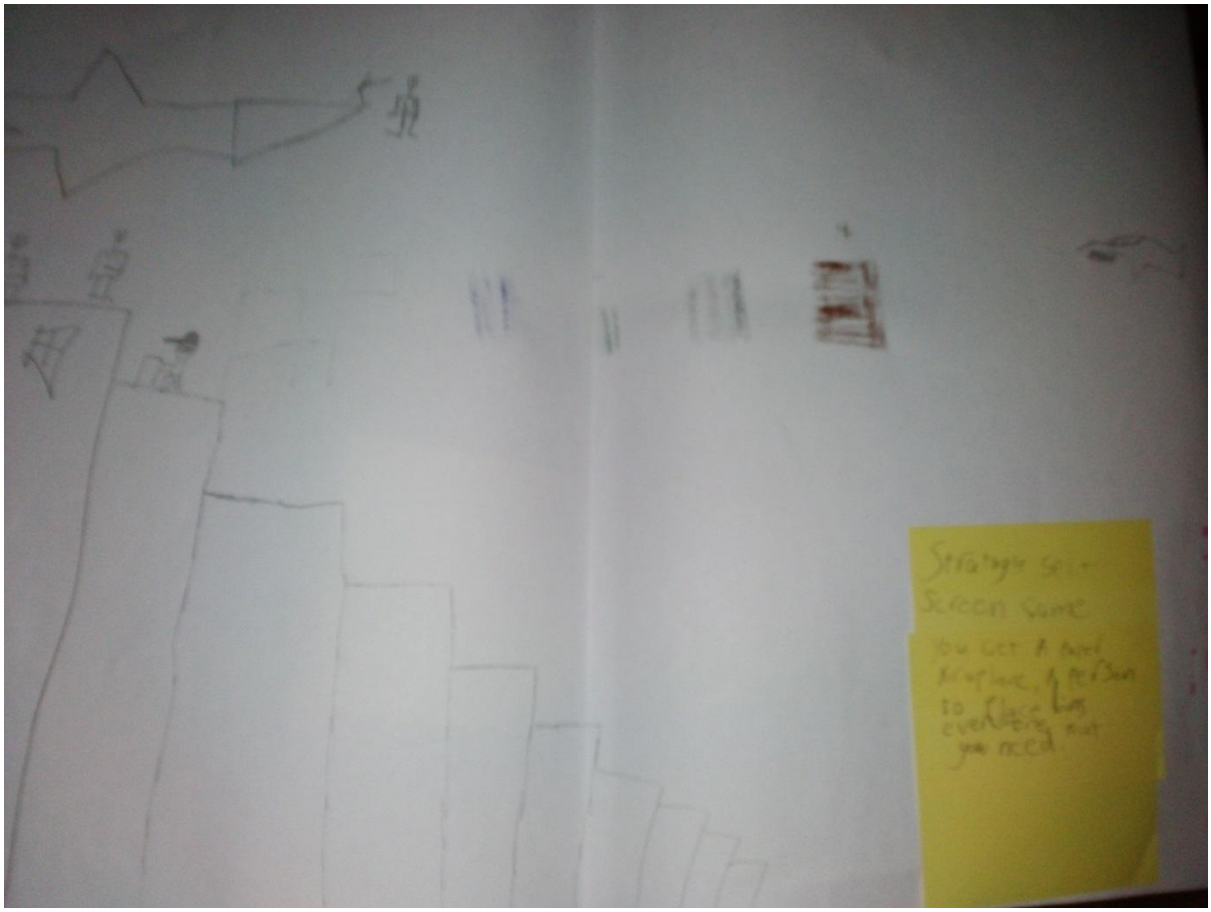


Figure 14 - The storyboard produced by the boys during the additional storyboarding task in the second design session

The Figure above demonstrates a storyboard created at the same time as the previously displayed storyboard, following all of the same rules that went into the creation of the previous storyboard but being created by the boys at the session instead. Although this storyboard is much harder to interpret just based on the image alone, this storyboard was described as featuring a paper aeroplane with refuse from out of it, whilst making the player place themselves correctly underneath in order to catch what is falling out of it. Like the

previous storyboard, the work done in this in terms of creating an interface and a background story went above and beyond the storyboards created at the various other points of the participatory design session.

In addition to the work previously mentioned, every storyboard was catalogued and the identified mechanics from it rated for their potential for use later within the development of the project. This formed a searchable catalogue providing the information required to analyse the various additional materials outside of the questionnaire.

3.4. Educational Content Delivery

The Participatory Design session served as a helpful tool in gaging how much the participants already knew about the chosen subject of recycling, and therefore served as a good indicator as to what should be included within the educational content of the gameplay and what should not be brought in for fears of over-complicating the learning process.

The information that was gathered regarding the pre-existing knowledge of recycling was collected in a similar manner as the information about favourite game genres and the like, with the information being gathered by first introducing an ice breaker in order to understand initially what knowledge of recycling the participants already had. A drawing of one of the universal signs of recycling was held up to the participants and they were asked to explain what they thought it meant, which ultimately led to the children present at the sessions explaining all of what they knew about the subject. Interestingly enough the amount of knowledge that the children had on the subject did not vary based on age, as the same information on recycling was gathered at all three participatory design sessions, the session including the Primary 6 children, the session including the Primary 7 children, and the session including a range of Primary 4 to Primary 6 children.

3.4.1. Participants Pre-Existing Knowledge of the Educational Content

Most, if not all of the children questioned within the sessions had the same limited amount of knowledge concerning recycling and general waste disposal. The knowledge that they already held was extremely localised, and dealt only in terms of the recycling programme already in place in the local area (Inverclyde Council's scheme), although there was some awareness of environmentalism and the damage done to the environment in cases where recycling does not happen or the wrong type of waste is dealt with in the wrong manner.

The basic facts collected from the children across all of the sessions held at the school were as follows:

- Paper, plastic, cardboard, and aluminium cans are recyclable and can be placed in the 'blue bins'.
- Leafs, grass, dead plants, and other garden waste are 'recyclable' and can be placed in the 'brown bins'.
- Uneaten or spoilt food can be placed in the small food waste 'green bins'.

- General waste that does not fit into any of the above categories should be placed in the 'black bins' (or 'grey bins' depending on their interpretation of the colour of their own bin).
- Waste that is thrown on the ground or into the water, instead of in bins can be harmful to the environment
- An understanding of the slogan 'Keep Britain Tidy'

All in all, the children were quite familiar with the local recycling scheme but were not entirely familiar with the extent of objects which could be recycled; for instance they were not aware that polystyrene was not an appropriate thing to place in the recycling bin, and they were mostly under the impression that glass bottles could not be recycled (meaning that they were unfamiliar with the concept of a bottle bank).

3.4.2. EDUCATIONAL CONTENT TO BE INCLUDED WITHIN THE GAME

Based on the knowledge already familiar to the users, and some additional knowledge that could conceivably be included within a game about recycling the following learning objectives will apply to the game:

Table 3 - The educational content to be shown in game and the justification for its inclusion

Educational Content	Justification
Basic contents of black, blue, green, and brown bins	Reinforcing the lessons that are already known by the player
The damage done to the environment by inappropriate disposal of refuse	Partial reinforcement for some, new information for others. This information is not all that complicated and can even be implemented by direct mapping.
Detailed recycling: When and when not the same type of item (i.e. sweet wrappers) can be recycled	New information, but fairly basic
Recycling outside of the home bins	The participants did not show any awareness regarding the types of recycling that can be done outside of the home, such as using bottle banks or battery bins. This should be included since it is an important aspect in the basics of recycling, and is currently one of the only basic concepts unknown to any of the participants within the design session.
What happens to refuse which is not recycled? Or refuse which is incorrectly dealt with?	The participants did not show any awareness regarding this information either. Learning that most refuse is just placed in land-fill could encourage recycling, or at least teach of its importance.

3.5. IDENTIFIED FUNCTIONAL REQUIREMENTS

Both the literature review and the participatory design contributed heavily in identifying the functional requirements of the game. The principal requirements established over the course of the problem analysis were:

1. The game must accommodate the learning outcomes
2. The game must feature a selection of the mechanics defined or outlined by the co-design process
3. The game must not rely on excessive text
4. The game should reach above the bottom rungs of Bloom's Taxonomy
5. There must be a balance between the gameplay and the educational content

The first functional objective is quite important to the overall project since the application being developed is a learning game, and will be tested on its effectiveness at delivering the content and an enjoyable experience. As discussed within the Background and the Literature Review, all serious games have an additional purpose outside of just exposing the players to the gameplay and story of the game – and in learning games the objective is to deliver educational content. The educational content due to be delivered was analysed in the previous section based on what was learned from the participatory design session and gaps in knowledge that could be filled by the project's delivery of educational content.

The most crucial requirement from this game – given that it is to be a Co-Designed game - is that it in some way reflects the work generated from the Co-Design session. Although this seems easy to say, it required the analysis of the storyboards as described in the previous section.

One of the biggest findings within the Literature Review concerning the failings of other similar games is that they often featured an over-reliance on text

4. DESIGN AND IMPLEMENTATION

This section of the report will present the design and implementation of the game created as part of this investigation, focussing upon the choices made by the author and developer in the development of the learning game.

4.1. FINALISING THE GAME DESIGN

The participatory design sessions had been instrumental in the creation of the game design. Since the game was intended to be a Co-Design session, it was intended that most if not all of the contents of the game would have originally been designed within the context of the participatory design sessions

4.1.1. GAME GENRE

Since the game to be designed has a target audience of children, there were obviously some game genres that were almost completely out of the question before even developing the materials to be used within the participatory design sessions detailed above. Unfortunately despite the inappropriateness of developing certain game genres for children and the potential ethical and psychological implications (see the supposed findings of Gentile & Anderson, 2006; and Sherry, 2007), the results generated from the participatory design sessions (see Chapter 3.3) seemed to push for the development of a game that was completely inappropriate in terms of genre, as explained in the next sub-section:

4.1.1.1. Inappropriate Game Genres for Children and Young Adolescents

Generally speaking there is no officially recognised list of game genres although there have been studies into some of the more established genres (Apperley, 2006). The most recognised game genres according to game information website GameFAQs (2013) are detailed below, with an explanation as to whether or not these games could be deemed inappropriate either for the target audience or for the purposes of developing an educational game focussing upon recycling.

4.1.1.1.1. Action

Action games are generally structured in the same manner as action films in that they often have some form of violent content within them – although this does not necessarily have to include intense violence or anything more dramatic than what could be seen on children's television. Action is a very wide genre including multiple sub-genres generally recognised as being massive genres in their own right such as:

- Fighting games
- Platform games
- First Person Shooters
- Third Person Shooters

Fighting games contain high levels of violence but the violence tends to be non-bloody. Generally however games like this are rated by the Pan European Game Information board (2013) as being only appropriate for children over the age of twelve, and the average

age of participants within the participatory design was eleven which is also the age average of the target audience.

Platform games can contain slight violence, but usually nothing worthy of restricting sales to any age group. Platform games are some of the most commonly used games within children games

4.1.1.1.2. Action-Adventure

Action-adventure games are generally recognised as being a combination between action and adventure games. These games often take a format which would not feel out of place within a typical action game, but generally shift away from the actual action of a game, examples include 'Stealth Games' and 'Survival Horror' which put the player in an action environment whilst restricting the ammunition or combat abilities available to the player meaning that they have to seek out alternative methods of play than they would within their game.

4.1.1.1.3. Driving

Although there is no real source of inappropriateness within these type of games (unless for instance a game was to include realistic crashes or the mowing down of pedestrians), there are probably very few if no possible ways to integrate teaching about recycling within a driving game.

4.1.1.1.4. Role-Playing

Like action games, Role-Playing games can be very mixed in terms of appropriateness, some of the most inappropriate pornographic Japanese games are considered to be RPGs, but there are of course many more mild examples. The main problem with using RPGs in this context is that generally RPGs are incredibly large projects and require detailed mathematical information to create character statistics. This could be very difficult to implement within the context of a game teaching about recycling.

4.2.1.1.5. Simulation

In general simulations do not contain inappropriate material, since they are designed to be realistic representations of real-life things.

4.12.1.1.6. Sports

Like Driving games, there is probably no real way of integrating Sports games into an educational game concerning the teaching of recycling.

4.1.1.1.7. Strategy

Strategy games generally involve larger scale control than would depict inappropriate content. For instance, although a war strategy game may include the option to perform a nuclear strike on a rival player, the violent content shown within the game will generally be restricted to a mushroom cloud indicating the location of strike and indicating some of the damage done. Some combat sequences may involve a dynamic camera zooming into troops

briefly fighting, but even in the most detailed of these games it is generally not much worse than the levels of violence found within children's cartoons.

4.1.1.2. Results of Genre Preference from Participatory Design

As already described in a previous section of this chapter, the Participatory Design sessions began with a short informal questionnaire, although due to technical problems the actual questionnaire sheets shown in Appendix B were not able to be deployed – again see the appropriate section above.

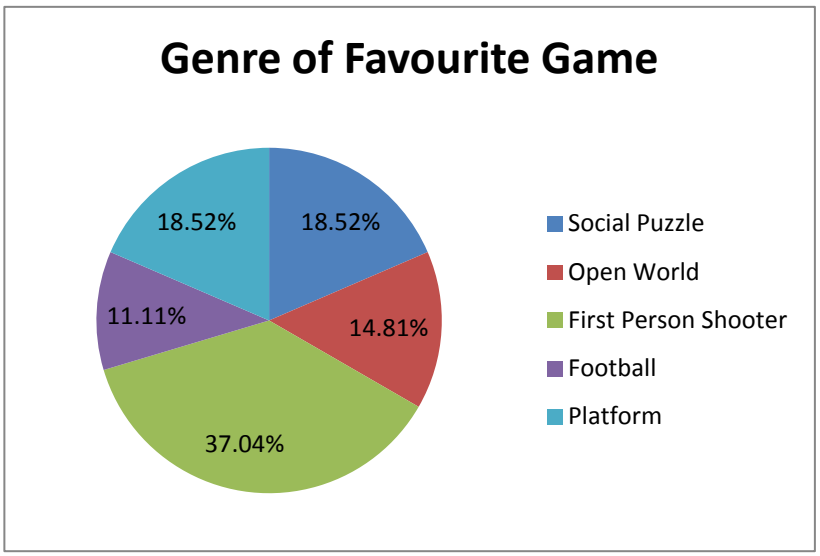


Figure 15 - A pie chart depicting the Favourite Game's Genre of the participants within the Participatory Design Sessions

Before the implementation of the Participatory session there were some genuine fears from many people associated with this project that there would be children participating within the project who would be unfamiliar with games according to typical stereotypes – for instance that there would be a lack of interest in games from girls, and a heavy bias towards violent games with boys, although the actual sessions carried out only included a single individual (a girl in Primary 6) who was not interested in the subject matter. The worry that the favourite genre of some children was inappropriate, unfortunately, turned out to be correct.

Of the children asked as part of the Participatory Design Sessions, 37% of the children involved with the process identified their favourite games as being in the 'First Person Shooter' (FPS) genre. All of the pupils who identified an FPS game as being their favourite were boys (making up approximately , and all were specifically talking about a game within Activision's *Call of Duty* series, particularly *Modern Warfare 2* (2009), *Modern Warfare 3* (2011), and *Black Ops II* (2012). The earliest of these titles has generated a lot of controversy due to the incredibly violent 'No Russian' level, allowing players to

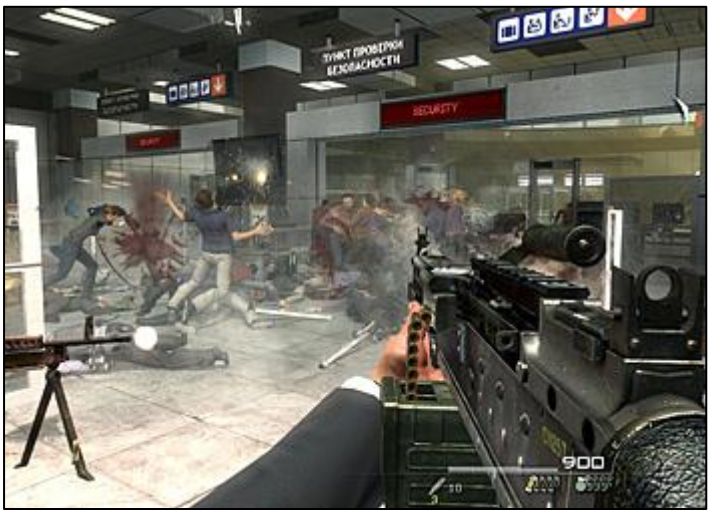


Figure 16 - Call of Duty: Modern Warfare 2 (2009)

gun down innocent civilians in a fictional Russian Airport (although the player need not shoot a single innocent), and this is obviously not the type of genre that should be implemented within a game designed for children no older than eleven years old.

One of the second most popular game genres gathered from the survey was the 'Platforming' genre, although this genre term was applied rather loosely when identifying the type of genre of the specified games during the design session. Eighty percent of the participants who preferred platform games were girls, although the group as a whole did not seem to find the prospect of a platforming game all that exciting – as none of the storyboards generated from the design sessions reflected anything similar to a very traditional platforming game such as *Super Mario Bros.* (1985). If there had been a clear preference for the creation of a platforming game, there would be no issue concerning what is appropriate for children under the age of twelve to be playing.

The joint second most popular identified genre was 'Social Puzzle', a semi-broad term used to identify puzzle and word games which had a social element, such as most of the games on Facebook or a large number of games available on mobile platforms. Based on the findings of Hanson (2011) it was expected that this genre would have been the most popular of the genres by far since it is highly likely that most of the exposure to games that the children happen to experience comes from mobile and Facebook gaming – since this is likely to be the type of exposure that their parents have to gaming. In terms of levels of appropriateness this was likely the most popular game genre based on an exclusion of First Person Shooters, and when participants were asked to discuss with their partners to find games that that they had both played, it was generally social games that were found to be in common. Whilst the creation of a 'Social Puzzle' game does seem like a good idea from the offset, there is the problem with the social aspect. Facebook is perhaps the biggest platform for social puzzle gaming, and even games released on Android or iOS which feature social interaction with other players often do this through Facebook – the problem being that Facebook's Terms & Conditions do not allow children under the age of thirteen to sign up for the site in-line with child protection laws in the United States. These laws protect children by restricting what they can say in games where children can sign up and interact with one another such as *Club Penguin* (2005), sometimes this is done by only allowing the selection of words and phrases from a pre-defined dictionary or sometimes through the implementation of heavy moderation of the players conversation; but the participants within the Participatory Design session said that they found the restriction on conversation of *Club Penguin* made the game much more unappealing than it first appeared. The information gathered from the Co-Design session did not clarify whether or not the majority of the players enjoyed the games for their social side or whether or not they just enjoyed the puzzle gameplay.

The fourth most popular genre identified was 'Open World' (alternatively 'Sandbox') although the games featured within this genre were limited to just two, *Minecraft* (2009) and *Grand Theft Auto IV* (2008), both quite different aesthetically and in terms of gameplay. Unfortunately despite the interest of the participants with this genre, this type of project scale is unsuitable for the time constraints of the project.

The last identified favourite genre of the participants was sports-games, in particular football games. Only one game was identified; *FIFA 13*(2012) which although being age-appropriate is unfortunately not something that can really be connected to recycling and made appealing to both boys and girls. There is also the difficulty of dealing with any sort of football game since any of the recognisable elements from football, excluding the standardised rules, are copyrighted and unavailable for use.

4.1.1.3. Compromising: Preference and Appropriateness

As already stated the most important part of Co-Design is ensuring that the actual desires of the participants involved within the design sessions are implemented in some way, rather than relying upon pre-established ideas of what the participants would like through the use of a HCI-evaluation tool such as Personas; the use of which would likely have led to the identification of a platforming game as being the most popular genre for children within the age group participating within the design process. Therefore it was important to take as much away as possible from the information gathered during the Participatory Design sessions despite the inherent inappropriateness and the unethical implications of the development of a First Person Shooter game for a group consisting mainly of ten-year-old children.

Looking at the literal genres identified within the survey, it becomes apparent that none of the genres can really be justifiably used as-is. Three of the five identified genres within the survey of favourite game genres definitely fell into the larger more generic genre of 'Action', and both of the 'Open World' identified games partially fall into this generic genre as well. Due to the findings of the survey it seemed appropriate to somehow incorporate the game within this genre whilst still maintaining a work suitable for children. Each of the main identified genres were taken and considered based on appropriateness, whilst also considering how this could be implemented within a game designed for children without violating the fact that the game is in fact built for children as according to the standards set out by the standardised age ratings systems of ESRB and PEGI, genres with considered appropriateness issues were considered further for possible compromise:

Table 4 - The results of the genre questionnaire and how they could be implemented through compromise.

Genre	Appropriateness	Compromise
First Person Shooter	First Person Shooters are not at all appropriate for children. At the present time, there are currently only 3 commercially released FPS games which are deemed appropriate for children under the age of 10 (Common Sense Media, 2013). Not only is the typical content shown within an FPS game inappropriate (featuring blood, swearing, and maiming), but the behaviour developed whilst playing these types of games online is generally negative – since the age of communication allows people with racist, homophobic, and sexist views, to speak unhindered whilst playing these games and use such terms as insults to other players.	Despite the fact that the content seen within these games is inappropriate, children really enjoy the mechanics of 'shooting'. It may be appropriate to have some form of representation of this genre as a small section of the educational game. The action element should be implemented since it stands out as a favourite across multiple genres.
Social Puzzle	The only real problem with Social Puzzles is the actual social aspect of it. Children under the age of 13 are prevented from talking freely on the Internet in the USA without expressed parental permission in order to serve as protection against paedophiles and bullies.	Omitting the social aspect or allowing a localised only social aspect with strict controls over who can have access to the social element could work. The puzzle genre expands far beyond pre-set puzzles, and crosses over with action in time-management games, which serves as an ideal platform for the educational content and the game itself.

4.1.1.4. Conclusion

The genre of the game should ideally be a mixture of action and puzzle. The action aspect of the games comes from the most frequently enjoyed game genre already expressed through the questionnaires at the participatory design session, but the action itself has been toned down in order to provide something that requires the player to remain on his/her toes whilst not actively being aggressive to other people or characters within the game.

Since Social Puzzles were deemed to be so appropriate, the main elements of social puzzles in the form of time management have been extracted in order to create a game genre that functions as an action-based time-management game.

4.1.2. GAME PLATFORM

The majority of the work done to decide the most appropriate platform for the final game was completed within the Literature Review chapter of this report, particularly within Chapter 2.3 and thus the actual participatory design session had very little influence over the selected development platform.

As previously identified, the game should be developed as a browser game in order to be as compatible with as many platforms as possible whilst also managing to be completed in a reasonable timescale. In order to accommodate multiple operating systems and browsers, a suitable tool for creation and publication of the game had to be found, and several different solutions were considered; including Flash, HMTL 5, and Unity 3D. During the appropriate section of the literature review, it was established that Unity 3D be chosen over other alternatives for the following reasons:

- Browser-based applications possible
- Application-based, multi-platform games possible in cases where browser based may not work
- Previous experience working with Unity and C#
- Total cost of production: £0.00
- Total cost of distribution: £0.00

Upon visiting the school during the Participatory Design session, the discussion held specifically within Chapter 2.3.2 on the hardware limitations of the school was found to be mostly true; however full testing of the theories on hardware and software limitations was not possible due to time limitations during the Participatory Design and the lack of an appropriate prototype to test whether or not the Unity engine would be fully compatible with all of the school's hardware and software.

4.1.3. GAME AESTHETIC

As game consoles have become more and more advanced, the graphical fidelity of games has increasingly reached higher and higher qualities and the expectations of the average player has followed this – with graphical quality being a deciding factor in many game reviews on the Internet and the opinions of many people who play said games. Despite this however, console-gaming has declined in market-share, and despite being worth the majority of the money spent on gaming, no longer has the majority of 'sales' in gaming – a privilege held by mobile gaming on the Android and iOS platforms, which has led to a two-tiered system when appealing to the audience aesthetically:

- Mainstream high-fidelity, high-quality, high-cost, three-dimensional graphics developed by professional modellers for console and PC gaming
- Cartoon-y two-dimensional or basic three-dimensional developed by artists or non-artists for mobile and browser-based gaming

The majority opinion of those who identified 'First Person Shooters' as their favourite game genre stated during the Participatory Design session that part of the reason why they enjoyed playing these games was because of the realistic nature of the graphics within the games, though only a small proportion of those who said that they enjoyed the graphics of the First Person Shooters said that they disliked games were the graphics were of a lower quality – especially on a mobile-based or web-based game.

Around 92% of the participants within the Participatory Design sessions regularly played some sort of mobile game, and 100% had played browser-based games due to an initiative within the school involving semi-educational browser games (which were played for recreational purposes rather than educational purposes). Since the chosen development suite and deployment platform is browser-based, the graphics of the game need not be of a particularly high quality and are expected to look less *Call of Duty* and more *Subway Surfers* (2012), a game that all of the participants who had played mobile games had played before.

Figure 17 - The stark contrast between Call of Duty: Modern Warfare 3 (2012) and Subway Surfers (2012)

Since the game is not a commercial venture, the artwork and models included within the game are not as consistent and high-quality as would be expected in a commercial game, however this is in part due to the short development timescale. As a result of the lack of a dedicated artist in use during the product's development cycle, some of the graphical resources used within the game were not especially created for the game, with recycled resources from other projects implemented within the final product – something that was done so that development would not be slowed in cases where models needed were too complicated to be created by inexperienced modellers.

Since the Participatory Design was such a massive part of the project, it seemed appropriate that like the general game concept and gameplay mechanics; the general aesthetics be heavily based upon the works of the participants. And thus the style of art presented within the game should be fairly simplistic, possibly even looking as though it could have easily been completed by a child. This style is beneficial for development time, since it reduces the amount of time required to be spent on the development of graphical resources.

4.1.4. GAMEPLAY MECHANICS

The heart of any game is the mechanics used when playing the game, since it is this which determines how the game plays more than the sound, graphics, or any other aspect of the game. It is of course possible to make a game which excels in other aspects and still have a successful game, but even in popular sports games which are realised year-after-year in near-identical condition (with an updated player roster) are sometimes criticised by their incredibly loyal fans for not being anything different from their previous incarnations.

This section of the report will look at the gameplay mechanics designed based upon the storyboarding sessions held earlier. There were no concepts introduced that could not be traced back to the storyboarding aspect of the process, meaning that the design of the game was a successful example of Co-Design. Some alterations were required in order to make the mechanics work with the rest of the world, with the engine, and be realistically programmable by a single-person-team within a very restricted time period; however despite all of this, the Co-Design led directly to the creation of the game mechanics finally implemented within the game.

4.1.4.1. Consolidating Storyboards

Based upon the information gathered within the participatory design sessions, and the evaluation done on the storyboards gathered within those sessions alongside the information gathered from the questionnaires and the conclusions that came from the problem analysis section of this report – enough information was gathered in order to implement a basic mockup of a storyboard attempting to merge several of the best ideas generated by the children during the participatory design sessions:

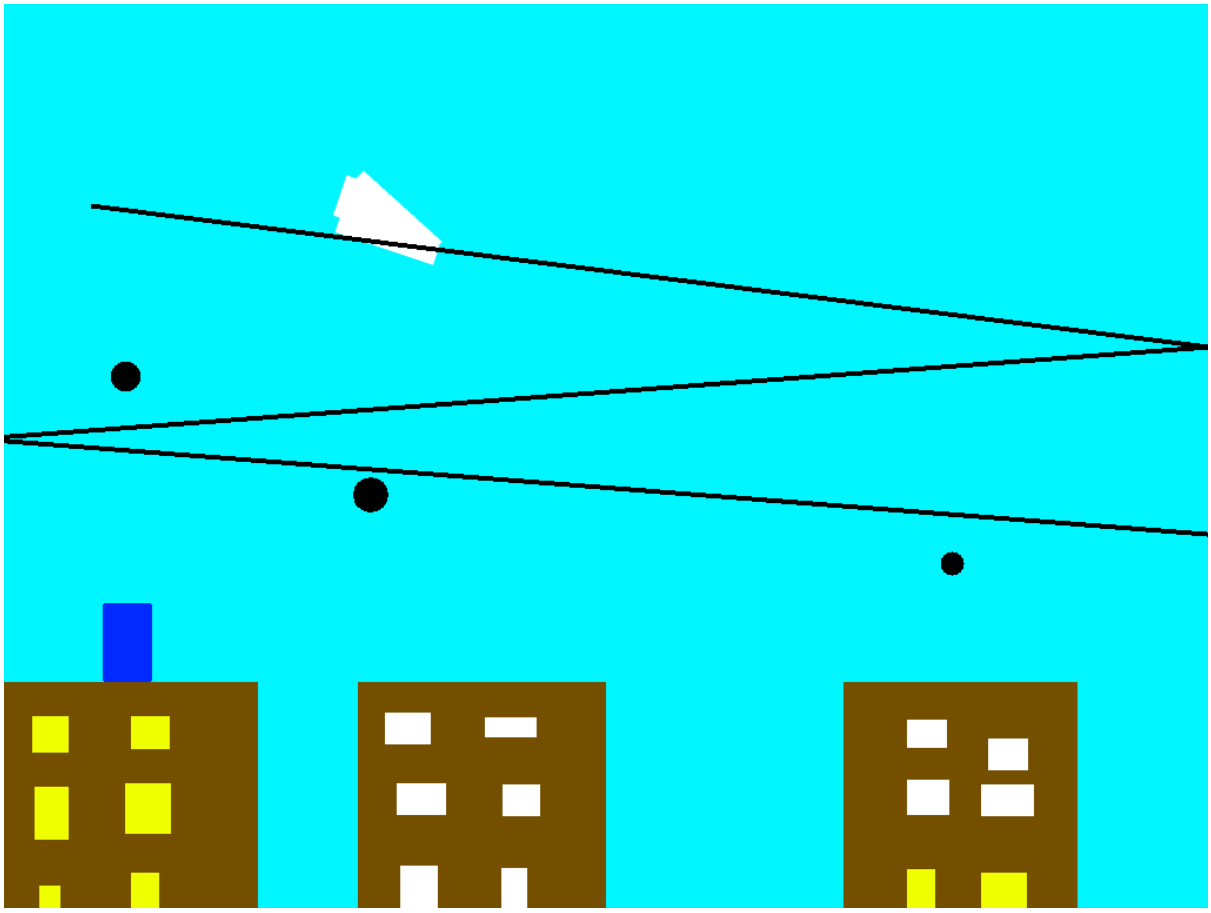


Figure 18 - A simple storyboard bringing toghether the various project requirements and the work done by the children.

The storyboard generated based on the works of the children itself was not all that advanced but the game designed based on this work is a fairly simple concept described below.

4.1.4.2. The Paper Aeroplane

The Paper Aeroplane, represented in the Figure on the previous page by a white triangle, is one of the most directly lifted concepts taken from the storyboarding sessions of the participatory design sessions. The storyboard from which this concept arose is visible in Figure 14 in Chapter 3.3.3.2 as it served as one of the higher quality storyboards produced during the storyboarding section of the participatory design sessions. The simplicity of the mechanic and its almost incoherent mapping to the game (why is there a paper aeroplane floating in the sky above buildings?) is really from the aesthetic borrowed from the participants within the Co-Design session, a *very* recent article published one day before the due date of this project by Gamasutra (Rose, 2013) explains that one of the things that makes designing for children so different from designing for adults is that children do not like it when everything makes perfect sense and is all perfectly explained, children like to come up with their own theories and back stories regarding unexplained things within games and are seen to genuinely engage more when they have that opportunity to provide their creative

input into an explanation . The Paper Aeroplane was considered one of the most popular concepts during the process of the participatory design session in which it was showcased by its creators.

In terms of actual gameplay, the paper aeroplane actually serves as the instigator of the game's action with the player's participation with the game being a reaction in accordance with what the paper aeroplane does. The fact that the aeroplane itself is made out of paper serves as an additional point in reinforcing the games message of recycling since the aeroplane was originally intended to be flown into a recycling bin towards the end of the level in order to change the gameplay slightly from the rest of the level and to really put the message across – unfortunately due to time constraints this was a mechanic that couldn't be implemented in time.

The Paper Aeroplane (henceforth PA) floats down the screen, indicated within the above storyboard by the black zigzagging line making its way down the screen, from left to right, in a similar way to a real PA – all the while dropping various types of refuse from the back of it by instantiating prefabs of GameObjects built in Unity to resemble various different types of refuse.

4.1.4.2. Falling Refuse

The other main component in what the player needs to react to is also the main driving force of the educational content within the game. Of all of the learning outcomes, the most basic of them all is establishing what kind of refuse goes in which kind of recycling bin or if it required 'outside recycling' by going to a recycling centre.

Like the previous mechanic, most of the inspiration from this mechanic came from the additional storyboarding session held within the second participatory design session, but was also inspired by the sheer number of storyboards that involved the 'throwing around' of various different types of refuse into bins featured within the storyboarding activities. This was a rather commonly held idea by the participants of the storyboarding session, and although the original concepts only featured the refuse falling from the sky infrequently, the main mechanic involving refuse being thrown around was overwhelmingly supported by the participants of the design sessions.

On the created storyboard, the falling refuse is represented by the black circles which as already stated are falling from their Instantiation point within the PA after being randomly generated. Each of these pieces of refuse has their own properties defining the type of refuse, the method it should be dealt with, and the aesthetic of it. This aspect of the game is actually outside of the player's control however it is the single biggest influencer within the player's actions.

4.1.4.3. Elevators and Buildings

The player's main aspect of control occurs in the mechanics surrounding the buildings featured within the previous storyboard and represented by the brown squares towards the bottom of the storyboarding screen. One of the underdeveloped ideas generated during the first storyboarding session but overwhelmingly supported by the peers of the designer who showered the idea with praise was the idea of being able to control two distinct movable

characters at the same time allowing for either a single player or multiplayer experience based on the preference of the player and whether or not they have someone else to play with.

The player is required to move these buildings using the appropriate keys to allow them to line up with the falling refuse, with the bins on top of the buildings being responsible for collecting the falling refuse. The control scheme was thought up independently twice during the design sessions, with only the outer buildings being controllable, requiring the user to 'push' the middle building by using the other two buildings.

4.1.4.4. Bin Control

The controlling of the bins was the most significant player controlled aspect within the game and is represented by the dark blue rounded rectangle on the storyboard on the previous page.

The idea of the bins is that they are kept within the building and need to be sent up to the roof to catch the refuse falling from the sky. This takes a certain period of time indicated by the lights within the building (see yellow/white rectangles), with the lights all being lit the bin will arrive on the roof ready to collect some rubbish. If the bin is then sent back down, another one can be sent back in its place.

Each building has an attached interface which allows the player to cycle through the bins before sending one of them up to the top of the building to collect refuse. This interface can then be employed again in order to send the bin back down to get another bin instead.

This element was implemented as a reaction to the falling refuse, since the player would need some way to react. Nothing similar was suggested during the storyboarding sessions, as most solutions would have just involved shooting down the refuse with a collection of guns – which would perhaps not have been all that effective in executing the learning outcomes of the game.

4.1.4.5. The Shifting Environment

One of the gameplay elements not displayed within the storyboard featured in the previous section is the effect that the player's failure has on the environment. When first seeing the background of the storyboard, there seems to be a lot of unused space which ends up looking out of place – but this is just the case when the game begins without the player having made any mistakes.

Environmentalism is one of the topics directly connected to recycling that became attached to the learning objectives of the game thanks to the direct connection of the consequences of throwing the wrong type of rubbish in the wrong type of bin – since recyclable materials which are thrown in a bin for general waste do not go through the sorting process and just become part of the landfill. There were multiple storyboards generated through the participatory design session which had slogans about keeping the environment clean attached to them, but there wasn't any real understanding about what this meant, with the general consensus of the participants being that litter that is thrown on the ground makes a mess and is unpleasant to look at – rather than the more serious effects of adding to unneeded land fill. One or two storyboards had built-in consequences or gameplay mechanics surrounding the way in which landfill is becoming overcrowded.

In order to portray the learning objective concerning the damage done by incorrectly dealing with waste, a direct mapping was implemented within the game. Basically the mistakes made by the player contribute to a landfill which gradually grows in size until it towers over the buildings under the player's control and blocks out the sky – leading to a Game Over.

It is especially hoped that the learning outcome directly connected to this mechanic is learned since the mapping involved within the learning outcome is so direct – mistakes in real life contribute to larger landfills, and mistakes in the game lead to larger landfills (which just so happen to block out the sun).

4.2. IMPLEMENTATION OF THE GAME

4.2.1. THE PAPER AEROPLANE

The Paper Aeroplane has multiple scripts associated with it and attached as components in the Unity interface involving the GameObject representing the PA. Firstly there is the issue of movement, handled through the script 'PlaneMovement.cs' which is responsible for moving the PA on the X-axis. The additional movement on the PA is caused by Unity's built-in 'Rigidbody' component by applying gravity to the GameObject whilst it is in the scene, allowing for movement within the Y-axis to be done automatically in accordance with some basic physics calculations. The 'Rigidbody' component also allowed for movement in the Z-axis to be locked in place since the game itself functions in a sort of 2.5D space – including 3D objects but only having the X and Y axes influenced within the world.

The movement of the PA is just a method of increasing the difficulty to the main gameplay mechanic involving the PA – since it is within the PA that the refuse falling from the sky is created. This refuse has its own properties and methods so the details of the refuse will be covered in the next section.

The refuse that falls from the PA is randomly generated from information gathered from a prefab containing a template piece of refuse. Unity works on a frame timescale so the calculation as to whether or not a piece of refuse is created happens approximately 60 times a second assuming that the player is using a reasonable computer; it happens less frequently on less powerful computers – but this means that players still have the same amount of reaction time since slower computers will also handle the players actions more slowly as well. Every frame the script 'RefuseTosser.cs' checks whether or not there has been a sufficient gap between checking for the last time on whether or not create a new piece of rubbish, and if there has been enough time a random number is generated to see whether or not the opportunity should be used to generate a new piece of rubbish. If the approval is given by the code in the form of an IF statement checking if the number generated is the correct one, then another random number is generated to check which prefab of refuse should be generated. As you can see from a view in Scene-view, this means that the trash generated by the PA (in this example represented by cubes and spheres) comes out at random intervals in a random order. These prefabs are also affected by their own gravity and fall independently of the PA.

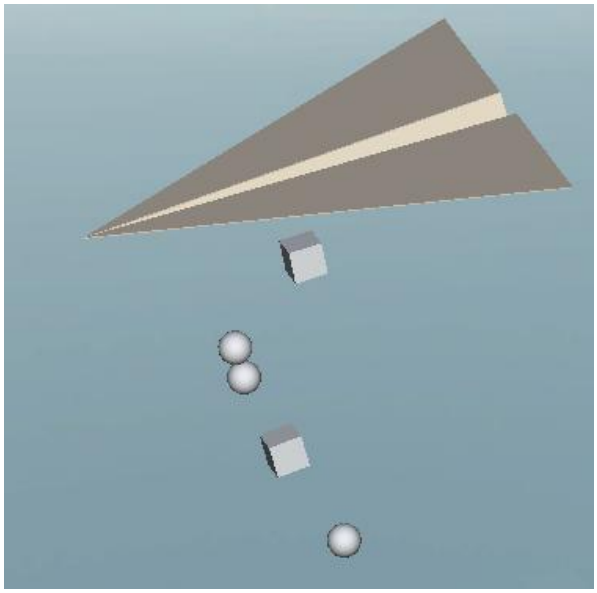


Figure 19 - Scene view of Instantiation of Rubbish in-game

The PA ultimately dictates when the level is over, assuming the player does not face the 'Game Over' screen, as when it reaches the end of its journey by falling below a certain point of the level, the next level begins.

4.2.2. FALLING REFUSE

The refuse being generated from the PA does not stop being generated until a Boolean variable is set to false to indicate to stop, so there is the potential to generate thousands of pieces of refuse within a single game. In order to prevent slow-downs caused by thousands of instantiated prefabs, an 'invisible' (really just off-camera) boundary was created in Unity out of elongated cubes to form a sort of picture frame expanded outside of the range of the camera, with the script 'Destruction.cs'.

In addition to this, each instantiation of the refuse had properties containing its name and type – and every piece was tagged with an in-game tag denoting which bin it should be placed in during normal gameplay. The coding for handling the reaction to any collisions done on the behalf of the refuse is all contained within the refuse, with refuse that hits the incorrect bin, as determined by this code triggering a certain condition.

```
void OnCollisionEnter(Collision collision)
    {
        string collisionTag = collision.gameObject.tag.ToString();

        if (Potential)
        {
            if (tag.Substring(0, 4) == collisionTag.Substring(0, 4) &&
!collisionTag.Contains("Refuse"))
            {
                Answer(CorrectAnswer);
                Potential = false;
                Destroy(this.gameObject);
            }
            else if (collisionTag.Contains("Refuse"))
            { }
            else
            {
                Answer(WrongAnswer);
                Potential = false;
            }
        }
    }
```

Using gameObject.tag, the collision is able to check the tags on both the piece of refuse and the object it collided with, before checking whether or not the colliding object has any way to interact with the collided object. For instance, a gameObject tagged 'greyRefuse' would react to a 'greyBin' with a method calling for a correct answer, on the other hand if both objects happen to be tagged with the 'refuse' property then nothing will happen since the fact that they are colliding is entirely coincidental and should not have a reaction. If the gameObject collides with anything else, such as the boundaries or an incorrect coloured bin, then the wrong answer condition is met.

In cases where models of the refuse were not entirely clear, a feature was introduced to allow for a mouse hovering over the refuse being given additional information by an

unobtrusive GUILabel which would also show the international recycling symbol for items which would be considered ambiguous otherwise (such as the fact that some sweet wrappers cannot be recycled whilst others can).

4.2.3. ELEVATORS AND BUILDINGS

The buildings, as described in the design section of this chapter, can be controlled through the use of keys on the keyboard: the left-most building being controlled with 'A' and 'D', and the right-most building being controlled with 'Left' and 'Right'.

```
if (Input.GetKey(KeyCode.A) && Building == BuildingEnum.Left)
{
    rigidbody.AddForce(new Vector3(-speed, 0, 0), ForceMode.VelocityChange);
}
```

The buildings also had an additional physics material attached to them in order to remain 'bouncy', meaning that their collision would not result in the two objects merging forever and being unable to be separated.

As for the windows on the buildings, these serve as an indicator as to how long ti will take for the activated bin to reach the roof. This is done by having an additional lighting layer only applied to the window panes, and having them light up yellow sequentially as an indication as to how close the bin is to the roof – although since the bin is instantiated this is just for the player's benefit and for the visual side of things.

4.2.4. BIN CONTROL

One of the most important aspects about the bin control is that it actually served as 3 interfaces at the same time, with each of the buildings requiring a GUI interface in order to allow for the deployment of bins.

Through the use of the following line of code:

```
ScreenPosition = mainCamera.WorldToScreenPoint(go.transform.position);
```

The bin interfaces were able to be mapped directly onto the building by taking ScreenPosition as a reference point to the centre of the gameObject. This interface allowed for the bins to be scrolled through with the use of a left and right button and a simple array, before being able to deploy the bins by sending the upwards and illuminating the elevator lights already discussed, while really just Instantiating a clone of a bin prefab to collect some of the refuse falling from the sky.

4.2.5. THE SHIFTING ENVIRONMENT

The shifting environment was perhaps one of the easiest elements to implement within the game and was directly connected to the Game Over condition. Upon the collision with a piece of refuse with the ground boundaries, an event is triggered raising a textured plane slowly upwards towards the sky, the texture on the plane depicts a refuse tip, and the

texturemapping allows for transparency to make the tip appear integrated into the game despite being a background image.

When the image reaches a certain point on the Y-axis, the game is triggered as having reached the 'Game Over' state and loads the appropriate Game Over scene, allowing the player to return back to the main menu.

5. EVALUATION

This section will provide information on the evaluation methods which were employed during the project in order to evaluate and gain a possible answer to the research question. The methods employed, and the findings gathered will be presented and discussed in relation to the project's aims.

5.1. EDUCATIONAL EVALUATION

As was originally proposed within the project proposal part of the evaluation of the educational element was to come from a basic test sat by the participants upon the conclusion of playing the game. It was originally intended that a group of children who had been exposed to the game would be tested separately from a group of children who had learned the same content through a more didactic method.

Unfortunately there was no real way to test this out in a completely unbiased manner as there were too many factors to consider in the arrangement of a lecture pertaining to the same content intended to be delivered through the educational aspects of the co-designed game; the quality of the lecture would be directly affected not only by the quality of the lecture material but also by the individual delivering the lecture – who in this case would be untrained and inexperienced. An alternative to the delivery of a lecture by an inexperienced individual would have been employing an experienced teacher to deliver the material, but this would have required much closer cooperation with educational professionals as the teacher themselves would have to be fairly familiar with the lecturing material rather than just being expected to deliver a high quality lecture based on materials provided by the same inexperienced person who would have conducted the biased lecture. Directly comparing the test results of the children in the four different categories available (participatory designer player, non-participatory designer player, participatory designer non-player, non-participatory designer non-player) would have served as an interesting comparison had the above been possible.

5.1.1. METHOD

The educational content of the game was evaluated in a less detailed manner whilst still allowing for comparison of the results of those who contributed to the participatory design session and those who did not. Since the lack of appropriate lecturing materials made the inclusion of non-players impossible (as they would have no way to gain access to the learning materials without actually researching it themselves – something that a 10-year-old child is incredibly unlikely to do) an alternative method of comparison was required.

The method employed instead focussed upon a 'before' and 'after' comparison of the knowledge of the evaluators, who were asked to briefly play the game for around 10 minutes. Before and after the children were given a test on their knowledge of recycling connected to the learning outcomes of the game detailed in Chapter 4. This was done in a rather simplistic attempt to see if the children had immediately learned anything – based on whether or not they changed their answers – as a result of the game itself. The children were given no

information regarding how well they did on either of the quizzes, something that was done due to the anxiety suffered by some of the participants about how well they had completed the tests, and the order and wording of the questions featured within the quizzes were slightly different whilst still seeking the same information from the participants. The children were aware that the same content was being asked of them in both quizzes but the slight differences employed within the two quizzes were implemented in order to attempt to prevent the children from memorising their answers from the first quiz and just writing them verbatim within the second quiz.

The two quizzes were issued to the pupils alternatively based on seating so that no children sitting beside each other would be able to copy their neighbour. The quiz issued after the short play session was the opposite quiz from the one they had already received.

Participation within the quiz was again voluntary, and like the other evaluation task, was comprised of 10 participants, with 4 of those participants having already been involved within the participatory design sessions. There were no incentives employed in order to have the children participate within this session, and the entire process lasted a lot shorter than the design sessions which occurred earlier on in the project.

5.1.2. RESULTS

The results generated from the children's participation in the first and second quizzes showed promising results in determining whether or not the game had been successful in teaching the learning outcomes set out in Chapter 4.

Almost every single pupil that participated within the quizzes was seen to have an increased test score based on the marking scheme seen within Appendix F, with 90% of the participants having an improved test score after a 10 minute play session. One of the pupils who participated within the evaluation session scored lower on the second test.

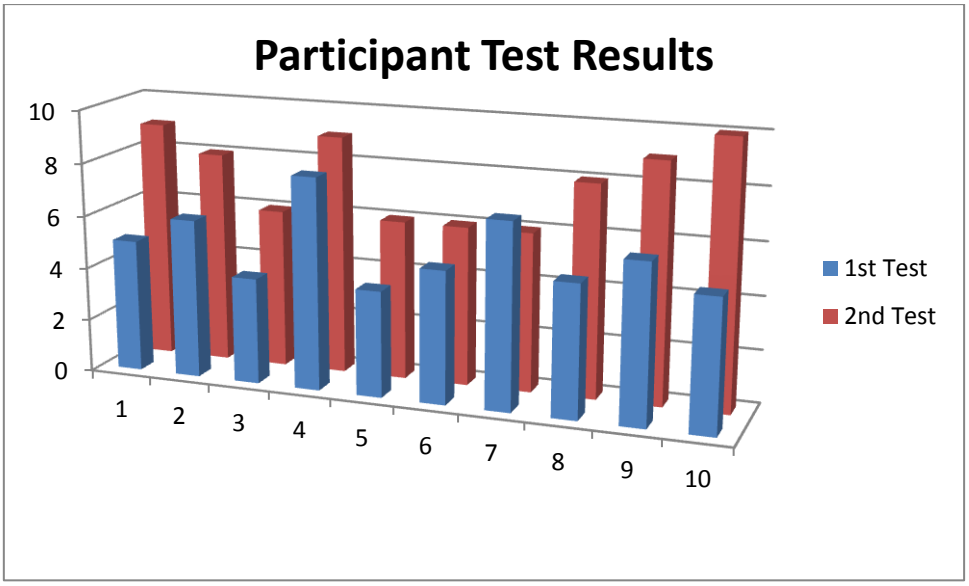


Figure 20 - A comparison between Participant Test Results

The low number of participants makes it quite difficult to obtain results which may be of any statistical significance, however the fact that the percentage of participants scoring higher on their second attempt after having been shown the material suggests that the material may have had something to do with the increase in test scores – hopefully meaning that the software was suitable in its purpose by increasing the knowledge of the participants.

On the other hand the fact that there were two different quizzes implemented implies that the knowledge of the subject had improved (at least in the short term) and that the content of the tests did not have an influence on the participants and remained at around the same difficulty. In the chart above, the first five participants took 'Test 1' first, and the last five took 'Test 2' first, and the average score among participants rose from '5.5' in the first test to '7.7' in the second test.

5.2. EMOTION BASED EVALUATION

Part of the evaluation considered the effectiveness of the learning games created during the Co-Design process versus the effectiveness of games created without the use of a Co-Design process. Part of Prensky's (2001) theory on game-based learning and indeed the theory of many psychologists is that learning is more effective if the method of learning is considered engaging by the user. One method of measuring engagement is through the use of the measurement of emotion as suggested by Bradley and Lang (1994) who, coupled with TRUE (2013) developed the Self-Assessment Manakin (SAM) seen overleaf.

By measuring emotion using we can have some sort of understanding as to how engaging the user finds a particular thing – whether it be music (as commonly used by TRUE) or applications. For this reason, some non-Co-Designed Learning Games were chosen for purposes of comparison at random from the Noble Prize Website (2013).

5.2.1. METHOD

Implementing the evaluation using SAM was much easier than the evaluation involving the educational content, since no additional materials had to be created in order to implement the SAM-based-evaluation. Each participant of the evaluation (the same 10 as participated within the previous evaluation), and were randomly assigned whether or not they would play the co-designed game first or a game developed on the Noble Prize Website, with the other game following later.

The games on the Noble Prize Website certainly contain a good source of educational content, being created by professors; however they lack the use of Co-Design within the design process. Therefore after playing the game, the children were asked to complete the SAM process based on their thoughts of the game, having the words associated with the different aspects explained to them but also being reminded of the graphical nature of this evaluation method and following the pictures if they are uncertain.

The following games were used by the participants in the SAM-evaluation:

- 'ECG' – a medicine based game
- 'MRI' – a medicine based game
- 'Namesearch' – a game based on the noble prize for literature
- 'Red Cross' – a game based on the Red Cross foundation
- 'Insulin' – a medicine based game
- 'Laser' – a physics based game

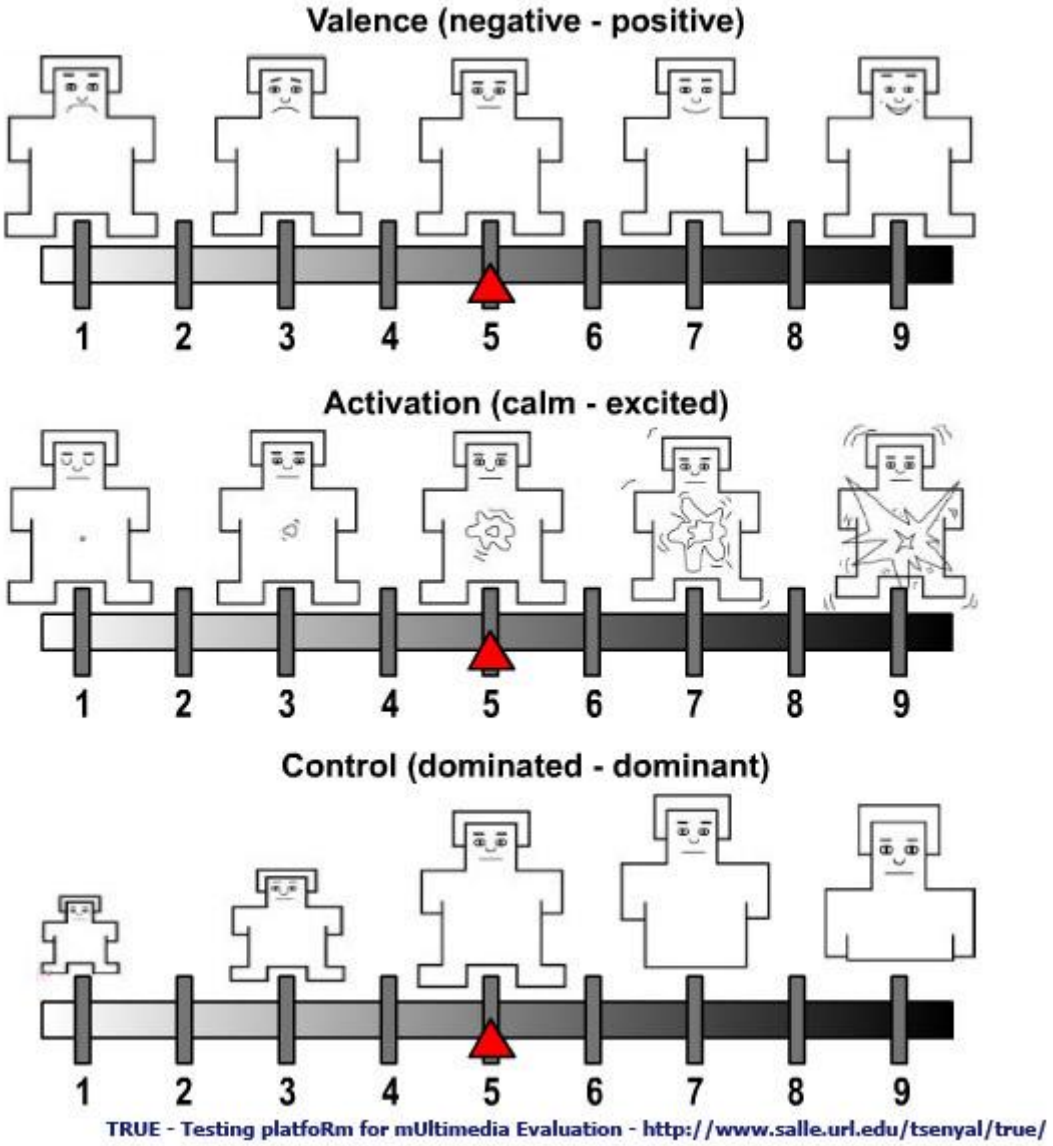


Figure 21 - Self-Assessment Mannakin used within the evaluation process (Bradley and Lang, 1994)

5.3.2. RESULTS

Due to the Co-Designed nature of the developed application it was initially expected that the game would be given high marks across all three components of the SAM test, however it was unknown how the Noble Prize Games would do.

Surprisingly there was little difference in the results given between the participants who had been involved within the participatory design session and those who had not, implying that the Co-Designed nature of the game had been successful in not only being engaging with those who had a hand in designing the game, but also those who had only seen anything resembling it on the first day on which they arrived for the evaluation process.

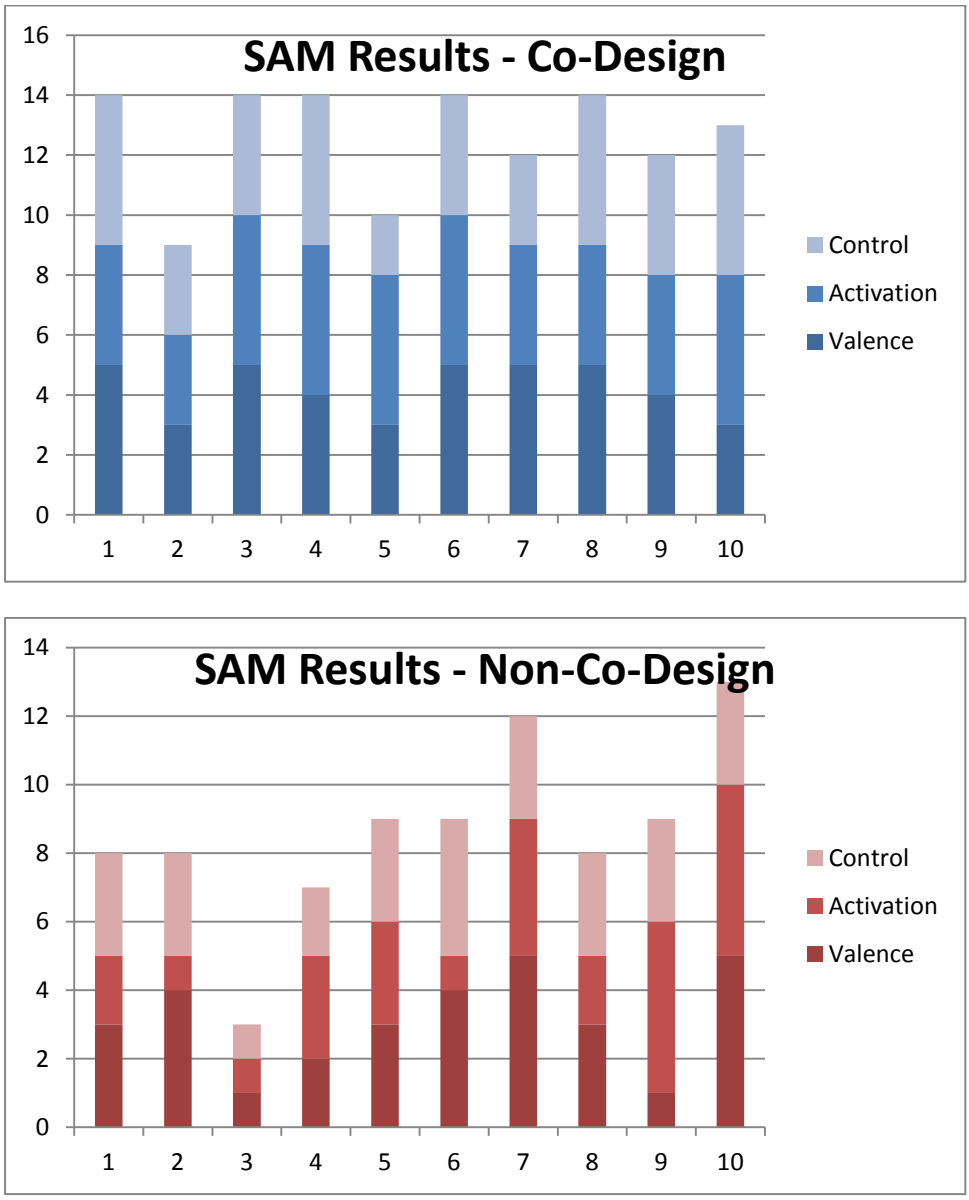


Figure 22 - The results generated from the SAM evaluation

As you can see from the graphs above, the results of the SAM evaluation are generally higher in the upper graph involving the use of Co-Design rather than omitting Co-

Design from the design of the game. This implies that the children who had been exposed to both a Noble Prize Game and the Co-Designed game were more engaged with the Co-Designed game and had enjoyed the experience more.

The problem with these results is that they are on such a small scale, other non-Co-Design games would likely need to be investigated in order to provide a more convincing result.

6. DISCUSSIONS AND CONCLUSIONS

This section of the report contains the final discussions and conclusions of the overall project. A brief résumé of the project will be presented in order to allow re-familiarisation with the project before discussing what the results generated from the evaluation could mean.

This section will also look at some of the limitations imposed on the project and where future work could go in the topic.

6.1. PROJECT RESUME

In recent years pupils have become less and less engaged with the teaching methods currently employed by their teachers in school (Prucell *et al.*, 2012), and these didactic teaching methods have begun to be believed to be outdated even by educational professionals (Esteve, 2000). New teaching methods in the form of using games as teaching tools and learning aids has become an increasingly more researched possibility in recent years (Prensky, 2001) and these have been found to be quite effective in teaching children new information.

Co-Design is a method of design employed as a more comprehensive version of user-centred-design, however educational games and Co-Design have not had much crossover, and the effectiveness of the design method employed traditionally without the user, and those involving the user has not been explored. A literature review was undertaken to investigate the methods required for conducting Co-Design and developing an application involving the processes in an attempt to see if the following research question could be answered:

To what extent is a learning-based computer game, for children of senior Primary School age and co-designed by the target audience, a suitable tool for teaching about a subject when compared to a traditional teaching game?

Based upon this research question, the project's purpose was to evaluate the effectiveness of a co-designed learning by comparing it to another learning game that had not gone through the co-design process, but also by measuring whether or not it is effective in eliciting a positive reaction out of the players. This was completed through a Develop and Test project, creating a game and evaluating it with a small group of users. This game was developed by following the design recommendations established from a number of participatory design sessions and from the initial research done as part of a literature review. Based on this information, a simple paper prototype was created in order to provide guidance for an implemented game. Upon the implementation of this game, an educational-based evaluation was carried out alongside a more traditional HCI-based evaluation involving the users.

6.2. Final Discussion of Results

This section will provide a final discussion of the results gathered both from the Co-Design sessions implemented in order to retrieve design-based information and to establish the game design, and the evaluations carried out on that application to test out the research question.

6.2.1. Of the Co-Design Sessions

The participatory design sessions were certainly a useful tool in establishing the games design and also provided some interesting ideas demonstrating very well that the reliance on other HCI-tools such as Personas can only go so far.

There were multiple times during the participatory design session where the children present demonstrated that they were capable of coming up with creative solutions even with a minimal amount of information to go on. There were instances were children did outright plagiarise from their favourite games but the type of imaginative contribution found particularly within children who are pre-high-school age showed that sometimes the plagiarism can lead to alternative interpretations of ways in which things could have been implemented instead.

Although the specially created resources to be used within the questionnaire section of the Co-Design were not able to be used, this method of quickly and efficiently gathering some background information about the participants interests in games was genuinely quite effective since it took a minimal amount of time. Choosing to ask the question "What is your favourite game?" as opposed to "What is your favourite game genre?" potentially saved time, confusion, and prevented leading (see Chapter 4.1.1.2). During this questionnaire there was a discussion section to be implemented with the 'neighbours' of each participant, and the lack of formal questionnaire papers may have actually been beneficial to this discussion since, by reading out the questions and asking the children to write their answer down rather than fill out a pre-printed questionnaire, the children were all at the same stage as each other during the questionnaire preventing the situation where children would be left waiting for their neighbour before starting a discussion or discussing whilst their neighbour was still writing – something that the boy-girl seating plan was implemented to prevent.

The use of a preliminary storyboard was found to be quite effective in encouraging children to come up with several ideas before focussing on a single more comprehensive idea. A common problem witnessed at GameJams and other situations were games have to be created quickly is that the first semi-plausible idea generated by a game developer will be focussed upon whether or not it is a good idea or not. Allowing for the children to create a first storyboard on their own allowed for them to get into the designing mindset – and since there was no rule preventing them from carrying over their ideas to the real group storyboarding exercise then it also allowed for them to look critically at their own creation and make a decision as to whether or not it was worth discussing with a group to submit/work on their ideas as part of the group storyboarding activity.

The improvised additional storyboarding activity carried out with the second group of participants within their testing session, encouraging larger team sizes and increasing the

likelihood of using friend-pairs within the group storyboards was also very successful in that there was a marked improvement in the storyboards produced.

Overall the process was very, very successful. A large number of potential ideas were created, with the correct mappings applied meaning that the techniques used to carry out the Co-Design process were a success

6.2.2. Of the Created Application Evaluations

There were two separate evaluations carried out upon the application, and each were used to ascertain the effectiveness of Co-Designed Learning Games, with one of the evaluations being used to check whether or not a Co-Designed Learning Game was more engaging to a user than a non-Co-Designed Learning game.

6.2.2.1. Educational Evaluation

The first evaluation carried out was the educational evaluation involving the participants being tested on their knowledge on the learning outcomes of the learning game before playing and then again after playing. The results of this evaluation seemed to overwhelmingly confirm that the game created as part of this project had achieved its goal of becoming a Co-Designed Learning Game in that it was possible to teach children the learning outcomes by simply playing through the game, whilst still avoiding the reasons for failure often used in learning games in order to get the 'learning' part out of the way such as an overreliance on the use of text.

In relation to the original research question which drove the project, the game was found to be effective in delivering its content, however this was not what the actual research question was looking for. Despite that, had the results of this evaluation returned back negative then there would not have been any way in which the game could be considered to be 'effective' as a learning game. It would have been possible to provide a more enjoyable experience than another typical learning game but this would not mean that the game served as more effective – therefore this result served as half a confirmation that the game created was more effective than a traditional learning game.

6.2.2.2. Emotion Based Evaluation

The second evaluation carried out measured the engagement of the users by having them participate in a SAM-based evaluation. The results of this evaluation implied that the game created through Co-Design methods was more engaging than games created without using this process. Several games were tested against the Co-Designed game and in most cases the Co-Designed game scored higher on each scale of the SAM-based-evaluation.

In relation to the original research question which drove the project, the game was found to be more engaging than the non-Co-Designed games; which coupled with the fact that the game was successful in teaching its learning objectives implies that the Co-Designed Learning Game was more effective than Traditional Teaching Games, since not only did it teach the material but it kept the pupils engaged.

Further testing of this research question would be required before anything fully conclusive could be spoken about this subject since there were a lot of variables involved

within the quality of the teaching of both games and the overall design of each game – and it may only be that the research question was proven because of the games which it was compared to.

6.3. Project Limitations and Future Work

Whilst the results of this project proved to be supportive of the authors hypotheses there are factors which may have imposed limitations on the research and its associated results, as already discussed in the previous section the project was on too small a scale to prove that anything found to be true within the context of the games compared would be found true outside of these games, although with the comparison of multiple games involved within the process – there is a chance that the results may have some validity.

In order to fully determine the answer to the research question, further work would need to be carried out by expert evaluators in order to determine whether these results would apply to different games with the same Co-Design/Non-Co-Design properties to see if there is a difference. In addition to this, it would be beneficial to generating a result if the game created during this project was tested with a game from a company other than the Noble Prize website since there games may just be poor examples of unengaging learning games rather than averagely engaging learning games.

Furthermore, investigation should be done using another recycling game to see if having two games with the same theme effects the results in any noticeable way.

The Co-Design method used within this project could also stand to be polished and made more efficient, something that would happen naturally if performed again – since the actual sessions did become more structured as more were carried out.

With so many variables involved within the evaluation, the results of the evaluation can in no way be interpreted as fact for the reasons already discussed, and a provision of additional resources, time, and further Co-Design sessions would need to be carried out in order to produce higher quality and more accurate research in this area

6.4. Conclusion

This project was undertaken to investigate the extent to which a Co-Designed game is more suitable as an educational tool than a non-Co-Designed game. Evaluation of the actual knowledge developed by the children during the playing of the game and their engagement whilst playing the game versus a non-Co-Designed games engagement to provide an answer as to whether or not Co-Designed learning games were more engaging than non-Co-Designed games and thus better at providing educational content.

The project began with the undertaking of a literature review into the various details surrounding Co-Design and the process of creating a Co-Designed game.

In the problems and systems analysis section of the report, a set of participatory design sessions were carried out in order to create a Co-Designed game and identify what the functional requirements of such a game would be.

Overall the participatory design sessions conducted as part of this project served very well in the creation of a Co-Designed Learning Game however the evaluation methods

carried out in order to evaluate whether this type of game was more efficient at teaching new knowledge to children was not insufficient and as such further research would need to be conducted in order to discover the answer to the research question.

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APPENDIX A: LETTER ISSUED TO PARENTS CONCERNING DATA PROTECTION

Cowcaddens Road
Glasgow
G4 0BA

14th March 2013

Dear Parent/Guardian,

Thank you for allowing your child to participate in this experiment and survey. This letter is just a reminder to say that any information collected from your child will be kept confidential and anonymous in any publication of the results of this survey in line with the Data Protection Act (1998).

If, for any reason, you or your child do not wish to have the information gathered from the child to be used within this project or would like any additional information about the project, please email me at *cmcger10@caledonian.ac.uk* with the subject line 'XX XXXXX Primary School – Participatory Design' and I will respond to it as quickly as I can.

Thank you for your cooperation,

Batman
BSc (Hons) Computer Games (Design)
School of Engineering and the Built Environment
Glasgow Caledonian University

APPENDIX B: DESIGN SESSION QUESTIONNAIRE

Name		Primary		Gender	
Currently I own or have access to the following games consoles (tick all that apply):					
PC		PlayStation 3		Xbox 360	
Wii		Wii U		Nintendo DS	
Nintendo 3DS		PSP		PSVITA	
Android Phone		iPhone / iPad		PlayStation 2	
Gameboy Advance		GameCube		Xbox	
The most recent game I played was: _____					
My favourite game to play is: _____					
A game I've played in common with my neighbour is: _____					

APPENDIX C: RAW STATISTICAL DATA FROM DESIGN SESSION

Name	Sex	Most Recent	Genre	Platform	Favourite	In Common	Genre	Platform	Age
Demi	F	Candy Crush Saga	Social Puzzle	Facebook	Y	Minecraft	Open World	PC	6
Josh	M	Minecraft	Open World	PC	Y	Dino Jump	Platform	Mobile	6
Megan	F	Red Nose Day	Social Puzzle	Mobile	N	Minecraft	Open World	PC	6
Connor	M	Call of Duty: Black Ops II	First Person Shooter	Console	Y	Call of Duty: Black Ops II	First Person Shooter	Console	6
Adam	M	FIFA '13	Football	Console	Y	Subway Surfers	Platform	Mobile	7
Cara	F	Four Pictures One Word	Social Puzzle	Mobile	Y	Subway Surfers	Platform	Mobile	6
Erin	F	FIFA '13	Football	Console	N	Subway Surfers	Platform	Mobile	6
John	M	FIFA '13	Football	Console	Y	Subway Surfers	Platform	Mobile	6
Beth	F	Candy Crush Saga	Social Puzzle	Facebook	Y	Subway Surfers	Platform	Mobile	6
Ross	M	Call of Duty: Black Ops II	First Person Shooter	Console	Y	Minecraft	Open World	PC	6
Chloe	F	Subway Surfers	Platform	Mobile	Y	Temple Run	Platform	Mobile	7
Brooke	F	Subway Surfers	Platform	Mobile	Y	Call of Duty: Black Ops II	First Person Shooter	Console	7
Naythan	M	Call of Duty: Black Ops II	First Person Shooter	Console	N	Call of Duty: Black Ops II	First Person Shooter	Console	7
Cory	F	N-Ball	Platform	PC	Y	N-Ball	Platform	PC	7
Jack	M	Call of Duty: Black Ops II	First Person Shooter	Console	Y	N-Ball	Platform	PC	7
Liam	M	Call of Duty: Modern Warfare 2	First Person Shooter	Console	Y	N-Ball	Platform	PC	7

Name	Sex	Most Recent	Genre	Platform	Favourite	In Common	Genre	Platform	Age
Lucy	F	Grand Theft Auto IV	Open World	Console	Y	Temple Run	Platform	Mobile	7
Lewis	M	Call of Duty: Black Ops II	First Person Shooter	Console	Y	Temple Run	Platform	Mobile	7
Brandon	M	Minecraft	Open World	PC	Y	Call of Duty: Black Ops II	First Person Shooter	Console	7
Mary	F	Hello Kitty and Friends	Platform	Mobile	Y	Temple Run	Platform	Mobile	4
Aidan	M	FIFA '13	Football	Mobile	Y	Call of Duty: Black Ops II	First Person Shooter	Console	4
Keir	M	Call of Duty: Black Ops II	First Person Shooter	Console	N	Call of Duty: Black Ops II	First Person Shooter	Console	5
Jai	M	Call of Duty: Black Ops II	First Person Shooter	Console	Y	N-Ball	Platform	PC	5
James D	M	Call of Duty: Modern Warfare 3	First Person Shooter	Console	Y	N-Ball	Platform	PC	6
James M	M	Call of Duty: Modern Warfare 2	First Person Shooter	Console	Y	N-Ball	Platform	PC	6
Samantha	F	Candy Crush Saga	Social Puzzle	Mobile	Y	Temple Run	Platform	Mobile	6
Jordan	M	Minecraft	Open World	PC	Y	Temple Run	Platform	Mobile	6

APPENDIX D: EDUCATIONAL EVALUATION QUIZ VERSION 1

Name:	**Primary**:	**Previous**: YES / NO
1. Which bin should an old school jotter be placed in?		
Black	Brown	Blue	Green
2. How can we tell if a piece of rubbish can be recycled in the blue bin?		
3. Which bin should glass bottles, that can't be taken back to the shop, be put in?		
Black	Blue	Bottle Bank	Brown
4. Name three things which should be put in the black bin.		
1. 2. 3.		
5. Where do the Council put our rubbish from the black bin?		
In a hole	In the water	They burn it
6. Leaves should be put in which bin?		
Blue	Green	Brown	Black
7. Last year we put our leftover spoilt food in the black bin, where do we put it now?		
Blue bin	Brown Bin	Green Bin
8. Name three things which can be recycled at special recycling centres		
1. 2. 3.		

APPENDIX E: CODE LISTING

```
using UnityEngine;
using System.Collections;

public class Destruction : MonoBehaviour
{

    public GameObject RubbishPile; //used so that when the user makes a mistake, the
rubbish pile shifts up
    public float StartPoint; //Position of the rubbish pile at Start
    public float EndPoint = -20; //When to terminate the level

    // Use this for initialization
    void Start()
    {
        StartPoint = RubbishPile.transform.position.y;
    }

    // Update is called once per frame
    void Update()
    {
        if (RubbishPile.transform.position.y >= EndPoint)
        {
            Application.LoadLevel("GameOver");
        }

    }




    void OnCollisionEnter(Collision collision)
    {
        if (collision.gameObject.tag == "Building")
        {

        }
        else
        {
            Debug.Log(collision.gameObject.name + " hit " + this.name + " - it was
destroyed");

            Destroy(collision.gameObject, 0.1f);
            RubbishPile.transform.Translate(0, 10, 0, Space.World);
        }

    }
}
```

```
using UnityEngine;
using System.Collections;

public class MainMenuScript : MonoBehaviour
{


    public Rect MenuBox;

    public GUIStyle style;

    int middleScreenW;
    int middleScreenH;


    // Use this for initialization
    void Start()
    {
        middleScreenW = Screen.width / 2;
        middleScreenH = Screen.height / 2;
    }

    // Update is called once per frame
    void Update()
    {

    }

    void OnGUI()
    {

        // Make the first button. If it is pressed, Application.Loadlevel (1) will be
executed
        if (GUI.Button(new Rect(0.1562f * Screen.width, 0.2607f * Screen.height,
0.2763f * Screen.width, 0.1981f * Screen.height), "", style))
        //if(GUI.Button(new Rect(0, 0,  5, 5), "Start"))
        {
            Application.LoadLevel(1);
        }

        // Make the second button.
        if (GUI.Button(new Rect(0.4785f * Screen.width, 0.6518f * Screen.height,
0.2714f * Screen.width, 0.1942f * Screen.height), "", style))
        {
            Application.Quit();
        }

    }

}
```

```
using UnityEngine;
using System.Collections;

public class PlaneMovement : MonoBehaviour
{

    public float moveSpeed = 0.05f;
    public float curX;
    public float maxX = 18;
    public float minX = -18;

    // Use this for initialization
    void Start()
    {

    }

    // Update is called once per frame
    void Update()
    {

        curX = transform.position.x; //Public floats so it can be monitored

        transform.Translate(moveSpeed, 0, 0, Space.World);

        if (curX >= maxX && moveSpeed > 0)
        {
            moveSpeed = -(moveSpeed);
            transform.Rotate(0, -180, 0, Space.World);
        }

        if (curX <= minX && moveSpeed < 0)
        {
            moveSpeed = -(moveSpeed);
            transform.Rotate(0, 180, 0, Space.World);
        }
    }


}
```

```
using UnityEngine;
using System.Collections;

public class RefuseBehaviour : MonoBehaviour
{

    public string Name;
    public string Category;
    string tag;
    public Rigidbody WrongAnswer;
    public Rigidbody CorrectAnswer;
    Rigidbody NewAnswerVerdict;
    bool Potential = true;

    // Use this for initialization
    void Start()
    {
        tag = this.gameObject.tag.ToString();
    }

    void OnCollisionEnter(Collision collision)
    {
        string collisionTag = collision.gameObject.tag.ToString();

        if (Potential)
        {
            if (tag.Substring(0, 4) == collisionTag.Substring(0, 4) &&
!collisionTag.Contains("Refuse"))
            {
                Answer(CorrectAnswer);
                Potential = false;
                Destroy(this.gameObject);
            }
            else if (collisionTag.Contains("Refuse"))
            { }
            else
            {
                Answer(WrongAnswer);
                Potential = false;
            }
        }
    }

    void Answer(Rigidbody answer)
    {//-15
        NewAnswerVerdict = (Rigidbody)Instantiate(answer, transform.position, new
Quaternion(0, 0, 0, 0));
        NewAnswerVerdict.transform.Translate(new Vector3(0, 0, -15 -
NewAnswerVerdict.transform.position.z),Space.World);
        NewAnswerVerdict.AddForce(new Vector3(0, 0.7f, 0), ForceMode.Impulse);

    }

    // Update is called once per frame
    void Update()
    {

    }
}
```

```
using UnityEngine;
using System;
using System.Collections.Generic;

public class RefuseManagement : MonoBehaviour {

    public Dictionary<string, int> IncorrectAnswers = new Dictionary<string,int>();
    public Dictionary<string, int> CorrectAnswers = new Dictionary<string, int>();

       // Use this for initialization
       void Start () {

       }

    public void WrongAnswer(string answer)
    {
        if (IncorrectAnswers.ContainsKey(answer))
        {
            int temp;
            IncorrectAnswers.TryGetValue(answer, out temp);
            IncorrectAnswers.Remove(answer);
            IncorrectAnswers.Add(answer, temp + 1);
        }
        else
        {
            IncorrectAnswers.Add(answer, 1);
        }
    }

       // Update is called once per frame
       void Update () {

       }
}
```

```
using UnityEngine;
using System.Collections;
using System;

public class RefuseTosser : MonoBehaviour
{

    public Rigidbody Refuse1;
    public Rigidbody Refuse2;
    public Rigidbody Refuse3;
    public Rigidbody Refuse4;
    public Rigidbody Refuse5;
    public Rigidbody Refuse6;
    int numOfRigidbodys = 6;
    System.Random random = new System.Random();
    public int chanceOfGeneration = 5; // 1/Frequency chance per second of Instantiate
being caused
    public int framecount;
    public int frameCheck = 10; //How frequently should the chance to generate come
up?
    bool IsThrowing = true;
    Rigidbody RefuseClone;
    Rigidbody newRigi; //Used for creating the RefuseClone randomly

    // Use this for initialization
    void Start()
    {



    }

    public void ThrowSwitch()
    {
        IsThrowing = !(IsThrowing);
    }

    // Update is called once per frame
    void Update()
    {

        framecount++;
        if (IsThrowing)
        {
            if (framecount % frameCheck == 0)
            {
                int num = random.Next(0, chanceOfGeneration);

                if (num == 0)
                {
                    int num2 = random.Next(1, numOfRigidbodys);
                    switch (num2)
                    {
                        case 1:
                            newRigi = Refuse1;
                            break;
                        case 2:
                            newRigi = Refuse2;
                            break;
                        case 3:
```

```
                            newRigi = Refuse3;
                            break;
                        case 4:
                            newRigi = Refuse4;
                            break;
                        case 5:
                            newRigi = Refuse5;
                            break;
                        case 6:
                            newRigi = Refuse6;
                            break;
                        default:
                            break;
                    }
                    RefuseClone = (Rigidbody)Instantiate(newRigi, transform.position,
transform.rotation);
                }
            }

        }
    }
}
```

```
using UnityEngine;
using System.Collections;

public class SelfDestruct : MonoBehaviour
{

    // Use this for initialization
    void Start()
    {

        Destroy(this, 5);

    }
}

using UnityEngine;
using System.Collections;

public class BinSender : MonoBehaviour
{

    public Camera mainCamera;
    public Vector3 ScreenPosition;
    public float offsetX;
    public Texture2D greybin;
    public Texture2D greenbin;
    public Texture2D bluebin;
    public Texture2D brownbin;
    public int currentPick = 0;
    Texture2D[] bins;
    // Use this for initialization
    void Start()
    {

        GetScreenPosition(this.gameObject);
        bins = new Texture2D[] { greybin, greenbin, bluebin, brownbin };
    }

    void GetScreenPosition(GameObject go)
    {
        ScreenPosition = mainCamera.WorldToScreenPoint(go.transform.position);
    }

    // Update is called once per frame
    void Update()
    {

        GetScreenPosition(this.gameObject);

    }

    void OnGUI()
    {
        // GUI.Label(new Rect(ScreenPosition.x, Screen.height-ScreenPosition.y, 100,
100), "Try");
        //GUILayout.BeginArea(new Rect(ScreenPosition.x, Screen.height -
ScreenPosition.y, 256, 20));
```

```
        GUI.Box(new Rect(ScreenPosition.x-20, Screen.height-ScreenPosition.y-20, 40,
40), bins[currentPick]);



    }
}
```

```
using UnityEngine;
using System.Collections;

public class GameOverScreen : MonoBehaviour
{

    // Use this for initialization
    void Start()
    {

    }

    // Update is called once per frame
    void Update()
    {

    }

    void OnGUI()
    {
        float sw = Screen.width / 2;
        float sh = Screen.height / 2;

        if (GUI.Button(new Rect(sw / 2, sh / 2, sw, sh), "Return to menu"))
        {
            Application.LoadLevel(0);
        }

    }
}
```

```
using UnityEngine;
using System.Collections;

public class Mover : MonoBehaviour {

    public BuildingEnum Building = BuildingEnum.Left;
    public float speed = 7;

       // Use this for initialization
       void Start () {

       }

    void OnCollisionEnter(Collision collision)
    {

    }

       // Update is called once per frame
       void Update () {

        if (Input.GetKey(KeyCode.A) && Building == BuildingEnum.Left)
        {
            rigidbody.AddForce(new Vector3(-speed, 0, 0), ForceMode.VelocityChange);
        }

        if (Input.GetKey(KeyCode.D) && Building == BuildingEnum.Left)
        {
            rigidbody.AddForce(new Vector3(speed, 0, 0), ForceMode.VelocityChange);
        }

        if (Input.GetKey(KeyCode.RightArrow) && Building == BuildingEnum.Right)
        {
            rigidbody.AddForce(new Vector3(speed, 0, 0), ForceMode.VelocityChange);
        }
        if (Input.GetKey(KeyCode.LeftArrow) && Building == BuildingEnum.Right)
        {
            rigidbody.AddForce(new Vector3(-speed, 0, 0), ForceMode.VelocityChange);
        }
       }
}
```