# Sorting Factory:

# Designing a game for children in hospital

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# Abstract

Play is essential for growth and development for every child, but for those staying in hospital it can also help provide distraction, entertainment and support. Collaborative play allows adults to communicate with children freely and provides children with support in their play. The hospital environment poses many additional complexities when considering how play can be both safe and effective. Touchscreen devices are examples of technology that can be used to build games for children in hospital since they are both portable and versatile. Effective game design with a focus on accessibility can overcome some of these environmental challenges. This project presents a participatory design approach in which groups of children directly contributed designs and evaluation materials to the project. The results of the evaluation show that this game is usable and provides opportunity for meaningful collaborative play.

## Acknowledgements

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I would also like to thank the Scout Group and all children involved in the design and evaluation workshops for their very useful suggestions and amazing designs for the game.

Finally, to all my family and friends - thank you for the endless support and encouragement to complete this, without you all I'm sure this document would be a lot shorter.

## Declaration

I declare that this thesis was composed by myself, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or professional qualification except as specified.

(*Amy Rodger*)

# Contents

# Chapter 1

# Introduction

This project describes the design and implementation process for building a minigame addition to a large game suite. This suite has been created for children who are staying in hospital for treatment or recovering from injury or illness. For this reason, the game itself proposes interesting design requirements and dynamics that will be addressed in this report. The full development will be user-centered, using a participatory design approach to create game materials and gather ideas. This report will document this process, noting where this lies within current research and literature and evaluating the outcomes outlined below.

## Project aims

The aims of this project are outlined below and are shown here as a framework for evaluation.

- The game will follow the design framework discussed in Chapter 5, and make extensive use of the results of the design workshop.
- The game will be usable, have a clear goal and be complete as a game prototype.
- The game will have instructions that are easy to understand by children within the target audience (3-6 years old) and reduce confusion with the rules or game mechanics.
- The game will encourage and provide a platform for meaningful collaborative play.
- The game will provide opportunity for fantasy play, the child will be playing as part of a world unlike their own and the game will be immersive enough to support this.

## Report Structure

**Chapter 2** assesses related literature and discusses some works similar to this project.

**Chapter 3** outlines a design workshop I carried out and discusses how the findings will be useful to the project.

**Chapter 4** presents some prototyping I carried out and a critical view of some key controllers for the technology, providing some context for decisions I made in the design and implementation stages.

**Chapter 5** provides an analysis of relevant design principles and outlines a framework this report will follow throughout design and implementation. It also shows some early design work, using both this framework and the findings in Chapter 3.

**Chapter 6** shows the implementation stage of this development. Discussing key features and mechanics of the game and presenting the prototype of the game that was shown during the workshop in Chapter 7.

**Chapter 7** provides a full evaluation of the design and implementation process. It outlines the results of any evaluation methods used and discusses their impact on the final prototype.

**Chapter 8** discusses t what extent the project aims were met and how the project can be taken into the future.

# Chapter 2

# Literature Review

## 2.1 Play

### 2.1.1 What is play?

Play is so important to the life and development of a child that it has been classified as a human right by the Office of the United Nations High Commissioner for Human Rights (1989). It is essential for the cognitive, social, emotional and physical well-being for young children and to facilitate a child's interaction with the world in the early stages of their life (Ginsburg et al., 2007). Children can discover passions and interests while practicing decision-making skills, developing communication and improving creative thinking (Ginsburg et al., 2007). Play has always been difficult to define due to it being used across academic contexts to mean any and all child behaviour (Pellegrini, 2010). Additionally, we see that play in one context may not be play in another context (Burghardt, 2012) which adds to the confusion around providing a complete definition of play. There is a wealth of literature that tries to understand and explain the complexities of play throughout history (Darian-Smith and Sleight, 2016)(Martin, 2016) however it is clear that play has persevered throughout time and societal change. The most recent evolution of play is the creation of digital play materials, and the expansion of the traditional play types to include these new interactions between child and technology (Marsh et al., 2016).

### 2.1.2 How do we define digital play?

While the concept of digital play can be traced back to the start of the digital age, with the invention of the transistor in 1956, the experiences of children growing up in the 21st century are prompting researchers to explore this topic further (Marsh et al., 2016). The development of touchscreen technology and mobile applications has brought digital play into the spotlight as another important resource for children's creative development (Marsh et al., 2016). There are some concerns over the potentially passive nature of playing games on tablets or other technology - with an additional apprehension regarding technology being used a form of 'unsupervised babysitting' (Stephen and Plowman, 2014). However recent research would indicate that children and parents both pursue a healthy balance between the imaginative and fantasy but perhaps passive play using tablets and video games and traditional toys (Stephen and Plowman, 2014). Digital play refers to the use of any technology-based games (such as apps on mobile phones, tablets, computers) or internet-enabled toys. These come with a host of potential benefits for children's creative and social development,

but by looking at touchscreen apps in particular we can see clear scope to further education and provide opportunities for both fantasy and imaginative play when children are supported by adults (Gillen et al., 2018). Developers are encouraged to create apps that are designed in such a way that enriches development and provides opportunities for immersive play while minimizing any potential negative impacts or dangers (Ginsburg et al., 2007).

### 2.1.3 Fantasy play and Collaborative Play

There has been many attempts to define a complete set of play types that can explain and categorize all occurrences of play (Pellegrini and Smith, 1998) (Caillois, 2001) (Bishop and Curtis, 2001). Most recently, Marsh et al. (2016) reviewed play types devised byHughes (2002) within a digital play context and adapted them to suit this setting. They found that digital play can support all play types in some context with the appropriate adaptations and supports the claims that digital playthings provide opportunities for true play such as that found with traditional playthings (Marsh et al., 2016). Fantasy play is one such play type and is defined by Marsh et al. (2016) as "Play in a digital context in which children can take on roles that would not occur in real life, e.g. be a superhero. This could be through the use of an avatar but may also include taking on a character off-screen whilst they engage in on-screen activities in the fantasy scenario". Collaborative play, while not considered in the taxonomy defined by Marsh et al. (2016), is ranked of great importance to a child's social development by many researchers (Gillen et al., 2018) (Ginsburg et al., 2007) (Mustola et al., 2018) as it can be seen to benefit family relationships, communication skills and social development. Collaborative play can also be employed within a medical setting. This therapeutic effect has been explored by physicians and academics and the potential benefits this could have for a child's healing and recovery process has resulted in the development and practice of 'Play therapy'.

## 2.2 Play Therapy

### 2.2.1 What is play therapy?

Play therapy refers to the therapeutic effect that can result from engaging a child in play guided by skilled individuals (Urquiza, 2010). Play therapy aims to deepen an established therapeutic relationship between a skilled adult and a child, using imaginative, creative play methods ((Kool and Lawver, 2010). These benefits can only be achieved for the child if this play is child-driven and adult supervised, allowing the children to fully engage and explore the area of play at their own pace (Ginsburg et al., 2007). It is agreed amongst researchers ( (Urquiza, 2010) (Ginsburg et al., 2007) (Burghardt, 2012)) that play itself and play therapy cannot have strict rules or a definitive guide because of this and Urquiza (2010) goes as far as to describe the creation of such a guide as an "anathema". Play therapy, while it can refer to any therapeutic affect resulting from play, is primarily used to describe a hospital setting in which play is guided by a skilled individual (Urquiza, 2010). Within this setting, we see play being used to improve communication skills, help the child express problems or concerns they have, and help to build strong family relationships (Rothman, 2017). While adult supervision is needed for safety within most play settings for young children, the idea of true adult-child cooperative play has many benefits itself. These include building a strong and enduring relationship with the child, allowing the child to communicate thoughts and emotion through play and the gain of a unique perspective of the world through the child's eyes (Ginsburg et al., 2007). Given these benefits and opportunity for healing through play and play therapy, the focus for app developers should be to realise this idea by creating play tools and games that allow for child directed, cooperative play.

### 2.2.2 Other uses for play in medicine

Play can also be used to support medicine throughout paediatrics - to combat loneliness, manage pain, and act as a distraction from distressing procedures. There have been many pilot studies analysing the effects of virtual reality and other games to manage pain during emergency procedures or long term illnesses ( (Arane et al., 2017), (Won et al., 2017), (Patel et al., 2006)). These studies evaluate how through distraction, pain can be managed, and patients have also shown a reduction in anxiety and distress when taking part in these studies. Pediatric wards, have created a position of 'Health Play Specialist', staff in this position coordinate play activities, helping children regain lost skills through play and advising caregivers on appropriate play activities for sick or injured children (Monkey Wellbeing, 2015). Additionally, staff in this role use play to prepare and support children through painful or distressing procedures (ibid.). These play specialists are not play therapists as previously discussed, but have a vital role in the hospital and ward environment, as well as for the recovery of the children (ibid.). Given the rise of digital technology use among young children, it could follow that this technology will start to be used by play therapists and play specialists as these tools are familiar for the children. Portability of touchscreen devices makes them a suitable candidate for these games as they can be used at bedside or in a play room setting. Therefor, creating age-appropriate, engaging digital games on portable devices can further study into this area and provide opportunities for staff to support children and their families and encourage healing.

### 2.2.3 Related work - Zora project

A group of researchers worked with a pediatric hemodialysis unit to test a virtual community using a computer application - Zora. The premise was to encourage communication, and introduce a form of coping with their chronic illness, since getting dialysis is physically debilitating. This research was conducted with 7 patients (4 girls and 3 boys) with a mean age of 15 years old and 5 members of staff that worked on the ward. The children created characters and interacted with each other and staff via the virtual reality for 5 months before taking part in the evaluation of the system alongside staff.

The system was evaluated using a series of semi-structured interviews in which participants answered the following four questions on a 7-point scale (1 meaning 'not at all' and 7 meaning 'a great deal'):

- Did you feel Zora is safe?
- Do you feel Zora is fun or enjoyable?
- How satisfied are you with Zora?
- Do you feel Zora was hurtful at all?

Overall, the results were very promising, with a mean score over 5 for questions 1-3 and a mean of 1.4 for question 4. These scores indicate that this system was a success with both patients and staff and that there is a very low risk to using this kind of system on a similar ward. They indicated different reasons for enjoying the system, the patients expressing that they liked ability to communicate privately while the staff used the system to understand how their patients were feeling (Bers et al., 2003). In one case, staff were able to trigger an evaluation of a patient due to the observations of his feelings about his current medication within Zora (Bers et al., 2003).

While the mean age for this study is much higher than that of the target group for this research, I believe it produced some relevant applicable data and points of interest. Firstly, this research had dedicated time in design and evaluation to consider safety. In a hospital setting these children are young and potentially vulnerable and any technology introduced to them should be properly considered to ensure no harmful effect can come of it. Additionally, the comparison with the same software being used with healthy children of a similar age showed that the children on hemodialysis made more use of fantasy themes in order to use Zora as an escape from their treatment - often choosing to not discuss or engage with treatment related conversations or content (Bers et al., 2003). Making the game proposed in this research immersive and providing opportunity for fantasy play could cause a similar effect amongst participants in the same situation of any age. Finally, the limitations of this study provide valuable insights into the potential of this research. 60% of potential participants in this hemodialysis ward chose not to participate because of their condition (Bers et al., 2003), and the same results could be seen when deploying this research. These children are undergoing extensive and sometimes very invasive procedures and may not wish to use the software that is available to them. Creating a game that has short rewarding levels could provide all children the opportunity to play for as long as their condition and treatment allows, without the long term commitment of a virtual reality system.

### 2.2.4 Related work - Preoperative distraction techniques

Many studies have been conducted to explore the potential of using video games, virtual reality and other technology to assist children before, during and after painful or distressing procedures. One such study, conducted by (Patel et al., 2006), assessed the effects of using a handheld video game to reduce anxiety before an operation and compared this approach to premedication and parental presence.

112 children, between 4 and 12 years old, took part in the study – all having surgeries that required the use of general anaesthesia. The children were randomly assigned one of three protocols: Parental presence (PP) only, PP & premedication and PP & video game distraction. A nurse working at the surgery performed a structured interview to establish a baseline for the participant and parents were given a full description of what to expect during the study. The children that were randomly selected to use the video game, chose a game themselves from a set of 10 games, appropriate for all ages.

After the child was anaesthetized, the parent participated in a parent satisfaction survey, and 7 to 10 days later took part in a telephone interview.

The results of this study appear to promise for the use of this technology to reduce anxiety. They report that 63% of patients that used the video game before their operation experienced no change or a decrease in anxiety levels, compared to 26% in the group that were premedicated and 28% for the group that had parental presence only. The decrease (or no change) in anxiety persisted across each age subgroup (4-5,6-9,10-12), and remained consistently higher than the other methods.

However, the extent to which I can rely on the data reported in this study is limited. The results discuss how the use of a video game as a distraction technique caused a decrease or no change in preoperative anxiety levels compared to the other methods used. The way the researchers present their data does not support the claims in their title "Distraction with a hand-held video game reduces pediatric preoperative anxiety". The table showing the data discussed above reveals that these

figures are categorised into "No increase" and "Increase" with 63% of patients having no increase to their anxiety score. Using these categories does not support their claims that the video game reduced preoperative anxiety because not increasing anxiety does not in itself indicate a decrease in anxiety. Without publishing the original results or providing a more in-depth analysis of how many patients involved had a distinct decrease in anxiety score, the validity of their findings cannot be confirmed.

The limitations and discussion included in this study can provide some insight that can be applied to this project. While the study shows that anxiety is reduced from the use of video games, they suggest that this could be as a result of the children considering the video game a "gift" and causing happiness and excitement, which contribute to lowering anxiety. This introduces a concern over the reliability of this data as well as how it can be generalised to future works like this project. An interesting point to note from this study is that they chose to perform 3 different protocols, so a child could randomly have no intervention other than parental presence. This allowed researchers to directly compare their findings with that of what was already being used in the hospital, allowing them to determine the success of their study.

## 2.3 Designing for kids

### 2.3.1 Game design for young children

As discussed, the use of touchscreen applications can provide many opportunities for play, learning, and growth. However, this can only be actualised when they are implemented with thoughtful design that facilitates, rather than inhibits, these potential benefits. Considering the four game design heuristics as discussed by Sykes (2006), some key requirements for designing games for children are found. The first heuristic "support the play experience", discusses the idea that every game mechanic should be chosen to support the established play types (ibid.). However, these game mechanics must allow the play to remain child-driven (Ginsburg et al., 2007) and promote a balance between engagement with the game, and the opportunity for imaginative and fantasy play (Maurice, 2016). The second heuristic "reward the player's ability" discusses the necessity for the player's actions to contribute to the final outcome (Sykes, 2006). Children seek accomplishment and feel empowered when they learn new skills and apply them to gain rewards(Maurice, 2016). Therefore, game designers should ensure that engaging with the game has positive consequences in order to keep the child involved and entertained (ibid.). The third heuristic is "make the game easy to learn" (Sykes, 2006). The ability of the player must be considered in the design of all game elements – if the learning curve for a game is too steep, the player is unlikely to continue to play (Koster, 2005). The child's ability to learn and retain information is also crucial, and game designers must create interfaces that provide the correct amount of guidance for the intended age group(Maurice, 2016). If handled incorrectly, the game may be too easy for the child, and discarded because it is boring (Koster, 2005). The final heuristic "provide sufficient complexity" discusses the need for challenge and skill growth, supported by Maurice (2016) who say that children as young as 5 look for challenges during play. Game designers should strive to create tasks that are short, but rewarding, and that challenge children to learn new things about themselves or the world around them (Maurice, 2016).

### 2.3.2 Game design considering accessibility issues

Designing games that are suitable for children comes with challenges as described above, but children using these apps in a play therapy session could have additional requirements to be able to

fully use and enjoy the game. Additionally, children with physical disabilities, weakness, injury or other physical impairments could have problems using the physical touchscreen device. There have been several studies researching the potential benefits of using touchscreen devices with children in schools with physical disabilities (Chmiliar, 2017) (Flewitt et al., 2015) (Wang et al., 2016) and some of the observations are applicable to the hospital setting. Children with limited movement and underdeveloped or restricted fine motor skills find it difficult to use the traditional mouse and keyboard, and the simplicity of use of a touchscreen device makes iPads and other touchscreen devices useful for these children (Flewitt et al., 2015). In a hospital setting, children are physically limited by their surroundings – being connected to machines and other equipment and possibly recovering from a physical injury or weakness could give a child a temporary physical impairment. In this case, the same benefits of the touchscreen technology apply, and its portability and ease of use for basic features such as tap to select and drag-and-drop (Flewitt et al., 2015) would allow children to interact with the technology while in hospital. However, managing proper infection control standards when using these devices is crucial. Each device should be treated as any other reusable equipment on the wards and included in the existing infection control efforts.

However, the hospital setting introduces some new challenges. As discussed above, its crucial to promote cooperative play (Ginsburg et al., 2007), and isolation and passivity using technology would be particularly harmful in a hospital setting as these technologies are often used to reduce loneliness with patients (Bers et al., 2003). In order to facilitate this cooperative play around the unique setting, some additional requirements are needed. Similar to that of the metal arm attached to a child's wheelchair discussed inFlewitt et al. (2015), a metal arm attached to each bed could provide the portability needed to require minimal movement from the child. Additionally, apps and games themselves have to be adaptable and accessible to children with physical disabilities or impairments. Providing options to adults and care professionals to customize the game to suit the child and the setting, would potentially expand the reach of these play therapy sessions to children with more complex needs.

The Bungie Foundation brought the iPads for Kids program to Seattle Children's Hospital in 2012 with the purpose of proving age-appropriate software on iPads to children during their stay in hospital to be used to reduce distress, distract and provide opportunities for therapeutic play (Comstock, 2017). Additionally, St Louis Children's Hospital are using iPads to facilitate their 'Ouchless Experience' (The Pulse, n.d.), and Alder Hey Children's Hospital in Liverpool have been using the 'Ask Oli' app with children to 'reward positive health behaviours' (Alder Hey, n.d.). These initiatives all strive towards an understanding of the needs of the children involved and the complexities to actualise these needs in a piece of technology or application.

## 2.4 Designing with kids

### 2.4.1 Participatory design

Sykes (2006) suggests a method for implementing the above heuristics is through participatory design. Participatory design, as described by Read et al. (2002) is a process in which users and developers work as partners to create designs that demonstrate the ideas and needs of the user. An extension of this that has been successful with children is informant design, in which children have input on the interface design, explain their interactions with existing technology and contribute to the list of initial requirements and overall themes (Read et al., 2002). Druin (2002) discusses the potential strengths of taking this approach, theorizing that including children actively in the design

of a piece of technology makes it easier for them to use and creates excitement about the product. She also mentions this benefit when discussing using children as testers – this approach has children take part in testing the product before it is released to the public. When using this method, all initial design decisions are made by adults and the product has been implemented and is ready to be released (Druin, 2002). Going a step further than this and including the children in the early design stages will ultimately result in a product that children are able to use and will want to use. Additionally, showing the children you value their input, and respecting the significance of their role can also improve their confidence and provide them with a sense of accomplishment when they return to the project during the testing stage (Druin, 2002).Druin (2002) discusses some issues with inviting children to be full design partners, which involves children being part of the entire development and ultimately acting as an equal partner in the project with the researcher. She comments that this type of research can provide huge benefit but it must be noted that this research is difficult as this partnership can be slow and difficult for both the researchers and the children to settle into their role in the process (ibid.). Within a hospital setting, this technique would not be appropriate as the workload would be excessive for both the child and their family.

### 2.4.2 Related work - Blood Quest

Participatory design as a method for creating user-centered products has been used across many research avenues and there are several reported benefits of collaborative design between adults and children for new technologies in healthcare (Druin, 2010). One such pilot study conducted by a team of academic nurses working with a haematology/oncology ward, to create a fun and informative game to ease pain and anxiety around having blood taken (Oulton et al., 2018). The study was conducted with 23 children between the ages of 4 and 12 and was performed in several phases.

Phase 1 had the children work on designing educational tools about blood, the process of giving blood and why they need to have the procedure. They created artwork about what they had learned about blood and visited a lab where they could ask questions about what happens to their blood after it is taken. The team then used this data to work with an advisory team made up of experts to create the paper prototype that was then evaluated by the children (Oulton et al., 2018).

Phase 2 had children trialling a paper prototype before having their blood taken at the hospital and then completing an evaluation with a member of staff answering a series of questions about the game and the effect on their blood test experience (Oulton et al., 2018).

The results of the evaluation showed that 50% of the participants felt better about their test after using the prototype while 50% felt the same. The team conclude that there is sufficient evidence to show that a full-scale project (developed as an app) could be used to successfully reduce pain, anxiety and suffering in children surrounding these invasive procedures.

This application of participatory design showed some significant benefits to the end product while offering insights into important considerations that must be had during planning, execution and evaluation of materials made in the workshops. They report that the children involved in the process enjoyed taking part, and welcomed the premise of a game that they could play before their procedure rather than relying on parents or other staff for support (Oulton et al., 2018). In particular they note that many of the children displayed their artwork in their rooms after phase 1 and continued to enquire about the project to hospital staff after the project was over (Oulton et al., 2018), supporting Rollins et al. (2012) comments on the benefit of showing the children that their

thoughts were understood and valued by having "visible proof". During the design workshops I will be conducting, participants will be presented with a certificate to document their involvement in the project and provide this sense of accomplishment Rollins et al. (2012) describes. They also note that they used their illustrator to ensure that the end product was both age-appropriate but included the insights and ideas from the children (Oulton et al., 2018). As I, myself, will be turning the designs gathered at the workshops into the final product, I will strive to take extra care to ensure that I am conscious of the age range of the target group but to use as many appropriate designs as I can from the children. This approach will yield a product that is more user-centered and hopefully improve feedback during the testing stage.

## 2.5 Methodology

### 2.5.1 Forming Research Question

From the reviewed literature and through analysis of related work the following points become clear:

- Play is crucial for a child's development and happiness yet creating digital accessible tools that facilitate safe and beneficial play remains a difficult task.
- Fantasy/Imaginative play can provide benefits to caregivers as well as children, allowing children to have an outlet for their imagination and also use created worlds and stories within play to communicate and grow closer to their caregivers.
- Collaborative play allows for caregivers to enter these worlds with the child, to understand their emotions and thoughts in situations where a child may not communicate effectively or is unable to communicate with the adult.
- Using these play types can encourage healing and provide safe coping strategies for children that are in hospital. However, many children that need this play therapy the most are not able to play with traditional toys due to mobility issues, so digital play is crucial in this environment.
- Touchscreen devices (such as tablets or iPads) provide the required flexibility and portability to host digital play opportunities. Allowing children with a range of mobility issues to engage in play by themselves or with others. They also provide a useful opportunity to add variability to the game, allowing for many aspects to be changed in order to be suitable each child.

These findings suggest that there is potential benefit to developing apps and games that encourage both fantasy and imaginative play and collaborative play that can then facilitate healing, distraction and comfort during a child's stay in hospital. Measuring these benefits and evaluating the success of programs like this is outwith the scope of this project and thus I propose a more detailed research question.

**How to design an accessible game for children within a hospital setting that promotes fantasy and collaborative play?**

The first step in answering this question is to propose a game design framework that will allow for this type of play and address some of the problems discussed in the literature. The second step is to provide a methodology for designing and developing this project that is beneficial to the overall outcome but appropriate for the target group.

### 2.5.2 Game Framework

The game will be designed for 3-6 year old children that are undergoing medical treatment in hospital. As discussed it is important to define a clear task for the game to ensure the game captures and retains the child's attention, and this is even more important when this game is part of a larger suite aimed at distraction and comfort during these periods of treatment in the hospital. The task for this game will be to sort objects into different categories and most of the storyline and any additional characters for this project will be created in a participatory design workshop described below. The game will require the children to identify items and send them to the correct place based on the category it belongs to.
In order to address the difficulties presented by children with additional and complex needs, there will be several adaptable features that can be changed by a caregiver to suit that child. From the literature and discussion with children at the workshop these will be the following:

- Volume Control (In game sounds and Music separate)
- Game difficulty
- Length of Game
- Positioning of control buttons

The game will be developed with both single-player and multi-player options available to promote play with caregivers, play therapists or other children. The game will be designed to be deployed on an iPad device and all features will be catered to a touchscreen and refined to be as usable as possible by young children.

### 2.5.3 Existing game suite

The game is to be built as part of an existing game suite to be deployed in hospitals. The games center around an established character "Lolly the space sheep" and her games tell a story of her journey in space. This game will also center around this established character and the central theme of space however will add elements and story designed in the workshop.

### 2.5.4 Design & Evaluation Methods

As discussed in the above literature, this project will be using participatory design as part of a user-centered design approach. The design section of the development will first document a design workshop with healthy children between 7 and 10 years old. These children were chosen to be older than the target group for the game in order to gain coherent storylines and ideas from the workshops and usable designs. I chose to run this study with healthy children rather than children with ongoing illness or disability to increase access to the study, to make the participant selection process easier and to reduce the ethical weight of the study. This demographic allowed me to approach my local scouting district to organise a workshop with a cub scout group of healthy children within this age range. The details of this study are provided in chapter 4.

The evaluation section of development will also follow this approach, I plan to conduct an evaluation session with the same group of children that took part in the design workshop. This session will have the children play with an initial prototype deployed onto an iPad and provide feedback on any changes or additions to the game.

### 2.5.5 Research Structure

The diagram below shows the research development process, showing an iterative evaluation process in which improvements to the prototype are made after each evaluation method.

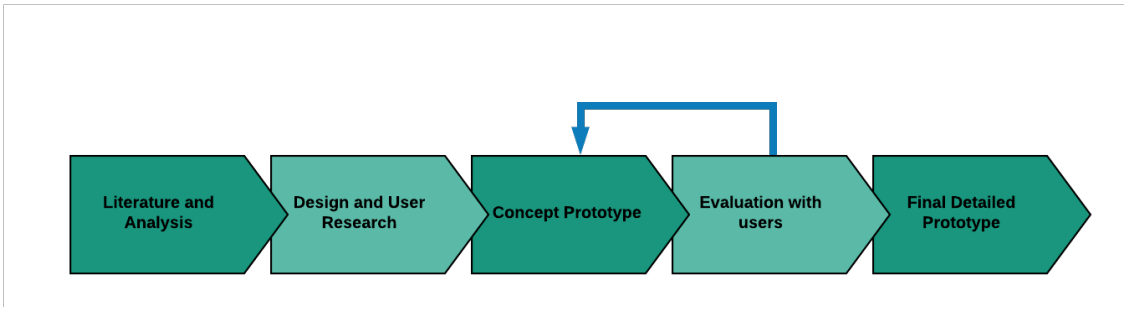



Figure 2.1: Development Plan Diagram

# Chapter 3

# Design Workshop

## 3.1 Methodology

As a method of working with kids as informants during my design process, I planned and ran a design workshop. The session was conducted with a Cub Scout group (a club run by adult volunteers, open to both boys and girls between 7 and 10 years old) on the west coast of Scotland over two nights lasting around 2 hours total. I applied for ethics through the School of Informatics Ethics committee, who approved this workshop and the consent forms I made to be given to caregivers and children.

To recruit a group to participate in my design workshop, I drafted an email explaining my project and the study and sent it out to the district. Most groups were busy with winter and holiday activities, but I was able to schedule and organise with one large group to do one design workshop session and one brief presentation of my project and distribution of consent forms the week previous.

I designed a worksheet to be completed by the children. In my presentation I proposed to them the initial idea for the game - A sorting factory, sorting items into the correct place. *Lolly* (the main character already implemented in this project) stumbles upon this factory and decides to help the factory workers sort the items. The entire storyline other than this - the design of the factory, any additional characters, the backstory for the factory and items to be sorted were all tasked to the children to design. The worksheet provided space for drawings of design ideas and I also took my own notes from the children as further context to their designs (See Appendix B for all workshop materials used)

The group had 25 regular attendees, both boys and girls, who were all given consent forms, and participation information sheets to take home. All children that attended the group on the night of the design workshop completed the provided worksheet, but only those that had completed child consent and returned a signed caregivers consent form were stored and used in analysis. All worksheets completed by the other children were destroyed at the university in accordance with the ethics guidelines. 10 children returned all necessary documents and completed the worksheet, 6 boys and 4 girls.

The design workshop was intended to gather designs for characters, settings and other game objects from a group of children aged 7-10. The children were chosen to be older than the target group for the game (3-6 years old) in order to gather coherent ideas and usable designs. I designed a

worksheet to gather these designs which included several activities where children could draw or describe designs in the given space. The worksheet asked the children to design a character, some game objects (items to be sorted and a method for collecting items) and a story for their character. It also asked them to combine their designs in one drawing of the full sorting factory featuring their own character. Each of the tasks were read aloud to all participants and they were all shown a worksheet I had completed myself prior to the workshop.

The workshop session was conducted in one night, but the week before I attended the group and introduced myself to the children. I explained the project, the purpose of the game (to sort items in a sorting factory) and asked the children to take home the consent forms and think about some possible designs they would like to draw. I also presented the worksheet during this visit and spoke about each of the drawing activities and answered any questions the children had about the workshop. This short presentation and discussion took around 20 minutes and I spoke to the children about this as a full group with their leaders present.

The design workshop itself which took place the following week, lasted around 90 minutes. I spoke to the children as a group with the leaders, discussing the game idea in more detail and introduced the main established character Lolly the sheep. The kids were then split into groups, with all children that had returned their consent forms sitting together in one group so that I could speak to them individually and take notes. Each group had 1 or 2 adults assigned to them that read the tasks aloud and explained them to the children, while I spoke to each group and explained in more detail, answered any questions they had and discussed an example worksheet I had drawn myself previous to the workshop. While they were drawing, I asked the children about their designs and noted any comments they had on designs or ideas they had not included on their worksheet. After they had finished drawing, they were brought together as a group and I answered any final questions they had and discussed some of the strong themes I found while looking at their drawings. They were then dismissed by the leaders to their parents and some returned with completed consent forms at that time. All of the participants had the opportunity to stop and leave the activity at any time, as an adult was playing a ball game in another room with any who had finished early or didn't want to finish. None of the children that returned consent forms left the activity early, and all returned a signed consent form when the activity had finished.

The data gathered during this workshop consisted of 2 signed consent forms per participant (one signed by caregivers and one by the participant) and one completed worksheet. Each participant was given a unique participant ID number, and this is the only identifying feature attached with the worksheet itself, and so any analysis will be discussed using these ID numbers. Any identifying information put on the worksheets by the children (e.g. participants name) were redacted from the worksheets by me prior to storing the data or any analysis of the results. The data was securely stored in a locked filing cabinet and the worksheets were scanned onto the university network and stored for analysis.

The worksheets completed by participants were used to identify themes and design requirements for the game. Some of the worksheets came with annotations from attending adults that explained the story or ideas behind the drawings, and some were annotated by the children themselves. These annotations allowed me to make sense of the child's drawings and fit these different characters and settings into more general themes. Any drawings that remained unintelligible, were not used as part of theme analysis, but the colours the child used were considered significant and used in the results.

## 3.2 Results

Using the drawings made by the participants, the annotations added by participants or scout leaders helping at the workshop, and my own notes I made throughout observation and discussion with the kids, some clear themes were identified. Upon hearing about Lolly the space sheep, space, planets, rockets and robots featured in many of the drawings - this is a suitable theme for the game because of the established character and space setting. Additionally, many of the children designed a character that would be friends with Lolly, perhaps showing her around the factories, or asking for her help working at the factory. Several of the children drew a unicorn character, that will be introduced to the game as a friend of Lolly's and participate in game narration or dialogue with Lolly (See Figure 3.1 & 3.2). The other characters designed by the children were often robots and described as workers at the factory, they all had a similar design that will be incorporated into the game within the factory.

The children also designed items to be sorted within the factory, and many of these were also related to space. An example of this would be sorting different materials to build rockets, or sorting different supplies needed to be taken to a different planet (food, clothes, equipment etc). The factory design itself was approached in many different ways, the children were told the items they had chosen will come into the factory on a conveyor belt system, so this featured throughout, but the overall design was usually tailored to the character they had made and an environment that would suit the character. (See Figure 3.4) An example of this is a bee character working in a factory shaped like a beehive. (See Figure 3.3) Throughout the drawings, the children all chose to make the factory very colourful, featuring multicoloured walls and conveyor belts to match their colourful characters. Since this was featured in most of the participants, I believe it appropriate to make the game as bright and colourful as possible, and as little like a regular factory we see in the real world.

There were several children who designed ideas I did not choose to be included in this game, as the themes were not suitable for the player age range (3-6 years old). For example, 2 children designed a school system in which the character sorted equipment and supplies into the different school subjects. The children in this demographic are unlikely to be at school or around items and environments like this and therefore will not understand the intended story. However, if this game were to be expanded to have levels aimed at different age ranges, this environment would be very suited to a child of similar age to the participants, and the idea would fit well into the game. These children both designed a unicorn that will be introduced to the game as Lolly's friend, and the colour use and factory design were both used in the analysis.

The following are the elements I will be taking from the design workshop into my prototyping stage:

- Colourful Factory, with a conveyor belt bringing the items in to be sorted
- A friend for Lolly, that will show her around and partially narrate the game
  - This friend will be a unicorn similar to the design featuring in the children's designs
- A space theme - the factory will be on a distant planet where Lolly finds Unity and tries to help her fix the factory by sorting the items.

## 3.3 Reflection

To conclude, there were many coherent stories and worlds created by the children, and the majority of children will have their designs included in the final game. Themes were easy to extract from the

designs, and only the drawings given by one child were not identifiable. This child's colour scheme was similar to that of the other children and thus is still represented in the final design. If I were to repeat the workshop again, I would provide space for writing the story behind the character on the worksheet. While many of the children wrote this down somewhere on the paper anyway, a dedicated space with a prompt may encourage more children to write some more thoughts about the game or design.

Figure 3.1: Design for a unicorn to be a friend to Lolly the space sheep (Drawn by 7 year old girl)

Figure 3.2: Second design for a unicorn to be a friend to Lolly the space sheep (Drawn by 8 year old girl)


Figure 3.3: Factory modelled after a hive for the bee character (Drawn by 9 year old girl)

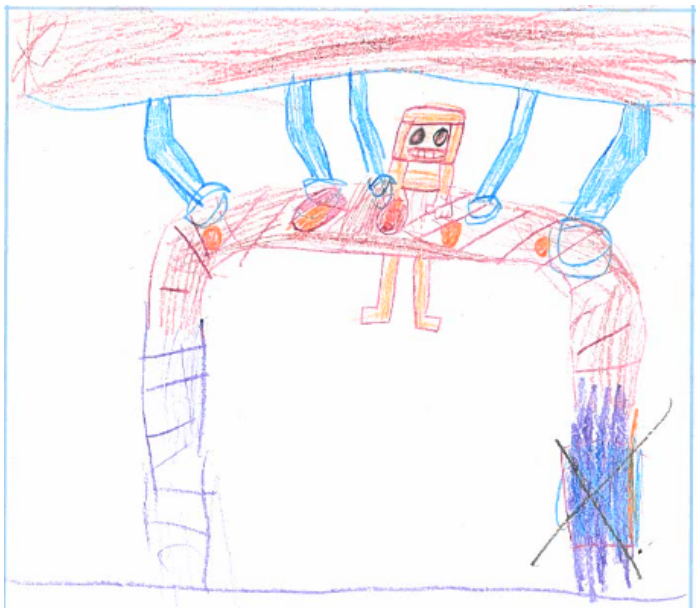


Figure 3.4: A factory with a conveyor belt system bringing items into the factory (Drawn by 8 year old boy)

# Chapter 4

# Prototyping

The use of touchscreen technology as discussed above can provide opportunities for meaningful play with young children, however this can only be achieved when game mechanics are chosen that are usable and suitable for the target audience. To explore some of these mechanics and evaluate their effectiveness for facilitating play, I chose to implement them in a series of small mini-games as can be seen below. The goal of theses games is to roll a ball into the goal area and I implemented this as a single player, co-operative two-player and competitive two-player.

## 4.1 Technologies

These prototypes were built in Unity using the following asset packages downloaded from the asset store:

- **Joystick Pack** by Fenerax Studios - Used to build the joysticks that can be seen in Figure 4.2.
- **Farland Skies - Cloudy Crown** - Borodar - Used for the skybox graphics that can be seen in the background of all gamemodes.

The coins, player balls and track were built using basic unity 3D objects with some simple gravity modules applied (rigid body).

## 4.2 Gamemodes

Exploring different gamemode options was an important part of this initial prototyping stage, I tried different methods of both co-operative and versus play and provide a discussion on my findings below.

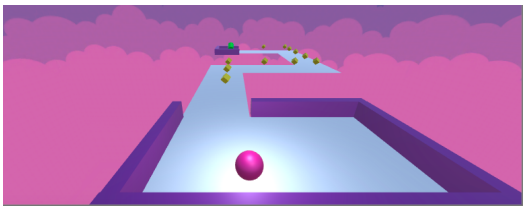


Figure 4.1: Single player mode view, ball rolled via tilting the iPad

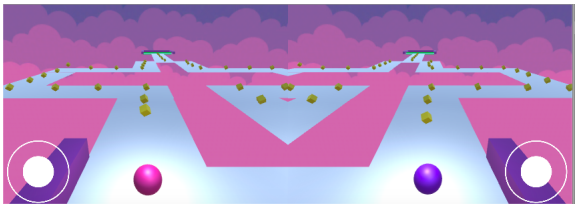


Figure 4.2: Multi player versus mode using split screen and joysticks

| | Implementation | Discussion |
|---|---|---|
| **Single Player** | This basic gamemode was implemented using the full screen size, with the camera view positioned above the player ball pointing at an angle down towards the track (Figure 4.1). The score was displayed at the end of the game and the repetitive goals were to collect more 'coins' for points and complete the course quicker (Figure 4.4). | These individual goals make the game re-playable and reduce risk of it getting boring and overly repetitive, and the game can easily be expanded to include additional levels and other difficulties. |
| **Multiplayer Co-operative** | The game mode was also across the entire screen, and was intended for only 2 players. The players physically hold each side of the screen and move the iPad together to tilt a maze to move a ball through as can be seen in Figure 4.3. | This method could have benefits in the hospital setting if the iPad is mobile, encouraging children to play with someone else, who can then also act as an aid for some of the issues with tilting that are discussed section 4.3 found ahead. The iPad can also be held from any side helping with accessibility for patients that are sitting across from the other player or beside them. Cooperative play is said to have many benefits for children within the target age group and thus is a very important aspect to explore fully. |
| **Multiplayer Versus** | This game mode as can be seen in Figure 4.2 was implemented using split screen. Each side of the screen had its own joystick controller, player, track and points counter. The end popup with the final points showed across both screens (Figure 4.4). | The split-screen aspect of this gamemode restricted players to have to be sitting beside one another, which could be an issue for children in the target group (in hospital) as they could have restricted mobility. The versus gamemode itself provides another form of play and encourages other players (staff, caregivers or other children) to get involved, which provides many of the same benefits as co-operative play. |

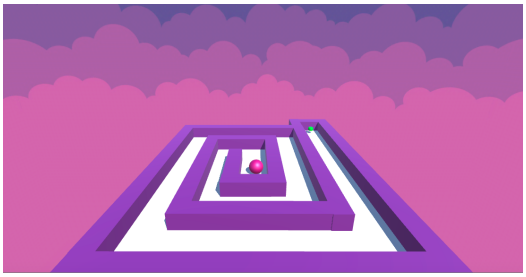


Figure 4.3: Coop player mode maze game view, ball rolled via tilting the iPad

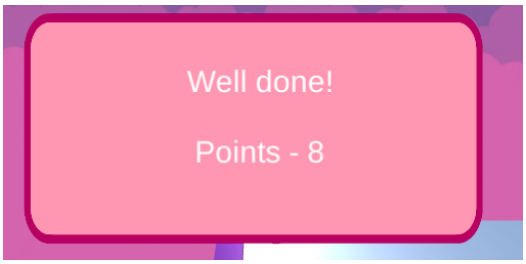



Figure 4.4: Multi player versus mode using split screen and joysticks

Overall, all of the discussed gamemodes described above would be suitable for this project. Single player could offer opportunities for distraction and comfort before procedures or as a tool to combat loneliness when children have to spend time away from family as they go to work. If the game supports multi-player modes (both cooperative and versus), there would be the possibility for it to be used in a play therapy setting. Additionally, it would give the child the option to play these games with caregivers, staff and other children if suitable in a play room or at bedside.

## 4.3 Interactions with the menus

Additionally, I created some initial menu views for choosing to play, selecting the gamemode, and applying some basic settings (Figure 4.5). This was implemented using a canvas in unity, with buttons opening the correct game scene when selected. The volume could be changed using a slider and each of the rest of the options were implemented using clickable onscreen buttons as can be seen below. This set-up was very intuitive as it is very similar to the standard used across applications and games on similar devices. There were no indicated problems using buttons or sliders, they were large with large text, spaced appropriately to reduce misclicking, and the 'quit' button clearly accessible from all pages.


Figure 4.5: Menu to choose the game mode

## 4.4 iPad specific ball movement features

Each of these games explored different methods for moving the ball towards the goal and I will discuss my findings during both implementation and informal usability testing below.

| | Implementation | Discussion |
|---|---|---|
| **Tilt** | I implemented this using the accelerometer and gyroscope to provide a value that could be applied to the ball to roll it in the tilted direction. The value between -1 and 1 is provided for each axis and applied as a force to the rigidbody element which rolls the ball. | This was a very immersive way to play the game. The requirement to physically move the iPad to cause the ball to move could be useful when building fine-motor skills and improving spatial awareness. However for very young children, the ability to keep the ball steady on the track by keeping the iPad still may be difficult and thus the tilt feature may be inappropriate for this age group in a single player setting. In a cooperative multiplayer mode as discussed in 3.2, the tilt feature could be usable when the child is assisted by an adult. |
| **Joysticks** | These were implemented using a unity package and were placed on either side for the screen as seen in Figure 4.2. When the centre circle was clicked and dragged towards the outer circle, this translates to a horizontal and vertical value between -1 and 1 which can then be applied to the rigidbody element attached to the ball. | These were considerably easier to use than the tilt motion as the iPad remains in the one place throughout gameplay. However, an onscreen 'joystick' is only intuitive to use for people who have used physical joysticks, those who hadn't used a physical gaming joystick would not find this mechanic easy to use. |

## 4.5 Conclusions

Overall, While using basic physics options for movement can be beneficial to the games functionality and aesthetic, relying on this too much may cause unnecessary difficulty. Children in the target audience (being in hospital), may have limited mobility and thus interacting with the physical iPad may be hard or simply not possible. Keeping interactions with this technology simple (clicking and dragging), could improve understanding of the game, and improve acceptability. This is also true for the adults the children may play the game with. They may not necessarily have interacted with a touchscreen device in a such an immersive way, and thus may find it difficult to help the child if they are unable to interact with it themselves. Additionally, the iPad's may not be mobile as they could be installed onto a mechanical arm suspended over the beds, or be installed in a playroom setting.

Prototyping proved very beneficial to test the suitability of different game features. From this stage, this project will aim to allow for both single player and multi player game modes, and make appropriate use of unity object physics and the iPad's touchscreen capabilities. While the tilt feature of the iPad provides a very immersive game experience it may not be appropriate for the intended age group and may cause some problems with the mobility of the device and abilities of the children who may be physically impaired.

# Chapter 5

# Design

## 5.1 Overview

This chapter provides context for the game rules and mechanics and will discuss the appropriate design principles that will be employed during this project and define the set of design requirements for this game. Some initial design concepts will also be discussed as part of the low-fidelity design process.

## 5.2 Game Design

Due to the aim of this project to promote fantasy and collaborative play in an accessible way, the game was chosen to be one that many children will **not** find a steep learning curve to play - sorting objects into categories ("categorising"). The game task will require the children to sort items into 2 categories and also filter out objects that belong to neither category. Additional difficulties that can be added would be increasing the speed of items, adding a timer on choosing a category, and adding more items that don't belong. However, the potential ease of this base task may be suitable for the children in this situation. A steep learning curve as discussed in Chapter 2, can cause the child to seek distraction outwith the game, ultimately leading to them no longer playing the game at all. An understanding of the task itself, with the added difficulties will also offer opportunity for collaboration, encouraging the children to take control of the play while also seeking help from caregivers or therapists.

## 5.3 Design Principles

Before embarking on any design work it is important to assess existing design principles for their relevance to this projectChiasson and Gutwin (2005) propose some principles specifically for designing children's technology and many of these are relevant to this project. However, they do not address touchscreen technology directly. The work of Soni et al. (2019), introducing the framework TIDRC (Touchscreen Interaction Design Recommendations for Children) supports many of these general principles proposed by Chiasson and Gutwin (2005) while also addressing touchscreen issues directly. Both of these works provide principles that can be grouped according to the original design heuristics proposed by Nielsen (1995).

The relevant principles extracted from these works are listed below categorized by their relevance to the Heuristics (Nielsen, 1995). Each will be annotated with the paper it was extracted/summarised from (C+G, TIDRC).

- Visibility of system status

  1. The interface should provide indication of the current state of the system, whether it is busy processing or waiting for input from the user. (C+G)
  2. Children are impatient and need immediate feedback showing that their action have had some effect. This feedback can be visual or audio, and be larger and longer than the same given to older users. (C+G, TIDRC)
  3. Provide corrective feedback, such as pop-ups or dialogues offering feedback for correct and incorrect answers. (TIDRC)

- Match system to real world

  4. Icons should be visually meaningful to children. (C+G)
  5. Children's technology should account for children's beliefs about computers. (C+G)

- User Control and Freedom

  6. Technologies should give children the ability to define their experiences and be in control of the interaction. (C+G)
  7. Provide choice and customization features to enhance children's intrinsic motivation and task engagement. (TIDRC)

- Consistency and standards

  8. Make sure that every sound used in the interface has a specific meaning and function. (TIDRC)
  9. Children's actions should map directly to the actions on the screen. These actions and gestures should be consistent to avoid confusion. (C+G, TIDRC)
  10. Be consistent with images or graphical metaphors used in interfaces and their real world use. (TIDRC)

- Aesthetics and minimalism

  11. Interfaces should be strongly visual but avoid using visually complex application backgrounds as children can get confused when interacting with them. (C+G, TIDRC)
  12. Children's interfaces should not make use of extensive menus and sub-menus. (C+G)
  13. Young children have difficulty targeting small objects on the screen. Items should be large enough and distanced from each other to compensate for some inaccuracy in targeting. (C+G)
  14. Visually differentiate clickable elements from the rest of the screen, e.g., use different colors or dark outlines. (TIDRC)

- Help and Documentation

  15. Instructions should be presented in an age-appropriate format and be easy to comprehend and remember. (C+G)

16. Use child-like on-screen characters as guides or pedagogical agents to improve learning outcomes. These characters should be strictly supportive and not distracting. (C+G, TIDRC)
17. Avoid using in-app tutorials for children; the interface should provide some form of guidance during tasks. Instead use animated prompts to help children understand gestures and rules and consequences of their actions. (TIDRC)

Some of the principles above could be critically analysed in more detail. For example, principle 5 may be disputed when considering an educational point of view. Children's technology should in fact strive to actively mould children's beliefs about computers into a safe and useful understanding. Due to this, this principle will be omitted from the requirements built below.
Additional to these principles highlighted above, both Chiasson and Gutwin (2005) and the TIDRC framework Soni et al. (2019)propose some recommendations for the design of the game activity itself. The following are recommendations extracted from these works and these principles should allow this game to be engaging and maintain interest.

18. Activities should be inherently interesting and challenging so children will want to do them for their own sake. (C+G)
19. Supportive reward structures that take into account children's developmental level and context of use help keep children engaged. (C+G)
20. Consider using an open-ended app structure to support children's engagement and creativity. (TIDRC)

## 5.4 Design Requirements

Using the set of design principles defined above and combining this with the findings from the design workshop (2.2), I can then define the following list of design requirements for this project, each annotated with the principle(s) this requirement was derived from.

- The app will contain system status elements (such as a loading wheel) in order to keep the user informed of continued interaction from the app during any background processes (1)
- The game interface will be minimalist and avoid clutter to reduce confusion and distraction. (11)
- The menus will be simple and contain little depth to reduce cognitive load (12)
- Clickable elements will be large, highlighted by colour/border, distanced from each other and consistent throughout the app (13, 14)
- The game will make use of a on-screen character who will offer suggestion and help. (15, 16, 17)
- Music, animation and visual changes in interface will be used to highlight positive action (2, 3, 8)
- Customisation options will be available to make gameplay both accessible and engaging (6,7)
- UI elements and necessary gestures will be consistent throughout the game and explained with age-appropriate instruction such as animation or metaphor (9, 10, 17)

- Any icons or metaphors used will be relevant to the real world and visually meaningful to children. (4)
- Game activities will be interesting, captivating, and have rewards. (18, 19, 20 )

## 5.5 Game Structure

The game will follow a simple structure, making use of a introductory menu, giving options to choose between single and multiplayer modes and also providing access to the settings menu (Figure 5.1).

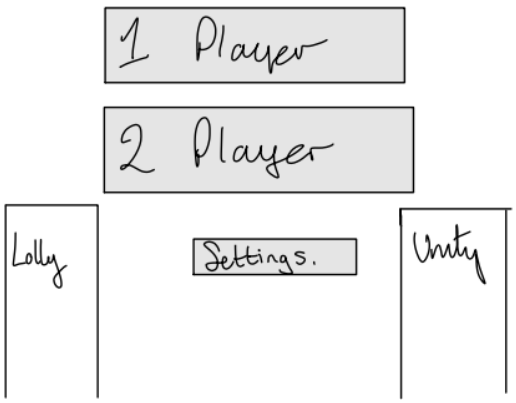



Figure 5.1: Original main menu sketch

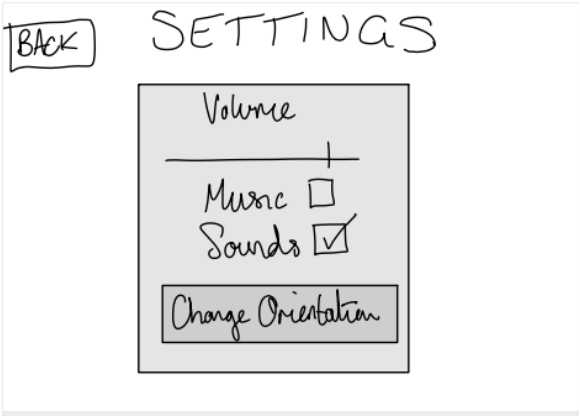



Figure 5.2: Sketch of settings page

The settings menu (Figure 5.2) will include options related to the entire game. For example, toggling sounds and music on or off as well as controlling the volume for these elements. Additionally, there will be a second settings menu (Figure 5.3) page linked from the first dedicated to changing the orientation layout for the two player gamemode.

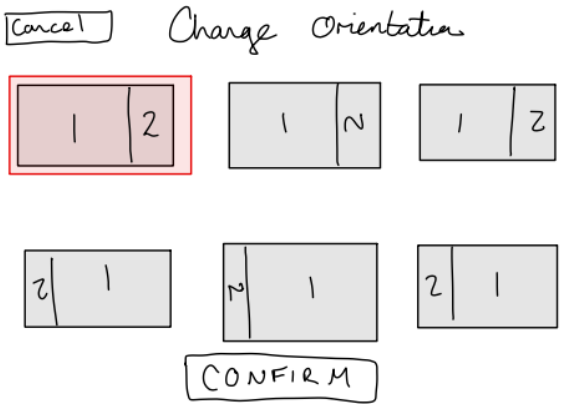



Figure 5.3: Changing the orientation for two player sketch

When single player is chosen, the player will be presented with customisation options (Figure 5.4) relating to game difficulty and length as well as options for toggling music and sound.

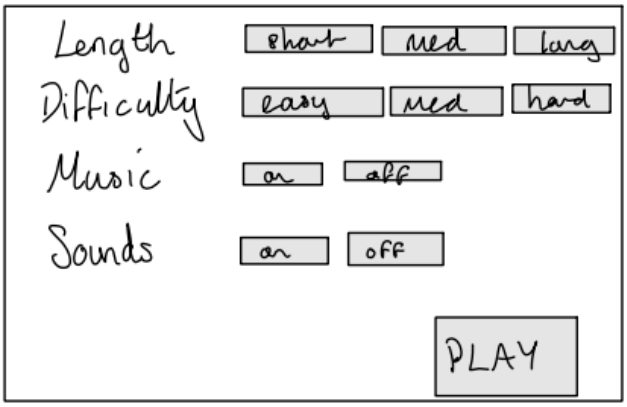



Figure 5.4: Customising single player gameplay sketch

Once selected, the tutorial will play and then the game will begin, fully customized by the player. The pause button will be positioned in the top right corner indicated by the standard icon for pause in all gamemodes (Figure 5.5). The pause menu will allow the player to resume the game, quit, change the volume and toggle both sounds and music on/off. The sketch below shows the guide that will be followed during implementation:


Figure 5.5: Initial game sketch - single player

Upon completion of the game, or if the user chooses to quit. A panel will appear, showing the score and amount of stars gained (Figure 5.6). An animation will show the points bar loading as

the player achieves each star available for the game (The player can gain between 0 and 3 stars for a single game). After this, the window will wait for 10 seconds before returning to the main menu automatically. I chose this method combined with a completely minimalist score panel so that the score and star rewards could be processed quickly by the player. It will return to the main menu automatically to indicate to the player that the game is over and no more interaction is needed.

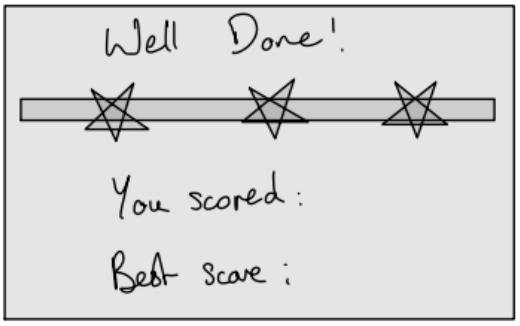



Figure 5.6: Loading bar with star scores to be reached per level

If the player chooses to play the two player mode, the game will launch immediately using the orientation settings chosen in Figure 5.3. These options will move the control panel as can be seen on the right of Figure 5.7 to match the orientation selected above. The sketch for the two player mode would correspond to the orientation setting highlighted in Figure 5.4.

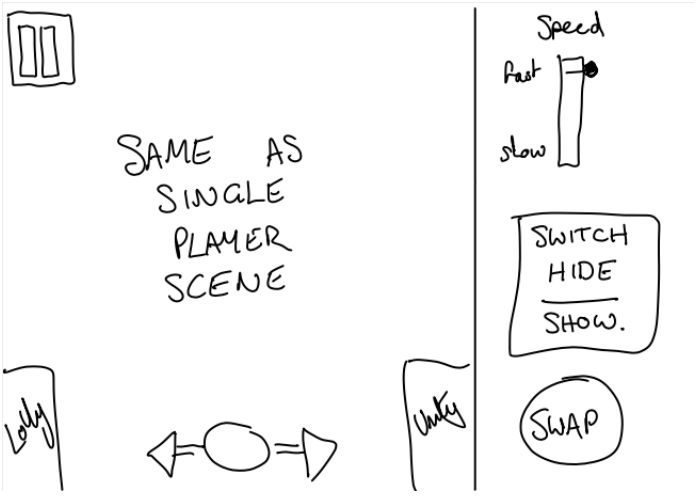



Figure 5.7: Sketch of one two player mode design option, control panel will change depending on choice

## 5.6 Art & Story

As the game suite (described in chapter 2.5.3) is focused around the main character Lolly the Space sheep (Figure 5.8) and her adventures through space, this game will follow a similar story. Using a prompt from both the literature and the design workshop, I designed a new character that will exist in the game with Lolly and play a crucial role in the game story (Figure 5.9). I also used the feedback from this session and the theme of the game suite to create a background for the game (Figure 5.10).

Figure 5.8: Lolly the Space Sheep

Figure 5.9: Unity the unicorn, inspired by Figure 3.1 and 3.2

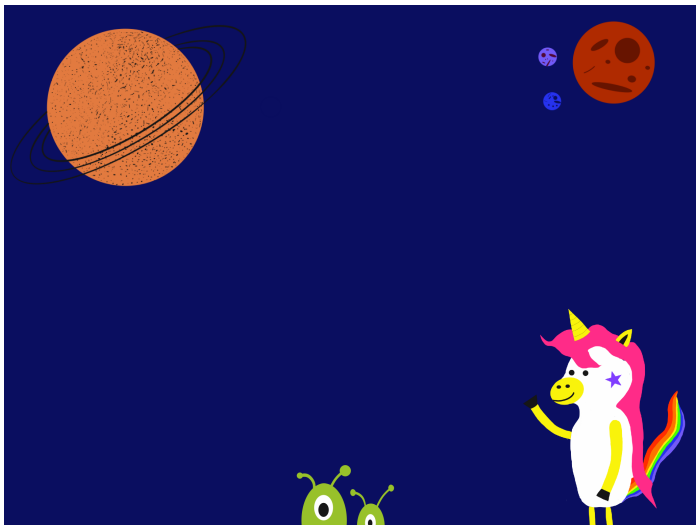


Figure 5.10: Custom menu background, all UI elements are added on top of this image

I created a simple story for each gamemode, that describes the purpose of gameplay highlighting both the setting and the additional character.

*"Lolly the space sheep is travelling space when she lands on an unknown planet! There she finds a factory, where Unity works sorting items onto rockets to be sent across the universe! The factory is broken when Lolly arrives, food is spilling everywhere and Lolly wants to help! Can you help Lolly and Unity sort the items into the correct rockets?"* - Single Player Story summary

*"Oh no! The factory is broken again! Player 1, can you help Lolly and Unity sort the items into the correct rockets? Player 2, you have the factory controls! Will you choose to help player 1 or try and stop them sorting correctly? You decide! But hurry! The last rocket is leaving soon!"* - Multiplayer Story summary

I used these stories to build both the gameplay and the tutorial which tells some of the story. I will then use these stories to compare the understanding of the game to what I intended to convey through the gameplay during the evaluation.

# Chapter 6

# Implementation

Throughout the game design process, implementation was continuous in the form of rapid prototyping. The result of this was the full design of the basic menu structure and factory scene. Additionally, game elements such as the conveyor belts and pipes were custom rendered in 3D using ProBuilder. Using these elements, with both the unity editor and extensive C# support, I implemented both of the gamemodes discussed above (See Appendix E for link to full game video). A walkthrough of the resulting games and the customisation features added are discussed within this chapter. Additionally, aspects of the game that were technically challenging or required innovative solutions are discussed in more detail.

## 6.1 Menus

As mentioned above, the menu and settings was created and had much functionality implemented during the design stage. The menu structure can be seen in the diagram below (Figure 6.1) in which the "Gameplay" object representents the game scene launching. Figures 6.2 and 6.3 show two menu states fully implemented within the game.

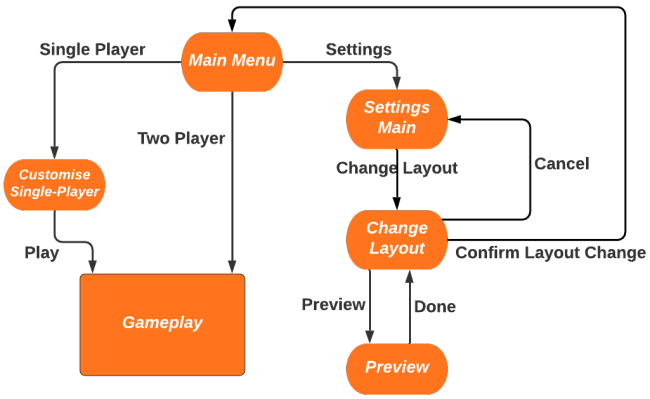



Figure 6.1: Diagram showing the menu structure for the game


Figure 6.2: Implemented menu from Figure 5.1

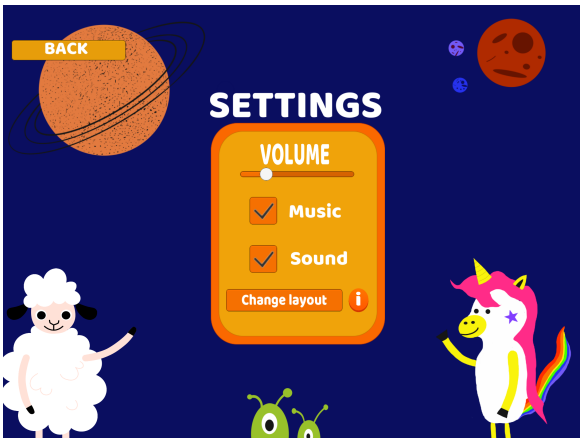



Figure 6.3: Implemented settings from Figure 5.2

## 6.2 Single Player Game

### 6.2.1 Gameplay walkthrough

The single player mode in the Sorting Factory asks the player to sort items that come down a conveyor belt. Both Lolly and Unity get randomly assigned an item for sorting, the player must identify this item and select the correct character to give it to based on the requested item in the speech bubbles shown. Any items not requested by the characters should be destroyed by the player. When the game begins, each item spawns and travel to the center of the screen, where the player can choose one of 3 options:

- **Right Pipe** - Indicated by the right arrow, if the player chooses this, the item travels towards Unity
- **Left Pipe** - Indicated by the left arrow, if the player chooses this, the item travels towards Lolly
- **Center Pipe** - Indicated by the red button in the center, if the player chooses this, the item travels into a red pipe and is destroyed.

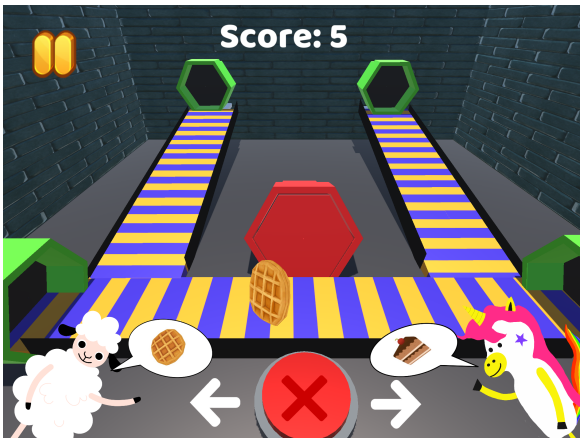



Figure 6.4: Item 1 waiting to be sent to pipe

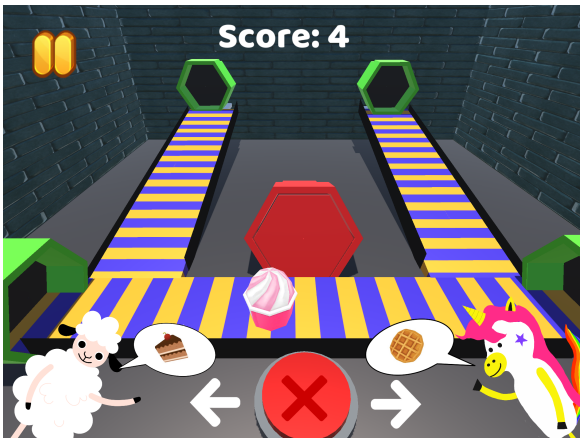



Figure 6.5: Item 2 waiting to be sent to pipe

Once the item enters the pipe it is compared to the items assigned to that pipe. If the player sorted the item correctly, they gain a point. If they sort the item incorrectly they lose one point. If the player chooses to do nothing, after 10 seconds a timer shows a countdown from 3. After this timer ends, the item enters the red pipe and is destroyed. In the figures above, the waffle item (Figure 6.4) should be sent to Lolly using the left arrow while the ice cream (Figure 6.5 should be sent to the red pipe/bin using the red x button.

According to the game length parameter discussed below, the game will have a fixed number of items to spawn. When this number is reached, the game ends and a panel shows an animation of the stars being achieved for the level (Figure 6.6). Each game difficulty/length pairing has different star points to achieve. Depending on the maximum number of items for this game length, the points needed per star is assigned. As the score bar loads, the function shown in Appendix A.4 shows how each star boundary is checked. When the score bar hits the score required to gain the star, the star changes color, plays a sound and begins to spin.

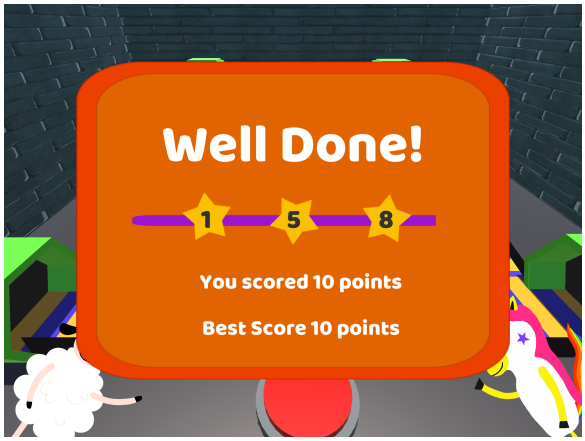



Figure 6.6: Game over panel showing score

### 6.2.2 Customisation

The single player gamemode can be customised in two ways: game length and game difficulty. These options have an effect on the amount of items that spawn, length of the timer and how many of the extra game features are used in gameplay. The impact of each setting on gameplay is shown in the tables below.

| Difficulty | % of decoy items (for red pipe) | Timer length (seconds) | Swap sides | Hide one item |
|---|---|---|---|---|
| **Easy** | 30% | 15 | No | No |
| **Medium** | 40% | 12 | Yes | No |
| **Hard** | 50% | 8 | Yes | Yes |

| Length | Maximum # of items |
|---|---|
| **Short** | 15 |
| **Medium** | 20 |
| **Long** | 25 |

While most of these effects are fairly simple, "Swap sides" and "Hide one item" were implemented as new features of the game. As can be seen in figure 6.7, Each character shows which item they are looking for in a speech bubble above their head.

"Swap sides" swaps these bubbles and thus, the required item for that pipe. A small sound plays indicating this change but it is up to the player to notice this and begin sorting the items into the opposite pipes. As can be seen above, this feature is enabled in both medium and hard difficulty, however only occurs once the player gains more than half of the available points.
"Hide one item" turns one of these speech bubbles to a question mark. The same sound plays indicating a change and this time, the player must remember which item was being requested by that character. This feature only occurs in the "Hard" difficulty games and triggers once the player gains more than 75% of the available points.

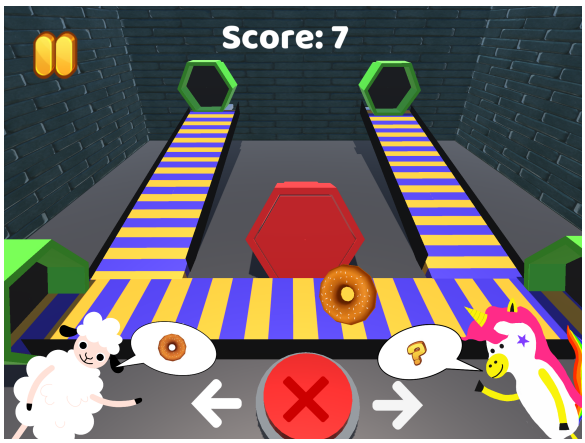



Figure 6.7: Hard mode when one item is "hidden"

These customisation options allow for more varied gameplay and add incentive for the player to try to achieve 3 stars in all difficulties. Additionally, as discussed in chapter 2, the dynamic setting of the hospital requires these games to be flexible around strict schedules and limited resources. Play therapists or other staff members can choose a game length based on the time they have with that patient, while ensuring the game is not too difficult for the child to play. If the child is playing alone or unsupervised, the game also offers both long and challenging options to entertain and distract the child. The menu the player can use to change these options before gameplay begins can be seen in Figure 6.8. The layout that can be seen here is different to that proposed in the initial designs where each option was on the screen at once. Through building this menu screen and deploying it onto the iPad for unit testing as development progressed, it was clear that the original design would be too cluttered for the small screen. Additionally, it could be hard for children to link each option to both each other as one category and to the labels associated with this. Instead, a menu wheel was chosen, using the arrows, the player can cycle through each option and handle one combination of game difficulty and length at a time.


Figure 6.8: Customisation options configured before launch

## 6.3 Two Player Game

### 6.3.1 Gameplay walkthrough

The two player mode in the Sorting Factory has player 1 perform the same actions as above in single player. They are tasked with sorting items into the correct pipes as requested by Lolly and Unity. However, in this mode, player 2 has a control panel that can be seen in Figure 6.9 which they use to help or sabotage player 1. This second role within the game is to encourage collaborative play with elements of competitive play. An adult would be much more suited to this role however two children could play together if supervised and assisted by an adult. This is due to the more complex nature of these elements, each lever or switch effects the game for player 1 and so, the player must be able to link these elements with the action.

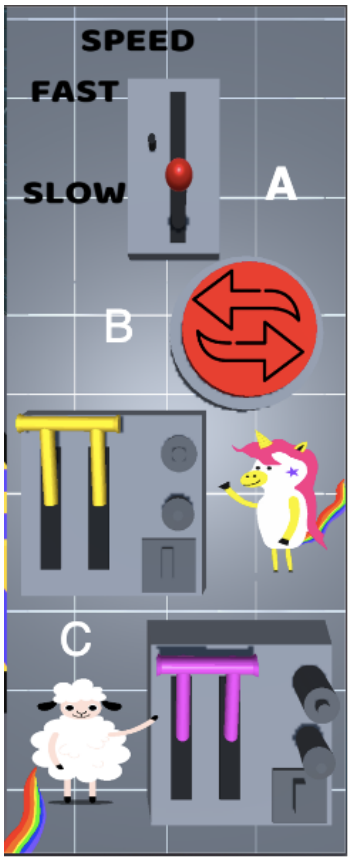



Figure 6.9: Labelled Control Panel used by Player 2

Player 2 has the following controls to use during gameplay:

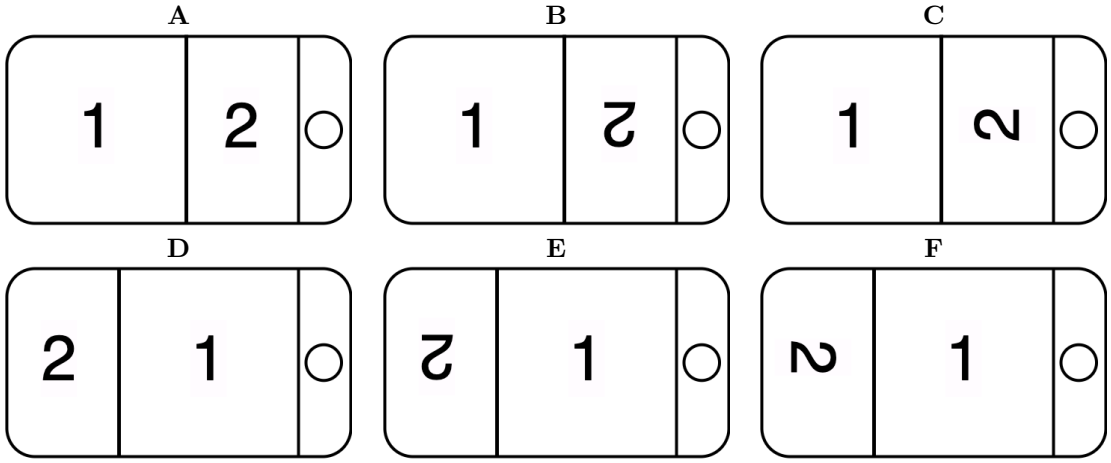
- Speed (A) - Player 2 can speed up or slow down the conveyor belts, increasing the speed will also decrease the time given to player 1 to make a choice of pipe.
- Swap sides (B) - Lolly and Unity swap the items they are requesting, the speech bubbles shown also swap
- Hide Lolly/Unity (C) - These levers allow player 2 to hide the item Lolly or Unity are asking for, showing player 1 a question mark instead

These options can be used by player 2 to sabotage player 1, adding competitive elements to the game. This is particularly useful for children who have played the game repetitively and are confident with the game elements in single player as well as children on the edge of the target age range who may find single player too easy and therefor boring. Conversely, player 2 may choose to help player 1 if they are struggling to gain points, revealing the item choices to them, slowing down the conveyor belts and giving them more time to decide on the correct pipe. In this way, an adult can monitor the child's behaviour, and assist the child without interrupting their gameplay experience. This would

allow a fully immersive gameplay experience and offer the intended distraction and comfort benefits intended with this game suite.

### 6.3.2 Customisation

Since this game is to be deployed on iPads that may be mounted in place, at a bedside or within a playroom, some customisation options were included to help the game be more **accessible**. Additionally to toggling sound and music and adjusting volume, the two player game orientation can be changed. In single player, the iPad itself will orientate the game to suit whichever position the iPad is being held in, but this cannot be used for two player games that share screen space. To combat this and to support gameplay in a hospital setting I added an orientation feature into the game itself. This allows the player to choose from a set of 6 layouts that matches the position of the players centered around the iPad. These orientation options for the second player, combined with the orientation of the iPad allows for the game to be fully flexible to the environment and accessible to a wider range of patients.




As can be seen in the above images, player 2 can play the game from any edge of the iPad and is fully accessible from any angle. Within the settings menu this layout can be changed. The orientation effects the game layout in the following ways:

- The tutorial panel with the instructions will face the player to match the orientation they have chosen.
- The control panel mechanics will be the same but rotated to match the orientation.
- The control panel labels will face the player so they can be read easily.


Figure 6.10: Gameplay when Layout E is chosen

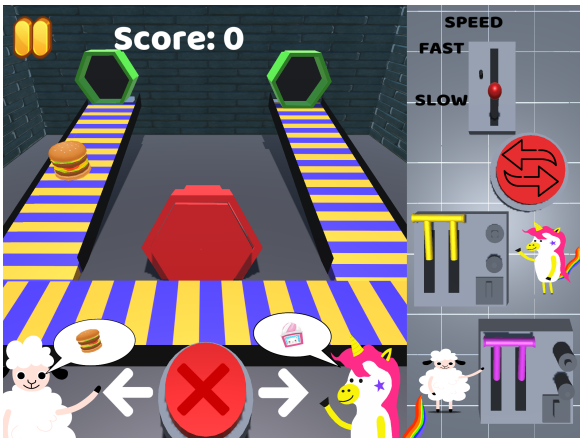



Figure 6.11: Gameplay when Layout A is chosen

Within the settings menu, the player can view each orientation option and "preview" this within the game. The preview screen shows an example of how the game will look with this orientation. The player can use this to ensure this layout best suits their environment before confirming their choice. Similar to that of the customisation for single player, this menu page (Figure 6.12) proved very cluttered when all the options were displayed on the screen at once. For consistency, and to improve learning across the game, this menu was implemented as a choice wheel with only one orientation setting showing at any time. Choosing to preview this option will show a single image of that orientation within the gameplay.

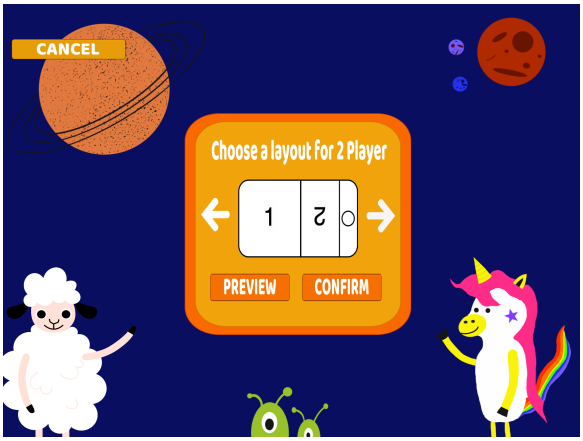



Figure 6.12: Settings page to change layout

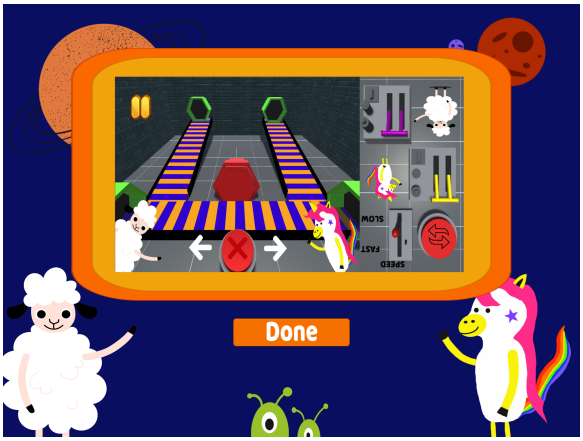



Figure 6.13: Preview of game layout chosen in Figure 6.12

## 6.4 Hints

As an additional feature, the player is tracked throughout gameplay in both modes and hints are provided dynamically when necessary. In both easy and medium difficulty, the first 2-3 items are indicated with a hint hand which points to the correct button. In all modes and difficulties, if the player loses points (incorrectly sorts or runs out of time 3 times in a row) the hints will turn on. These small indicators as can be seen in Figure 6.14 show the player which button should be chosen. Once the player gains their first point after hints turn on, they turn off and the counter resets to 0. This feature albeit small is a direct response to the design requirements and framework in chapter 5. Children playing the game alone can be assisted by the game itself, to ensure the game remains immersive and not frustrating for the child.

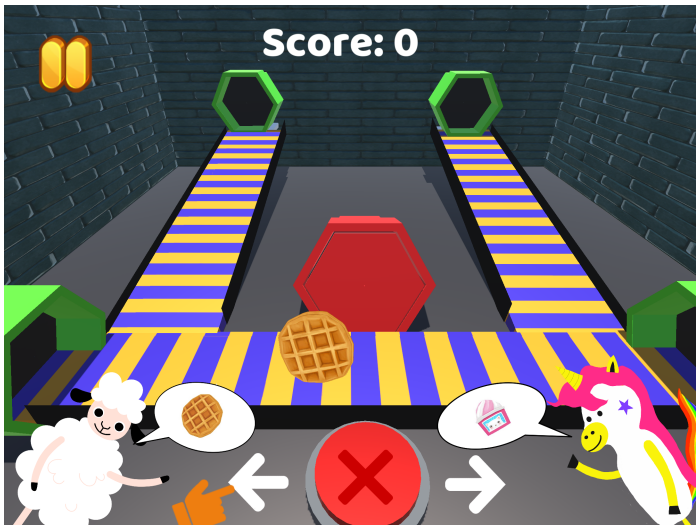



Figure 6.14: Hint displayed to player showing intended action is the left arrow

## 6.5 Technical Challenges

### 6.5.1 3D rendering

The two main components that appeared in the results of the design workshop were delivery pipes for items and conveyor belts for the items to travel on. Based on these designs provided by the children, I created 3D objects to be used within the game (Figure 6.15 & Figure 6.16). The pipe prefab was used for both the green pipes and the red bin pipe. The red pipe had an additional front panel "door" which when activated spins open and pulls the item down into the pipe (See Appendix A.3 for source code). I used ProBuilder to render these, combining and adapting series of basic objects together into a single prefab.

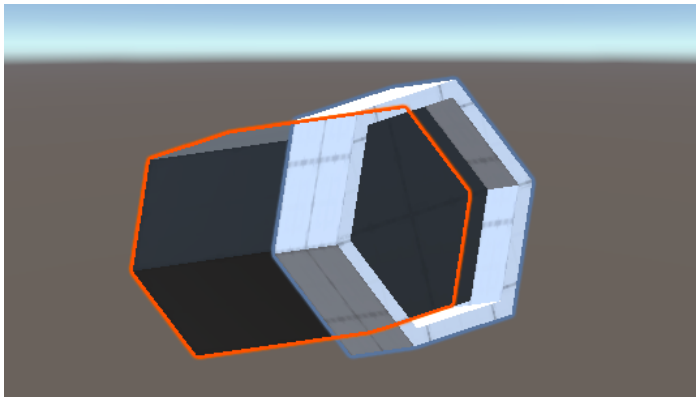


Figure 6.15: 3D pipe rendered using ProBuilder

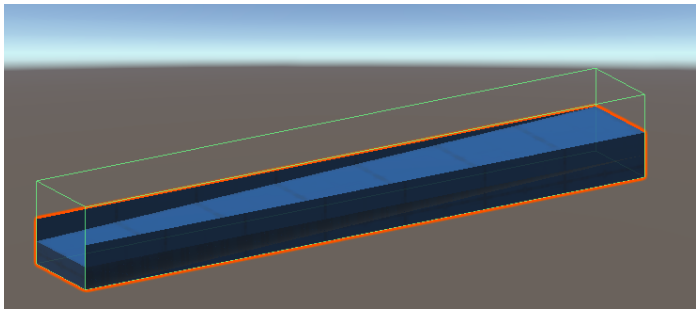


Figure 6.16: 3D conveyor belt rendered using ProBuilder

I added a basic material to each of the pipe elements to create the pipe we see within the game. For the conveyor belts, a basic material was added to the barriers while a custom striped material was created for the belt itself. The items travel down the center of the conveyor belts, and so to convey the movement of this component, this material was animated using C#. I experimented with the scroll speed to match the speed at which the items would travel down the belt. This was done by extracting the mesh from the component, and subtracting or adding the speed value. Adding to the mesh uv will appear to move the belt across the screen from left to right, while subtracting from

the mesh uv will appear to move the belt from right to left. The following code snippet was used to achieve this motion:

```
componentMesh = GetComponent<MeshFilter>().mesh;

void Update() {
    Vector2[] componentUV = componentMesh.uv;

    for (int i = 0 ; i < componentUv.Length ; i ++)
    {
        componentUv[i] -= new Vector2(conveyorSpeed * Time.deltaTime,
        ↪  conveyorSpeed * Time.deltaTime );
    }

    conveyorMesh.uv = componentUv;
}
```

Figure 6.17: Move item towards endpoint when in conveyor belt trigger space

The factory scene as can be seen in Figure 6.7 and Figure 6.10 was rendered using a combination of basic Unity 3D shapes as well as the prefabs discussed above. The items that can be seen travelling down the conveyor belts are 3D objects as provided by the "3D Bakery Objects" asset package. Each has rigid body applied to mimic physics and allow them to travel down the conveyor belts which have been tilted downwards towards the center of the screen. The conveyor belts are tilted in such a way to help convey the depth of the game and its 3D aspects. Similarly, the pipes at the back of the wall are slightly smaller than the pipe in the center as the player is "closer" to the red pipe. The scene is in 3D within the unity environment and so the elements at the back are truly further away from the camera, however emphasising this helps convey the setting on a 2D screen and create a more immersive experience for the player.

### 6.5.2 Conveyor Belts

In order to move the items down each conveyor belt towards the middle of the screen, I first created a single conveyor belt and added a trigger space above the component. Each conveyor belt has an attached empty game object with a fixed position. This acts as a pull for the item - when the item is within the trigger space, the conveyor belt moves the item towards the endpoint. The conveyor belt trigger spaces overlap in such a way that the item is passed from belt to belt, moving towards each endpoint until it reaches a predefined stopping point. Figure 6.18 and Figure 6.19 below show this setup - the green boxes indicate the trigger spaces for the conveyor belts. As an item travels down a conveyor belt from the back it it within the green boxes on the left side of the image, as it exits this trigger, it enters the green box on the right side of the image. This trigger then turns this belt to on, and begins pulling the item towards the center of the screen. When it reaches the endpoint goal it stops and begins to spin, waiting for the player to choose a pipe for it to travel to.

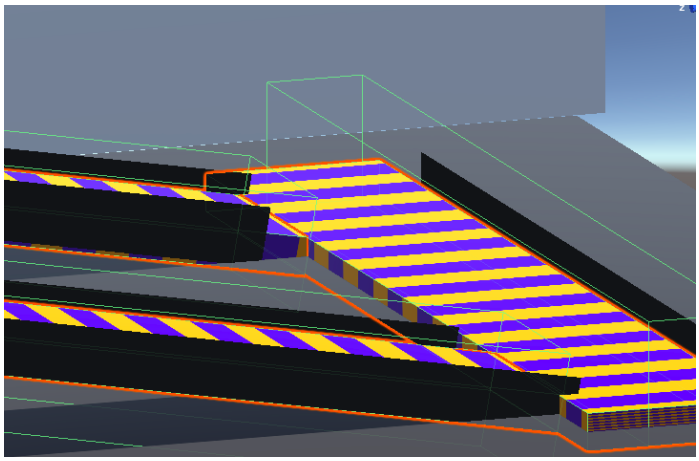


Figure 6.18: 3D pipe rendered using ProBuilder

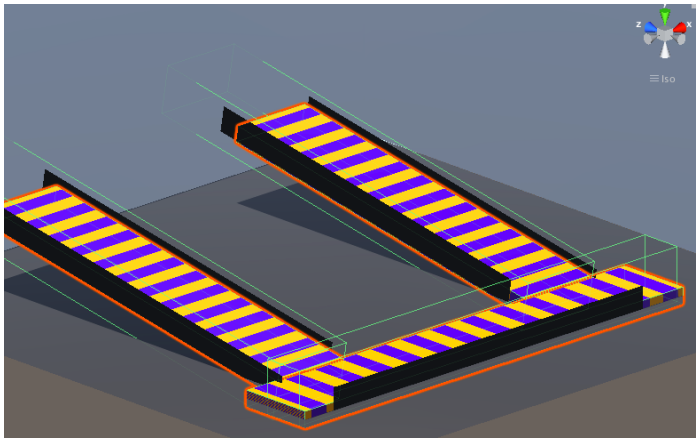


Figure 6.19: 3D conveyor belt rendered using ProBuilder

The endpoint assigned to the conveyor belt by the button the player uses. The right arrow will set the `pipe.position` on line 4 below to the right pipe, after this pipe has been assigned the conveyor will turn on (`go = true`) and pull the item towards the pipe. The following code shows this process which is standard across each conveyor belt:

```
1     private void OnTriggerStay(Collider other)
2     {
3       if(go) {
4         other.transform.position =
          ↪  Vector3.MoveTowards(other.transform.position, pipe.position, speed
          ↪  * Time.deltaTime);
5       }
6     }
```

Figure 6.20: Move item towards endpoint when in conveyor belt trigger space

### 6.5.3 Spawning items

In order to spawn the items dynamically, ensuring each game is different for the player, I created a `spawnObjects` function within the `Controller` class. This function holds a fixed list of available objects to spawn and each has an index referring to their position in the list. The function first uses `System.Random` function to produce two numbers which will be the items Lolly and Unity are asking for. The rest of the items can then be used to spawn any "decoy" items. The `spawnObjects` function will pick the following parameters for the spawn action using this `System.Random` functionality:

- A pipe for the item to spawn within
- Whether the item will be a decoy or requested item
- Which of the available items will spawn

The previously assigned variables `winObjects`, `loseObjects` (decoys) are decreased (See lines 7 and 17) depending on these parameters and then used to determine when the game is finished. This full function can be found in Appendix A.1 but below Figure 6.21 shows the section of code for the description above with lines 8 and 18 showing the instantiation of the object prefabs.

```
System.Random rnd = new System.Random();
  int choice = rnd.Next(5);
  if(loseObjects>0 || winObjects>0) {
    while(true) {
      if(objects[choice].Equals(leftChoice) ||
      ↪  objects[choice].Equals(rightChoice)) {
        if(winObjects>0) {
          winObjects = winObjects-1;
          Instantiate(prefabs[choice], spawn, Quaternion.identity);
          break;
        }
        else{
          choice = rnd.Next(5);
        }
      }
      else{
        if(loseObjects>0){
          loseObjects = loseObjects-1;
          Instantiate(prefabs[choice], spawn, Quaternion.identity);
          break;
        }
        else{
          choice = rnd.Next(5);
        }
      }
    }
  }
  else{
    isfinished = true;
  }
```

Figure 6.21: Move item towards endpoint when in conveyor belt trigger space

### 6.5.4 Orientation

To implement the customisation options for two player gameplay as discussed above, I added a second camera to the scene. This camera pointed downwards at a plane containing all control panel elements. By accessing the `Viewport Rect` for each camera, the screen was split dynamically depending on orientation settings between these views:

```
    //Player 2 positioned on left side of screen
    cam1.rect = new Rect(-0.3f, 0,1,1);
    cam2.rect = new Rect(0.7f,0,1,1);

    //Player 2 positioned on right side of screen
    cam1.rect = new Rect(0.3f, 0,1,1);
    cam2.rect = new Rect(-0.7f,0,1,1);
```

Figure 6.22: Move item towards endpoint when in conveyor belt trigger space

The above code splits the screen 30/70 between the two cameras, allowing both the main sorting factory and the control panel to be shown together. Using `PlayerPrefs` to obtain the chosen layout for the game, the screen is split to place the control panel on player 2's side of the screen. Depending on the position of player 2 that was chosen, the control panel and labels were rotated. The tutorial panel was also rotated to be facing the same direction as the game elements.

## 6.6 Assets imported from unity asset store

The following packages and assets were imported from the Unity Asset Store for this project:

- **3D Bakery Objects** by Layer Lab - Provided the 3D food items that are to be sorted by the player
- **Music - Fun and Games** by SD Sound Tracks - Used for background music
- **Textures - Brick and Tile** by Mixaill - Used for wall texture
- **Interactive Objects** by Monqo - Used for control panel elements
- **Puzzle User Interface Sound** by Craft Media Group and **Fantasy Menu SFX** by Chris M Audio - Used for assorted chimes and sound bites.
- **Simple Button Set 01** by That Witch Design - Used for pause menu and check boxes
- **PSD Logo Templates** by Unruly Games - Used template to create logo

# Chapter 7

# Evaluation

Once implementation was complete, an evaluation could be carried out to assess the system for bugs and heuristic issues as well as gathering feedback on the game design. The evaluation method discussed in chapter 2.5.4 was organised and planned but changed in response to the global pandemic COVID-19, moving to a combination of methods and techniques that observed the current government guidance.

After I conducted the design workshop discussed in chapter 3, I proposed the evaluation workshop to the group leaders. They were eager to see the prototype and the children were excited to see their designs implemented in the game. That night, the group committed to planning the workshop in the new year for a week in March to align with my project timeline. The workshop was then confirmed in January for the 9th of March 2020 and I began planning the details of the session with the group leader and my supervisor. I planned to bring two of my own personal iPad devices with the game loaded to allow the children to play in pairs or individually. I would then gather feedback and take personal notes of any points of interest as well as my own observations of the interactions with the game. I found that this would be the easiest form of data collection as the group has approximately 25 children in a small hall which would make recording and transcribing the session a very difficult task.

Covid-19, as named by the WHO on February 11th 2020, was then declared a global pandemic on March 11th 2020. Before this official declaration from the WHO, the public began limiting social interactions in an attempt to slow the spread of the virus. Due to this, in discussion with my supervisor, I decided that in order to avoid risk to both myself, the children involved and their families that the workshop should be cancelled. Soon after this, the university began moving to remote learning and we were officially advised to cancel any upcoming user studies. After this, I began planning a replacement evaluation study and the following plan was created.

## 7.1 Evaluation Plan

Without the opportunity to run an interactive workshop with a large number of participants, I decided that I would use a combination of Heuristic Evaluation with HCI experts and online surveys with children and adults to perform some iterative evaluation of my game. First, I planned the heuristic evaluation, recruited participants and created the materials needed for that study. While planning this, I drafted and submitted all documents necessary for the ethical approval needed for

the online survey study I would be conducting at a later date. After gathering results from the heuristic evaluation, I planned to make any necessary changes to the prototype using the severity ratings as described below to prioritise these usability concerns. This updated prototype would then be used to record videos which participants in the second user study would watch and answer questions about. A combination of these studies allowed me to gather feedback on both the technical aspects of the system, including usability issues that a child may be unable to identify as well as design aspects and game mechanics.

## 7.2 Heuristic Evaluation

### 7.2.1 Methodology

The first method used in my iterative evaluation was a heuristic evaluation based on that described by (Nielsen, 1992). This type of evaluation is typically conducted with a small group of HCI experts who perform a walk-through of the system, completing tasks while considering a subset of Nielsen's heuristics. To conduct this study, I recruited 4 participants that, according to the definitions provided in Nielsen (1992) paper describing heuristic evaluations, would be classified as "Regular usability specialists". I recruited these participants via email, from a group of students that have completed several university modules centered around usability and human-computer interaction.

To conduct this study I created a worksheet for participants to document the usability problems found while they completed each of the tasks. The instructions informed the participants about the heuristics chosen for the study with a short explanation for each one. The heuristics I chose to include in the study and a brief justification for each can be found below:

- **Visibility of System status** - An important heuristic for apps and games aimed at children, this heuristic is required to achieve design principles 1, 2 and 3.
- **User control and freedom** - Given the focus of this project on customisation controls, this was a particularly important heuristic to evaluate.
- **Consistency and standards** - In order to avoid confusion when creating software for children, consistency is crucial. Principles 8, 9 and 10 can be evaluated here.
- **Flexibility and efficiency of use** - As implementation progressed, this became a key heuristic to consider. Evaluating it in this way was very important as it was a requirement that emerged after the creation of the initial design framework.
- **Aesthetic and minimalist design** - Elements of design that do not follow the guidance of this heuristic can have a butterfly effect through the entire system. Evaluating the success of these elements can encourage solutions to problems both unseen and identified within this study under a different heuristic.

Additionally, in order to prioritise fixing these problems discovered, I provided a severity scale to the participants that they could use to rate each problem they discovered:

**1** I don't believe this is a usability problem at all

**2** Cosmetic problem only: need not be fixed unless extra time is available on the project.

**3** Minor Usability problem: fixing this should be given low priority.

**4** Major usability problem: important to fix before project deadline.

**5** Usability catastrophe: imperative to fix before the project deadline.

The participants were also supplied with the design framework from chapter 5.3, as well as the following tasks and space to document any usability problems:

- **Task 1** - Choose a difficulty, length and sound/music settings and complete 1 game of single player.
- **Task 2** - Find and set the layout orientation that best suits how you and the researcher are currently sitting.
- **Task 3** - Play and complete one game of multiplayer using the layout from task 2.

The full document provided to participants can be found in Appendix C. Each participant was provided with the document and my personal iPad with the game loaded. There was no time limit imposed on the study but each participant spent approximately 20 minutes completing the tasks and documenting issues found.

### 7.2.2 Results

This user survey provided a list of usability problems annotated with a severity rating and the heuristic that was violated. A summary table showing the total number of problems found per heuristic an the average severity rating:

| | **Quantity of Problems Encountered** | **Average Severity Rating** |
|---|---|---|
| **Visibility of System Status** | 4 | 2.75 |
| **User Control and Freedom** | 1 | 3 |
| **Consistency and Standards** | 11 | 2.45 |
| **Flexibility and Efficiency of Use** | 3 | 2 |
| **Aesthetics and Minimalist Design** | 4 | 2.25 |

Analyzing these results it is clear that the majority of usability problems found by the experts were violating the Consistency and Standards heuristic. The definition provided to the participants for this heuristic was "Users should now have to wonder whether different words, situations, or actions mean the same thing".

Some examples of problems noted by the experts are shown below in their own words:

- Pause button not always in the same location on the screen.
- Some labels display a highlight colour when clicked, similar to that of the buttons, this suggests these labels are also buttons.
- There is a tutorial for single player but no matching tutorial for two player.
- Swap button not as clearly labelled as the other controls for Player 2, leaves the function of the button ambiguous/confusing.

Calculating the average severity rating for these issues shows that while each heuristic had at least one violation found by the 4 experts, the issues were mainly cosmetic problems or minor usability problems. Across all 4 evaluations, there were no reported problems that reached a 5 on the severity scale, and the only problems classified as a 4 on the severity scale were related to the tutorials. As seen above, one evaluator commented that a second tutorial should be added that offered instruction to player 2. Additionally, two evaluators noted that the beginning of the single player tutorial required a loading wheel or similar icon to instruct the user to wait as the initial scene shows the factory pipes breaking.

## 7.3 Prototype changes in response to user study

After analyzing each of the worksheets submitted by the experts, I created a list of design aspects and game mechanics that I could improve using this feedback. Additionally, I created two new mechanics that would be added to the game to help with user understanding and consistency: A tutorial for two player and a confirm layout screen to be placed before the two player game launches. I started by implementing some basic changes such as relocating the pause button and disabling the "destroy" button during the tutorial. After I had addressed these problems, I designed and implemented the two new features. For the new tutorial, the single player tutorial first launches to show player 1 their role in the game, and then a new tutorial section was created for player 2. The instructions for this tutorial are positioned relative to the chosen orientation for this gamemode as can be seen below.


Figure 7.1: Two Player tutorial for the orientation confirmed in Figure 7.2 (Layout B from section 6.3.2)

The confirm layout screen shows the current layout option to the user before the tutorial launched, and offers two options to proceed: **change** and **confirm**. "Change" redirects the user to the orientation change page within the settings menu (Figure 6.12), cancelling this change will return the user to the confirm page (Figure 7.2). Clicking "Confirm" will launch the tutorial and game for two player with this orientation setting (Figure 7.1).

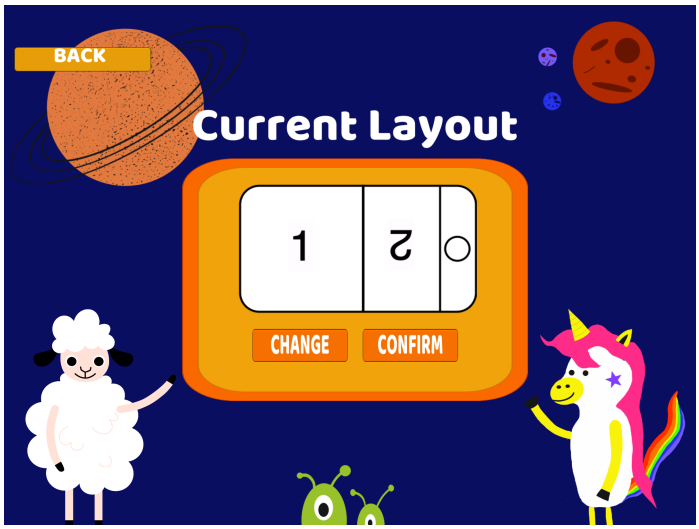



Figure 7.2: Confirm screen shown before two player launches

This feature added a new route for the settings page orientation section. The page was updated to track from which page the player had come from, so that cancel and confirm would take the player to the correct panel or scene. This change to the menu structure can be seen below in Figure 7.3 where the purple path shows changing orientation within settings and the red path shows when the orientation is changed from Figure 7.2.

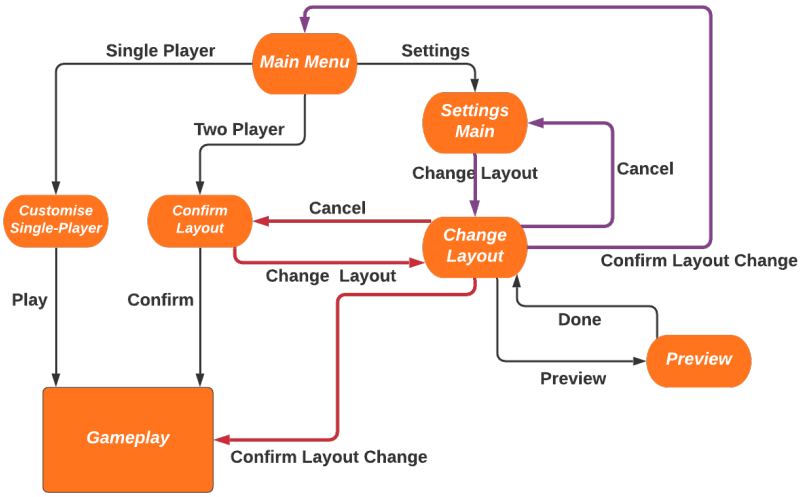



Figure 7.3: New menu structure showing highlighted paths

Additionally, most of the small aesthetic changes suggested were made to the game, and a loading bar was added to the tutorial screen to indicate system status to the player. This update can be seen in Figure 7.4.

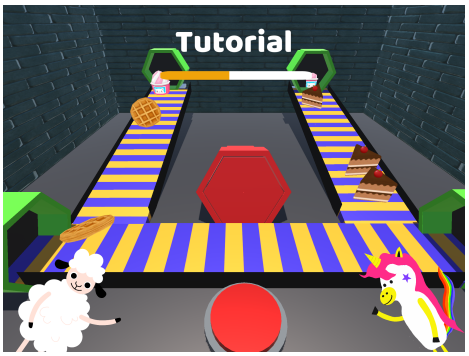



Figure 7.4: Tutorial showing loading bar as first destruction scene plays

## 7.4 Video review and survey

### 7.4.1 Methodology

After making the changes to the prototype as detailed above, I conducted a second user study with a small group of children. In lieu of having the children play the game and provide feedback directly, I instead chose a remote asynchronous method. As described I created videos of each tutorial and each gamemode, and designed a survey around these videos to gain feedback on design as well as assessing how effective the tutorials were for the children involved. To recruit children for this user study I reached out to relatives and family friends who had children between the ages of 9 and 11 years old. 5 families were interested in taking part in the studies which results in 6 individual responses to my survey. In line with government guidance at the time regarding the pandemic, I reached out to all families via email or skype and communicated all instructions and information about the study in the same way. The survey was split into the following sections:

- Tutorial - Single player Video  questions
- Gameplay - Single player Video and questions
- Tutorial - Two player Video and questions
- Gameplay - Two player Video and questions

The questions included in the survey can be seen in detail in the discussion of the results below but were aimed at gathering feedback on the participants understanding of the tutorial as well as offering opportunity to note aspects they liked and disliked about the game. Creating a survey for children to answer requires some additional thought and consideration. Questions must be designed in such a way that children can understand and answers gathered in a form that allows the child to successfully return their answer (Read and Fine, 2005). Considering this, I used mainly free text response questions, to allow the participant to answer freely and avoid misinterpretation of multiple choice answers.

### 7.4.2 Results

The children successfully completed the survey, however it should be noted that parents were free to type on behalf of the children and so the answers given may be paraphrased. Their insights into future works and improvement for the game were invaluable and their understanding of the main objectives showed the success of the single player tutorial. Without having the children play the game themselves, an understanding of the players actions within the game shows successful communication of the game mechanics and rules through use of the tutorial for single player. A more detailed analysis of each question for both the single player tutorial and the single player gameplay section can be found below.

## Section A - Single Player Tutorial Questions

1. **Did you find the tutorial easy to understand?**
   100% of the participants answered "Yes I understood all of the tutorial"

2. **Do you think you would know how to play this game after watching the tutorial?**
   100% of the participants answered "Yes"

3. **What do you think the player has to do in this game?**
   The free-text responses to this question varied in detail but 100% of participants wrote a correct interpretation of the players role. Some examples of these answers can be seen below:

   "Sort items into 3 different places (Lolly, Unity and bin)"

   "You need to swipe the burgers and donuts away but throw things that aren't burgers or donuts in the bin"

   "Sort the food items out"

## Section B - Single Player Gameplay Questions

1. **Now that you have watched the game, is there anything you think would make the tutorial easier to understand?**
   Four participants answered that they would not change anything about the tutorial.
   Two participants noted that some audio element would make it easier to understand - "voice commands" and "voice reads instructions out".

**2. What age group do you think would enjoy this game the most?**

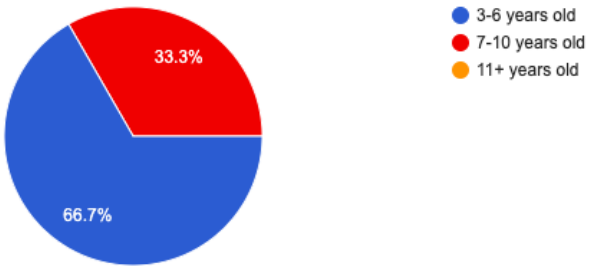



Figure 7.5: Chart showing answers to question 2.

**3. How easy/difficult do you think this game would be for 3-6 year olds?**

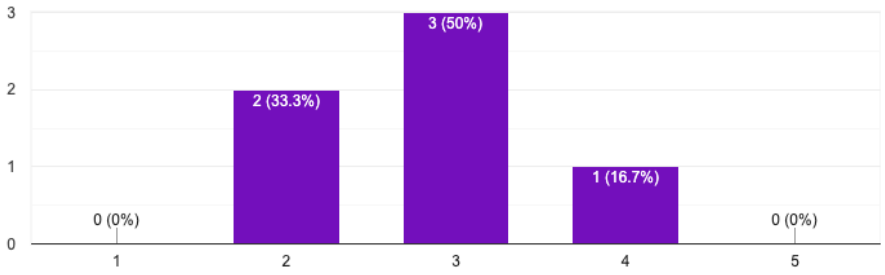



Figure 7.6: Graph showing answers to question 3

The scale assigned to the points above was as follows: 1 - Very easy, 2 - Easy, 3 - Moderate, 4 - Difficult and 5 - Very Difficult. As can be seen in the graph above, the responses on this scale were varied. This could partially be due to misinterpretation of the scale as each number was not labelled within the form. Using the data from Question A.3 we know that all respondents understood the game, so these difficulty ratings are likely influenced by their understanding of the scale, or informed opinion on difficulty rather than lack of understanding of the mechanics.

**4. Is there anything you liked about the game?** The answers to this question were very positive and were centered mostly around the graphical elements such as the items and the conveyor belt and bin movements. Some examples of these responses are:

> "Clicking buttons. Exciting if lots of sweets/cake came together/got faster"
>
> "The conveyer and bin graphics look good. The two colours help the motion of the conveyer I dont think you would see the motion without two colours, it would look like its sitting still."

5. **Is there anything you would change about the game?** While the majority of respondents claimed they would not change anything about the game, one participant answered that being able to pick your own character or avatar would make the game more fun.

### Two Player

Some children found the two player tutorial for player 2 hard to understand and some could not ascertain the role of the second player within the game. This could be due to this role being inherently designed for adults (caregivers or hospital staff) to play but suggests that this tutorial or perhaps the role itself is confusing for children. Running a lab study in which the children play the game together and with an adult would provide more insight on the problems with this gamemode/tutorial. The following shows a more detailed analysis of these findings.

## Section C - Two Player Tutorial Questions

1. **Did you find the tutorial easy to understand?**

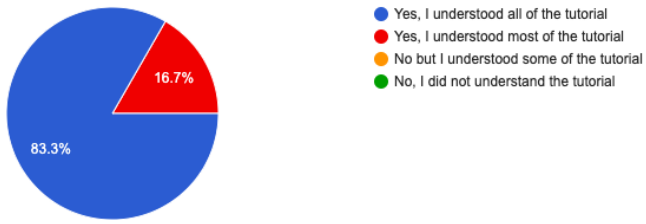



Figure 7.7: Chart showing varied answers to question 1.

2. **Do you think you would know how to play this game after watching the tutorial?** 100% of respondents answered that they would know how to play the game after watching the tutorial.
3. **In this mode, what do you think player 1 does?**
Most (83%) of the respondents successfully identified the role of player 1 within the game. This would be expected as 100% of respondents identified the same role watching the same tutorial in question A.3.
4. **In this mode, what do you think player 2 does?**
Only 50% of respondents successfully identified the role of player 2. The incorrect answers included sorting the items as is Player 1's role and splitting the conveyor belt where 1 player gives items to Lolly and one gives items to Unity. This clearly identifies the problem with this tutorial is with Player 2's role description specifically.

## Section D - Two Player Gameplay

1. **Now that you have watched the game, is there anything you think would make the tutorial easier to understand?**

Similarly to the responses given in question B.1, respondents noted that voice commands or voice over for the tutorial would make it easier to understand. Additionally, there were suggestions for a test screen like is included in the first tutorial where the player can try each button and switch and see the effect they have or to have instructions appear during gameplay to help with confusion.

2. **Is there anything you like about the two player mode?**
   Answers to this question were entirely based on the cooperative aspects of the game. Some examples of responses can be seen below:

   "You can play with your friends"

   "That Its co-operative"

   "It means that its not an alone player playing"

   "That you can have fun with someone else"

3. **Is there anything you would change about two player mode?**
   50% of respondents answered that they would like to change the tutorial for this mode, which matches the findings from Section C above. Other answers included adding bonuses and an item shop where you could spend points gathered on coins, characters or items.

4. **Do you think the two player mode is easier/harder/same as single player?**

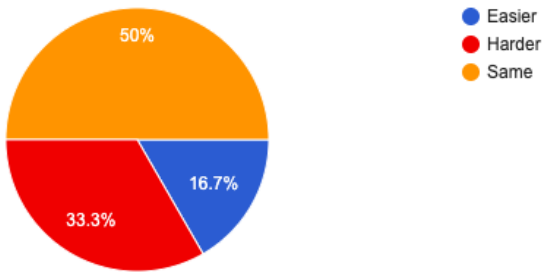



Figure 7.8: Chart showing varied answers to question 4.

Given the analysis of the above answers relating to the two player gamemode, the response to this question is varied but can be expected. Preparing this question in the survey, there was no "expected result". The game can be more difficult, or easier depending on whether player 2 chooses to help or hinder player 1's sorting. Perhaps the answer that would fit most with the new rules is "Same" as any difficulty added by the new features can just as easily make the game easier for player 1.

### 7.4.3 Summary

This survey provided very valuable insights about the game and the quality of the tutorials. There is clear evidence for the success of the player 1 tutorial, even over video it conveyed the role of player 1 and the game rules and mechanics. An improvement to this and the game in general would be a

voice over to the tutorial or ongoing voice instructions as gameplay progresses.

Through Section C and D it was revealed that the two player tutorial requires improvement to be used by children. This role was created to be used by adults and so the tutorial has more written text and doesn't include as many "Try it out" options as the player 1 tutorial does. Due to this, it would be expected that the tutorial would be understandable to adults that would be reading it to learn about their role in the game. To test this hypothesis, I used Sections C and D of this survey to create a short survey for a small group of adults to complete. If adults have the same misunderstanding and confusion with the two player tutorial, then a complete redesign of the tutorial would be recommended. However, if the adults find the tutorial easy to understand and can identify player 2's role within the game from the videos, then a solution may be to add an adult tutorial and a child tutorial for the two player gamemode.

## 7.5 Repeated Survey with Adults

### 7.5.1 Methodology

This survey was entirely created using Sections C and D of the survey described above, these sections can be seen in Appendix D. The intention was to ascertain if the two player tutorial is less confusing for adults than it is for children. The participants were recruited from the group of experts that were eligible to complete the heuristic evaluation in section 7.2. An additional restriction on participation for this small study was that they had not completed the heuristic evaluation for this project. This was to ensure the participants had no prior knowledge of the two player gamemode, allowing all responses to be that of knowledge gathered directly from the tutorials. The participants watched the videos of gameplay used in the survey for the children and answered the same questions that can be seen in Appendix D.

### 7.5.2 Results

#### Section C - Two Player Tutorial Questions

1. **Did you find the tutorial easy to understand?**
   100% of respondents answered "Yes I understood all of the tutorial"
2. **Do you think you would know how to play this game after watching the tutorial?**
   100% of respondents answered "Yes"
3. **In this mode, what do you think player 1 does?**
   100% of respondents correctly identified player 1's role in the game.
4. **In this mode, what do you think player 2 does?**
   100% of respondents correctly identified player 2's role in the game.

#### Section D - Two Player Gameplay Questions

1. **Now that you have watched the game, is there anything you think would make the tutorial easier to understand?**
   75% of respondents answered that they would not change anything about the tutorial. 1 Suggestion for improvement was highlighting each control panel element when it was being discussed within the tutorial panel.

2. **Is there anything you like about the two player mode?**
   Similarly to the results from the children, the answers centered around the cooperative nature of the two player gamemode. Additionally, respondents commented on the orientation options:

   > "It is nice that you can change he orientation of the screen layout to make it more comfortable no mater the play area."

   > "I also think its a great idea to have the option to move the player sections around on the screen. I don't think i've seen this in an app before but I like it."

3. **Is there anything you would change about two player mode?**
   The respondents suggested that the game could last longer and have a popup or sound to trigger when player 2 changes the game with a control panel element. None of the respondents mentioned changing the tutorial, in contrast to the responses gathered in section 7.4.

4. **Do you think the two player mode is easier/harder/same as single player?**

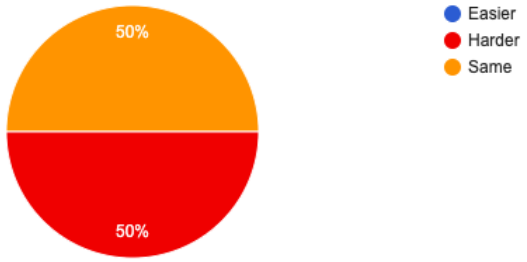



Figure 7.9: Chart showing varied answers to question 4.

Unfortunately, there was no clarity on the difficulty comparison after running the survey with adults. Running a lab study allowing both children, child-child pairs and child-adult pairs where they can play the game and feedback directly would provide more insight into this question.

### 7.5.3 Summary

This survey showed that the tutorial could be understood by adults, and would suggest that an appropriate improvement would be another tutorial for children. When two player is selected, the players could choose whether gameplay is with 2 children, or a child-adult pair. On the other hand, the tutorial could be amended to be easier to digest by all to remove the need for another menu screen between the main menu and gameplay. This would include voice commands, ongoing instruction and interactive elements like that included in the single player tutorial.

# Chapter 8

# Discussion

The aim of this project was to develop a framework and methodology for designing and developing a game for children in hospital. The initial project aims as set out in Chapter 1 and the discussion of the research outcomes are listed below:

- **The game will follow the design framework discussed in Chapter 5, and make extensive use of the results of the design workshop**

  This aim was actualised primarily by modeling the 3D game setting as well as the designing the characters based on the drawings made by the children in the workshop. Additionally, as is mentioned within discussion surrounding each element, the design framework was referenced throughout both design and implementation. The effects of these efforts can be seen in the feedback from the children in chapter 7.4. This outcome would have been evaluated further when returning to the original group of children that provided the design drawings the game elements were inspired from. However, I believe the results from the survey as well as general feedback from the HCI experts is sufficient to say that this aim was achieved.

- **The game will be usable, have a clear goal and be complete as a game prototype**
  To evaluate the success of this aim we can look to several pieces of evidence. First, the game is complete as a prototype as can be seen in the gameplay videos, screenshots and code snippets. To assess whether the game was usable and had a clear goal we can look to the evaluation chapter above. From unfortunate circumstances came a unique opportunity for evaluation of this aim in particular. The participants of both surveys conducted in chapter 7.4 and 7.5 watched videos of the tutorials and then gameplay for each gamemode. Without being able to interact with the system or play the game, all responses to the questions for Section A and C were reliant on reading and understanding the tutorial. As discussed in the results of this survey, many of the children correctly identified the main goal of game for both gamemodes. The heuristic evaluation showed that the game had some usability problems in its first iteration but now these have been rectified within the changes made to the prototype between evaluation sessions.

- **The game will have instructions that are easy to understand by children within the target audience (3-6 years old) and reduce confusion with the rules or game mechanics**
  As discussed above, this aim is supported in both the design framework created (framework

points 15-17) and through use of both tutorials and in-game hints. The survey shows that the children could understand the single player tutorial with 100% success rate. The children had some difficulty identifying the goal after watching the two player tutorial so this aim would require future work and development to be fulfilled. Additionally, the evaluation performed was with children of an older age group (7-11), while these results are valuable from this age group they do not provide any insight into the target audience specifically.

- **The game will encourage and provide a platform for meaningful collaborative play.**
  The game in both design and implementation inherently provides opportunity and actively encourages collaborative play. To ascertain whether this play is meaningful, we can look to both the features implemented and the feedback given. The main aim of this project was to provide an accessible environment for collaborative play. Features like game length, game difficulty and most prominently the orientation settings provide much more flexibility for play than that of some commercial games. The orientation settings is a unique feature tailored to the hospital with an understanding that one or both players will be unable to move around the iPad. Restricting the gameplay to assuming that the players are sitting closely next to each other, or opposite each other directly does not take into account the complexities of using a game within a hospital. Additionally, allowing the adult player to make the game harder or easier as gameplay progresses creates an immersive experience for the pair. These features combined with a clearly defined story and goal (as evaluated in chapter 7.4 and discussed above) show that this game does provide opportunity for meaningful collaborative play. An additional lab study where pairs of players test the game as well as a pilot study for the game suite within a hospital would provide more feedback and support the use of this as a key accessibility feature.

- **The game will provide opportunity for fantasy play, the child will be playing as part of a world unlike their own and the game will be immersive enough to support this.**
  Aspects of the game that maintain the immersive nature of play have been discussed at length above, however I believe the design process itself helped achieve this aim. Allowing design to be lead by children created a story and setting that is endorsed and enjoyed by children. The character and story was informed by the creativity and imagination of children and this resulted in a game that can be understood by them and entertain them. Participatory design was key in meeting this aim, with minimal guidance the children created whole worlds and stories for these characters and communicated them through their drawings. Providing them with the basic idea however was also necessary, within the scope of the game I presented, there was a vast array of ideas and incorporating as many as possible was difficult. In conclusion, this aim was achieved through the combination of the collective imagination of the children involved and the decisive actions of the developer.

## 8.1 Research Limitations

Due to the 2020 COVID-19 pandemic, the evaluation workshop I had planned with the children from the design workshop was cancelled. From this, feedback on the functionality and usability from a large group of children could be gathered. I would have used this to make improvements to the final prototype and inform my plans for future work.

Additionally, with the extent of the ethical process for conducting user studies with NHS patients or staff, this was outwith the scope of this project. Running a pilot study with the game suite within a children's ward or similar environment would provide invaluable feedback for the project. Additionally, expert interviews with play therapists or specialists and parents of children in hospital would offer important insight into the unique difficulties of this target group

## 8.2 Future Work

The future work for this project is categorized into two subheadings: system and research.

### Game

- Adding narration or voice element to tell the story, speak as the characters or provide instruction
- A more developed reward system, perhaps adding live scoreboards or the ability to group the iPads on a ward so that the children can compete locally with each other
- Adding a levels system, creating scenes with more pipes and conveyor belts to increase difficulty and provide more goals to achieve (completing each level and obtaining 3 stars)
- Adding a create your own character, or other personal items or achievements which enhance gameplay. These could be added as a points and shop system or direct rewards for achieving different milestones.

### Research

- As mentioned above, running further evaluation studies with groups of children in the target group would be a key piece of future work for this project
- Additionally, I think this project would benefit from expert interviews and feedback from both academic HCI trained staff and hospital play therapists and nurses. Their experience and knowledge could provide insight on any additional accessibility features a hospital may need to deploy this project.

## 8.3 Research Question

Using literature, participatory design techniques and detailed evaluation, I successfully created a game that could answer the research question detailed in Chapter 2:

**How to design an accessible game for children within a hospital setting that promotes fantasy and collaborative play?**

Previous work of (Bers et al., 2003) showed how creating short but rewarding game levels is the best way to provide children with distraction tool and entertainment. The work of (Chiasson and Gutwin, 2005) and (Soni et al., 2019) provided the basis for what became a detailed game framework used in this project that proved successful and supported by the feedback gathered in the evaluation. Additionally, through analysis of the work of (Druin, 2010) and (Oulton et al., 2018) we could discern a successful way to include children in the design and evaluation process. Children provide

the imagination needed to create fantasy play and as developers, we must endeavour to create games that harness this imagination, and build immersive experiences accessible to all. This project has shown that by building a framework that considers the needs of the target group, and the complexities of their environment can lead to successful design and development. Play is essential for all children and we can see the tangible benefits of meaningful collaborative play in the work of (Bers et al., 2003) amongst others. Accessibility has been a prominent theme throughout this project, and I believe that the game presented here and specifically the emphasis on customisation development is just one example of the steps we can take to make our games more accessible and bring play into the hospital.

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# Appendix A

# Implementation Code

## A.1 SpawnObjects Function

```
public void spawnObject() {
  //Create empty spawn position to be populated once pipe is chosen
  Vector3 spawn = new Vector3();

  //Pick pipe 1 or 2 and assign pipe to number
  System.Random rnd2 = new System.Random();
  int conveyorNum = rnd2.Next(2);
  if(conveyorNum==1) {
    conveyor = "left";
  }
  else {
    conveyor = "right";
  }
  //Set spawn position to pipe and turn on corresponding conveyor belt
  if(conveyor.Equals("right")){
    spawn = spawnRight.transform.position;
    ConveyorRight.GetComponent<ConveyorRight>().SetBeltOn(true);
  }
  else if(conveyor.Equals("left")) {
    spawn = spawnLeft.transform.position;
    ConveyorLeft.GetComponent<ConveyorLeft>().SetBeltOn(true);
  }
  //Get number between 0 and 5 to spawn object
  System.Random rnd = new System.Random();
  int choice = rnd.Next(5);
  //If there are still objects left to spawn for this game length
  if(loseObjects>0 || winObjects>0) {
    while(true) {
      //Compare choice with the selected objects characters are asking for
      if(objects[choice].Equals(leftChoice) ||
      ↪  objects[choice].Equals(rightChoice)) {
```



Figure A.1: SpawnObject function discussed in Chapter 6.4.3 Part 1

```
//If a character selected object is chosen we have to check if we
↪  have allowance to spawn 1, if so spawn and if not pick a new
↪  number
if(winObjects>0) {
  winObjects = winObjects-1;
  Instantiate(prefabs[choice], spawn, Quaternion.identity);
  break;
}
else{
          choice = rnd.Next(5);
        }
      }
      else{
        if(loseObjects>0){
          loseObjects = loseObjects-1;
          Instantiate(prefabs[choice], spawn,
          ↪  Quaternion.identity);
          break;
        }
        else{
          choice = rnd.Next(5);
        }
      }
    }
  }
  else{
    //Sets global variable to true, this is checked by each of the
    ↪  receiving pipes to trigger the game over panel when the
    ↪  last item is received and points counted
    isfinished = true;
  }
}
```

Figure A.2: SpawnObject function discussed in Chapter 6.4.3 Part 2

## A.2 Red Bin Door Rotation

```
//Go is set to true from the controller when the player hits the red button
if(go) {
        float rotation=rotationspeed*Time.deltaTime;
        if (rotationLeft > rotation)
        {
        //When the door reaches halfway rotated, the conveyor belt starts and
        ↪  the item is pulled towards the red pipe endpoint
            if((rotationLeft>180 && rotationLeft<200) && pulled == false) {
                pulled = true;
                middleTrigger.gameObject.GetComponent<MiddleTrigger>().on();
            }
            rotationLeft-=rotation;
        }
        else
        {
                rotation=rotationLeft;
                rotationLeft=360;
                soundOff();
                go = false;
        }
        //This line applies the rotation calculated above to the door
        door.gameObject.transform.Rotate(0,rotation,0);
}
```

Figure A.3: Function that enables the door to the red pipe to spin open and pull the item in

## A.3 GameOver star rewards panel

```
if(image.fillAmount>limit-0.05 && image.fillAmount<limit+0.05) {
      load = false;
      StartCoroutine(gameoverCoroutine());
    }
    if(image.fillAmount>0.2 && image.fillAmount<0.25) {
      star1.GetComponent<Image>().color = new Color32(250, 193, 0, 255);
      if(PlayerPrefs.HasKey("sounds")) {
        if(PlayerPrefs.GetInt("sounds")==1) {
          if(play1) {
              starSound.Play();
              play1 = false;
          }
        }
      }
      spinstar1 = true;
    }
    if(image.fillAmount>0.5 && image.fillAmount<0.55) {
      star2.GetComponent<Image>().color = new Color32(250, 193, 0, 255);
      if(PlayerPrefs.HasKey("sounds")) {
        if(PlayerPrefs.GetInt("sounds")==1) {
          if(play2) {
              starSound.Play();
              play2 = false;
          }
        }
      }
      spinstar2 = true;
    }
    if(image.fillAmount> 0.75 && image.fillAmount<0.8) {
      star3.GetComponent<Image>().color = new Color32(250, 193, 0, 255);
      if(PlayerPrefs.HasKey("sounds")) {
        if(PlayerPrefs.GetInt("sounds")==1) {
          if(play3) {
              starSound.Play();
              play3 = false;
          }
        }
      }
      spinstar3 = true;
    }
    if(load) {
      image.fillAmount += 1.0f/10.0f*Time.deltaTime;
    }
    if(spinstar1) {
      star1.transform.Rotate(new Vector3(0,0,20) *8.0f* Time.deltaTime);
    }
    if(spinstar2) {
      star2.transform.Rotate(new Vector3(0,0,20) *8.0f* Time.deltaTime);
    }
    if(spinstar3) {
      star3.transform.Rotate(new Vector3(0,0,20) *8.0f* Time.deltaTime);
    }
```

Figure A.4: Function that fills the score bar to the players score and shows each star achieved

# Appendix B

# Design Workshop

## B.1 Participant Information Sheet

**Project Title** – Developing an app for children in hospital

**Invitation to participate** – Your child is invited to participate in research study for the University of Edinburgh held at the 1st Gourock Scout Group. This document explains our study, what your rights are, and what will be done with the data we collect. You should keep this page for your records.

**What is this study about?**
This project is to build a game that will be used by children during their stay in hospital alongside parents/carers/staff, this research will gather ideas and feedback in the form of drawings for design of the game.

**What will happen?**

If you agree for your child to participate, they will listen to a brief presentation about the game and current design ideas and then work in groups to draw ideas for an iPad game. They can work in small groups, pairs or individually on designs for the characters, setting and other objects that will be featured in the game. We will then discuss these ideas and what this game may look like. These drawings will be kept until my project is finished for analysis and design decisions.

**Risks and benefits**
There are no known risks to participation in this study. There are no tangible benefits to you or your child, however you will be making a contribution to our knowledge about game design preferences for young children.

**Confidentiality and use of data**
All information we collect during the course of the research will be processed in accordance with the Data protection Law. In order to safeguard your own and your child's privacy, we will never share personal information (like names or dates of birth) with anyone outside the research team. Your child's data will be referred to by a unique participant number rather than by name. We will store any personal data (eg signed forms) in a locked filing cabinet at the University of Edinburgh. The anonymised data collected during this study will be used for research purposes.

**What are my data protection rights?**
The University of Edinburgh is a data controller for the information you provide. You have the right to access information held about you. Your right of access can be exercised in accordance Data Protection Law. You also have other rights including rights of correction, erasure and objection. For more details, including the right to lodge a complaint with the Information Commissioner's Office, please visit www.ico.org.uk. Questions, comments and requests about your personal data can also be sent to the University Data Protection Officer at dpo@ed.ac.uk.

Voluntary participation and right to withdraw. We will ask your child's permission before we begin the study, and we will make sure they understand that they can stop at any point. You may also choose to withdraw your child from the study at any time. Any data supplied up to that point will be deleted.



If you have any questions about what you've just read, please feel free to ask, or contact us later. You can contact us by email at Judy.Robertson@ed.ac.uk. This project has been approved by the Informatics Ethics Committee. If you have questions or comments regarding your own or your child's rights as a participant, they can be contacted on 0131 661 5661 or rdmpublications@inf.ed.ac.uk.

## B.2 Consent Form Parent/Caregiver

THE UNIVERSITY of EDINBURGH
informatics

**Project Title** – Developing an app for children in hospital

PLEASE MARK EITHER YES OR NO FOR THE STATEMENT BELOW

| Consent for participation: | Yes | No |
|---|---|---|
| I consent to my child taking part in the above study | ☐ | ☐ |

| Caregivers name | Childs name | Childs Date of birth |
|---|---|---|
| Caregivers Signature | Caregivers relationship | Todays date |

## B.3 Consent Form Child

THE UNIVERSITY of EDINBURGH
informatics

Hello, My name is Amy Rodger, I go to the university of Edinburgh and I'm currently building a fun game to be used by children that are staying in the hospital. They can play it by themselves, or with their parents or the hospital staff!

I'm here to work with you to make designs for the game, characters and setting! You will be working in small groups or pairs to draw your ideas for the game that I will put onto my computer at university and use for my project. Some of the designs we come up with will end up in the final game.

At any time throughout tonight you can stop participating, and if you don't want to participate that's also okay, just tick the 'No' box below.

PLEASE MARK EITHER YES OR NO FOR THE STATEMENT BELOW

| Consent for participation: | Yes | No |
|---|---|---|
| I agree to take part in the above study | ☐ | ☐ |

Participants name _____ Todays date _____

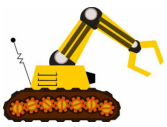
## B.4 Design Workshop Worksheet

What do the characters look like? Draw one here!

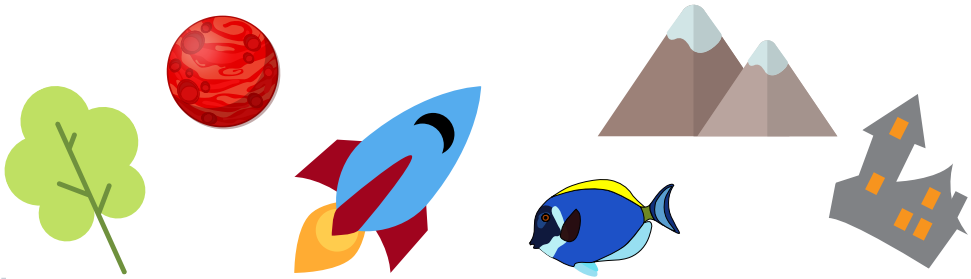
Fill this box with some items to be included for sorting in the game!

**How will the items be collected from the conveyer belt?**

**Where are the sorted items going?**

# Draw your character in the sorting factory below!



# Appendix C

# Heuristic Evaluation Materials

## Heuristic Evaluation Form

**Introduction**

This heuristic evaluation form is meant to test the usability and user experience for certain tasks that can be completed on the Sorting Factory game. We can better understand the user experience through evaluating certain tasks that a user would have to do when playing the game.

Below you will find 3 tasks that a user may wish to complete when playing the game. Please evaluate these tasks and the processes for completing these tasks from a user perspective based on the following 5 usability heuristics with reference to the framework provided.

1. **Visibility of System Status**

The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.

2. **User Control & Freedom**

Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.

3. **Consistency and Standards**

Users should not have to wonder whether different words, situations, or actions mean the same thing.

4. **Flexibility and Efficiency of Use**

Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.

5. **Aesthetic and Minimalist Design**

Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.

# Design Framework

Please read the design framework below I created for this project. Note any framework points that are linked to the issues you find.

1. Children are impatient and need immediate feedback showing that their action have had some effect. This feedback can be visual or audio and be larger and longer than the same given to older users.
2. Provide corrective feedback, such as pop-ups or dialogues offering feedback for correct and incorrect answers.
3. Icons should be visually meaningful to children.
4. Technologies should give children the ability to define their experiences and be in control of the interaction.
5. Provide choice and customization features to enhance children's intrinsic motivation and task engagement.
6. Make sure that every sound used in the interface has a specific meaning and function.
7. Children's actions should map directly to the actions on the screen. These actions and gestures should be consistent to avoid confusion.
8. Be consistent with images or graphical metaphors used in interfaces and their real world use.
9. Interfaces should be strongly visual but avoid using visually complex application backgrounds as children can get confused when interacting with them.
10. Children's interfaces should not make use of extensive menus and sub-menus.
11. Young children have difficulty targeting small objects on the screen. Items should be large enough and distanced from each other to compensate for some inaccuracy in targeting.
12. Visually differentiate clickable elements from the rest of the screen, e.g., use different colors or dark outlines.
13. Instructions should be presented in an age-appropriate format and be easy to comprehend and remember.
14. Use child-like on-screen characters as guides or pedagogical agents to improve learning outcomes. These characters should be strictly supportive and not distracting.
15. Avoid using in-app tutorials for children; the interface should provide some form of guidance during tasks. Instead use animated prompts to help children understand gestures and rules and consequences of their actions.
16. Activities should be inherently interesting and challenging so children will want to do them for their own sake.
17. Supportive reward structures that take into account children's developmental level and context of use help keep children engaged.
18. Consider using an open-ended app structure to support children's engagement and creativity.

# Severity Ratings

**1 -** I don't agree that this is a usability problem at all

**2 –** Cosmetic problem only: need not be fixed unless extra time is available on project

**3 –** Minor Usability problem: fixing this should be given low priority

**4 –** Major usability problem: important to fix so should be given high priority

**5 –** Usability catastrophe: imperative to fix this before project deadline

Task 1 – Choose a difficulty, length and sound/music settings and complete 1 game of single player.

| Brief description of issue | Which heuristic/framework was violated? | Severity Rating | Recommendation |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

Task 2 – Find and set the game the layout orientation that best suits how you are sitting.

| Brief description of issue | Which heuristic/framework was violated? | Severity rating | Recommendation |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

# Task 3 – Play and complete one game of multiplayer using the layout from Task 2

| Brief description of issue | Which heuristic/framework was violated? | Severity rating | Recommendation |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

# Appendix D

# Online Evaluation

## D.1 Participant Information Sheet



**Participant Information Sheet**

| | |
|---|---|
| Project title: | Developing an app for children in hospital |
| Principal investigator: | Judy Robertson |
| Researcher collecting data: | Amy Rodger |
| Funder (if applicable): | N/A |

This study was certified according to the Informatics Research Ethics Process, RT number XXXXX (will add once assigned). Please take time to read the following information carefully. You should keep this page for your records.

**Who are the researchers?**

The researchers are Amy Rodger, 4th year undergraduate Computer Science BSc student supervised by Judy Robertson.

**What is the purpose of the study?**

The purpose of this study is to gather feedback on aspects of a game I have designed for my honours project.

**Why have I been asked to take part?**

You and your child have been asked to take part in this study as your child is within the ages of 7-10 – the target group for my design and evaluation sessions.

**Do I have to take part?**

No – participation in this study is entirely up to you. You can withdraw from the study at any time, without giving a reason. Your rights will not be affected. If you wish to withdraw, contact the PI. We will stop using your data in any publications or presentations submitted after you have withdrawn consent. However, we will keep copies of your original consent, and of your withdrawal request.

**What will happen if I decide to take part?**

If you decide to take part, your child will be invited to play my game on an iPad, exploring all of the features and game types. You are free to play with your child or to provide any assistance they require when interacting with touchscreen technology.

After they play the game, I will ask your child for any verbal feedback in an open conversation in which I will take personal notes. They, and you will also be invited to answer a short questionnaire to gather any additional thoughts about the game

**Are there any risks associated with taking part?**

There are no significant risks associated with participation.

**Are there any benefits associated with taking part?**

There are no direct benefits to taking part in this study, however you will be helping us gain knowledge about game design preferences amongst young children

**What will happen to the results of this study?**

The results of this study may be summarised in published articles, reports and presentations. Quotes or key findings will be anonymized: We will remove any information that could, in our assessment, allow anyone to identify you. With your consent, information can also be used for future research. Your data may be archived for a minimum of 2 years.

**Data protection and confidentiality.**

Your data will be processed in accordance with Data Protection Law. All information collected about you will be kept strictly confidential. Your data will be referred to by a unique participant number rather than by name. Your data will only be viewed by the researcher/research team – Judy Robertson and Amy Rodger.

All electronic data will be stored on a password-protected encrypted computer, on the School of Informatics' secure file servers, or on the University's secure encrypted cloud storage services (DataShare, ownCloud, or Sharepoint) and all paper records will be stored in a locked filing cabinet in the PI's office. Your consent information will be kept separately from your responses in order to minimise risk.

**What are my data protection rights?**

The University of Edinburgh is a Data Controller for the information you provide. You have the right to access information held about you. Your right of access can be exercised in accordance Data Protection Law. You also have other rights including rights of correction, erasure and objection. For more details, including the right to lodge a complaint with the Information Commissioner's Office, please visit

www.ico.org.uk. Questions, comments and requests about your personal data can also be sent to the University Data Protection Officer at dpo@ed.ac.uk.

**Who can I contact?**

If you have any further questions about the study, please contact the lead researcher, Judy Robertson at judy.robertson@ed.ac.uk.

If you wish to make a complaint about the study, please contact inf-ethics@inf.ed.ac.uk. When you contact us, please provide the study title and detail the nature of your complaint.

**Updated information.**

If the research project changes in any way, an updated Participant Information Sheet will be made available on https://web.inf.ed.ac.uk/infweb/research/study-updates.

**Alternative formats.**

To request this document in an alternative format, such as large print or on coloured paper, please contact Amy Rodger, s1630045@sms.ed.ac.uk.

**General information.**

For general information about how we use your data, go to: edin.ac/privacy-research

## D.2 Consent Form Parent/Caregiver

Participant number:_____

# Participant Consent Form

| | |
|---|---|
| Project title: | Developing an app for children in hospital |
| Principal investigator (PI): | Judy Robertson |
| Researcher: | Amy Rodger |
| PI contact details: | Judy.robertson@ed.ac.uk |

**Please tick yes or no for each of these statements.**

| | | Yes | No |
|---|---|---|---|
| **1.** | I confirm that I have read and understood the Participant Information Sheet for the above study, that I have had the opportunity to ask questions, and that any questions I had were answered to my satisfaction. | | |
| **2.** | I understand that my participation is voluntary, and that I can withdraw at any time without giving a reason. Withdrawing will not affect any of my rights. | | |
| **3.** | I consent to my anonymised data being used in academic publications and presentations. | | |
| **4.** | I understand that my anonymised data can be stored for a minimum of two years | | |
| **5.** | I allow my data to be used in future ethically approved research. | | |
| **6.** | I agree to take part in this study. | | |

| Name of person giving consent | Date dd/mm/yy | Signature |
|---|---|---|
| | | |

| Name of person taking consent | Date dd/mm/yy | Signature |
|---|---|---|
| | | |

## D.3 Consent Form Child

Participant number:_____

# Participant Consent Form

| | |
|---|---|
| Project title: | Developing an app for children in hospital |
| Principal investigator (PI): | Judy Robertson |
| Researcher: | Amy Rodger |
| PI contact details: | Judy.robertson@ed.ac.uk |

Hello, My name is Amy Rodger, I go to the university of Edinburgh and I'm currently building a fun game to be used by children that are staying in the hospital. They can play it by themselves, or with their parents or the hospital staff!

I'm here to work with you to evaluate the game that I have made! You can play the game – helping Lolly the space sheep save the sorting factory – and let me know what you think!

At any time, you can stop participating, and if you don't want to participate that's also okay, just tick the 'No' box below.

**Please tick yes or no for each of these statements.**

| | | Yes | No |
|---|---|---|---|
| **1.** | I understand what I am being asked to do. | | |
| | | **Yes** | **No** |
| **2.** | I agree to take part in this study. | | |

Name _____ Date dd/mm/yy _____

## D.4 Survey



# Sorting Factory User Survey

*Required

### Participant Information - Parents/Caregivers

The purpose of this study is to gather feedback on aspects of a game I have designed for my honours project. The researchers are Amy Rodger, 4th year undergraduate Computer Science BSc student supervised by Judy Robertson.
This study was certified according to the Informatics Research Ethics Process, RT number 4603.

Participation in this study is entirely up to you and your child. You can withdraw from the study at any time, without giving a reason and any data collected up to that point will be deleted.

To request this full document detailing your data protection rights and further information on the study, please contact Amy Rodger, s1630045@sms.ed.ac.uk.

1. Do you consent to your child taking part in this study and understand your rights as participants as outlined above? *

   *Mark only one oval.*

   ◯ Yes

Sorting Factory User survey

### Participant Information - Child

Hello! Thanks for taking part in a survey of the game I've been making this year! This game is for children who are staying in hospital to play with their parents or hospital staff. Its about Lolly the space sheep and her adventures that bring her to the sorting factory!

I'm going to ask you to watch 4 videos and answer some questions, you can ask an adult to help you read the questions and write the answers if you want. I'll use your answers to improve my game and write my report.

At any time, you can stop participating, and if you don't want to do this survey at all that's also okay, just let your parents know :)

2. Do you understand what you have to do and agree to take part in this study? *

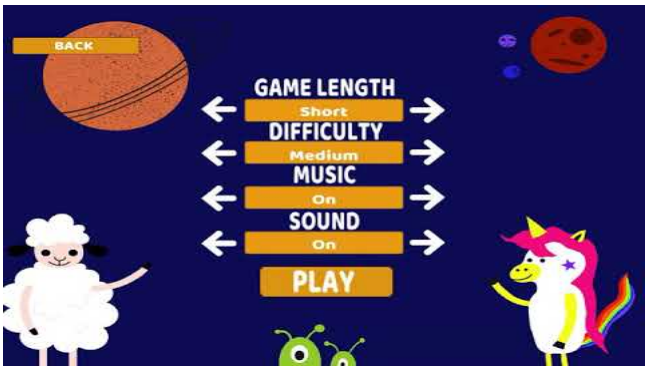
   *Mark only one oval.*

   ◯ Yes

Tutorial for Single Player

Please watch the video below and then answer the questions!

Click the title of the video to open it in your youtube browser




http://youtube.com/watch?v=lYeMvf3YbIg

3. Did you find the tutorial easy to understand?

*Mark only one oval.*

- ◯ Yes, I understood all of the tutorial
- ◯ Yes, I understood most of the tutorial
- ◯ No but I understood some of the tutorial
- ◯ No I did not understand the tutorial

4. Do you think you would know how to play this game after watching the tutorial?

*Mark only one oval.*

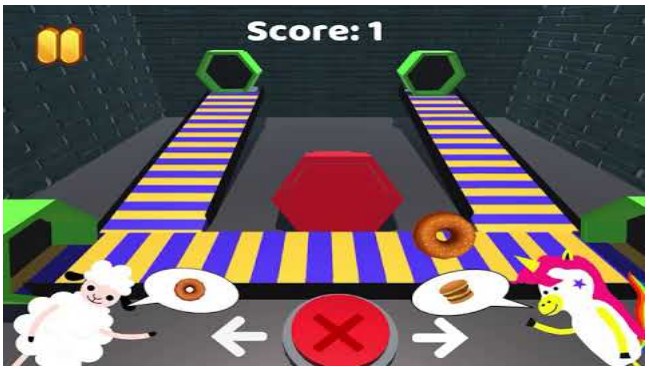
- ◯ Yes
- ◯ No

5. What do you think the player has to do in this game?

Gameplay for Single Player

Please watch the video below and then answer the questions!

Click the title of the video to open it in your youtube browser




http://youtube.com/watch?v=e2h7LmWjUiM

6. Now that you have watched the game, is there anything you think would make the tutorial easier to understand?

7. What age group do you think would enjoy this game the most?

*Mark only one oval.*

- 3-6 years old
- 7-10 years old
- 11+ years old

8. How easy/difficult do you think this game would be for 3-6 year olds?

*Mark only one oval.*

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Very easy | | | | | | Very diffcult |

9. Is there anything you liked about the game?

10. Is there anything you would change about the game?

## Tutorial for Two Player

Please watch the video below and then answer the questions!

Click the title of the video to open it in your youtube browser


http://youtube.com/watch?v=vLozcaSq4fo

11. Did you find the tutorial easy to understand?

*Mark only one oval.*

- ◯ Yes, I understood all of the tutorial
- ◯ Yes, I understood most of the tutorial
- ◯ No but I understood some of the tutorial
- ◯ No, I did not understand the tutorial

12. Do you think you would know how to play this game after watching the tutorial?

*Mark only one oval.*

- ◯ Yes
- ◯ No

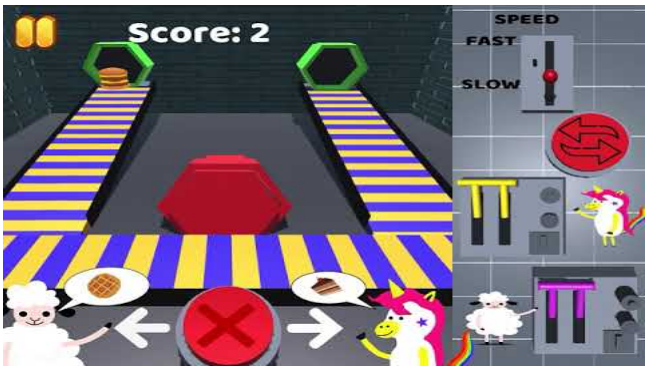
13. In this mode, what do you think player 1 does?

14. In this mode, what do you think player 2 does?

## Gameplay for Two Player

Please watch the video below and then answer the questions!

Click the title of the video to open it in your youtube browser




http://youtube.com/watch?v=oNhQjAe9nRo

15. Now that you have watched the game, is there anything you think would make the tutorial easier to understand?

16. Is there anything you like about the two player mode?

17. Is there anything you would change about two player mode?

18. Do you think the two player mode is easier/harder/same as single player?

*Mark only one oval.*

- Easier
- Harder
- Same

# Appendix E

# Video of gameplay

A video of the gameplay and full walkthrough of the system can be found here: `https://drive.google.com/open?id=1tG69UoPqVUEWTLiQLQcBOeR__M57ZKed`