Encouraging Active Play Through Augmented Reality Toys

ABSTRACT

The following research pictorial sets the stage to answer the hypothesis that suggests children will feel less lonely if they can interact physically with an augmented reality (AR) smart toy. The research adopted a user-centred approach to gathering data by creating user stories and personas. A 10-question survey was also used to gather data from the public. The survey returned 17 results in total. The results from the 17 participants were analysed which found that soft toys were the most common toy type and are primarily used for comfort or as a sleep aid. The results also found that parents took on the role of supervisor more often than that of student or advisor, suggesting parents are less inclined to get involved with children's play. The development of the prototype created new scope for this research to investigate the possibilities of a toy hacking kit that will allow children to create their own soft toys. The outcomes of the research have provided enough justification to conduct further research into the relationship between children, parents, and toys to create needed bonding experiences. .

INTRODUCTION

The following research will demonstrate how a research through design approach and the use of the double diamond framework has been used to investigate the potential for adults and children to turn their soft toys into AR smart toys through the art of toy hacking. In a world of limited resources, ECO-AR is a self-contained kit that allows parents and children to transform soft toys into immersive AR experiences by following a step by step 'how to guide'.

Note: The fundamentals of using ECO-AR to promote parent-child bonding through collaborative experiences will be discussed in another document.

BACKGROUND RESEARCH

Before delving into the defining stages of this project, it is important to realise why it has been done in the first place. To do this, the following section will explore the realms of child development, the use of AR in toys and toy hacking.

Smart Toy

Recent research has shown that the global million-pound smart toy market has skyrocketed as parents become more eager to produce tech savvy children. Smart toys are also being used as a solution to communication problems amongst children. Developer of TangToys, Kieran Woodward et al. designed a smart toy that uses motion sensors and Bluetooth to portray states of well-being amongst children. In their report they found that in children who find it difficult to communicate, the use of Tangible User Interface (TUI) provided them with alternative modes of communication. Woodward also argues that children's toys represent the ideal embodiment for TUI's as they provide significant space, i.e. inside a stuffed bear. Adding that they also encourage interaction as children already naturally know how to play with them. The sensor rich TangToys were given to a group of teachers to test, during which time they were asked to give their opinion. The research found that all teachers were all in favour of them as a tool to promote the well-being of their students and agreed that putting the sensors in already designed toys was the bast way to encourage continuous interaction, i.e., hacking the toys (Woodward, Kanjo, Brown and Inkster, 2020).

Augmented Reality

AR is commonly described as 'blending two worlds': the physical and digital. Unlike Virtual Reality (VR) which transports you away from the physical world, AR brings components of the digital word to you. A frequently cited and successful example of this is Pokémon Go which saw players from all over the world venture out into the streets in search for virtual Pokémon. Pokémon Go uses geo-location and visual markers, each marker contains visual information about a particular Pokémon. Visual markers are a popular method used in AR as they have the capacity to store visual information that is detected by location. Ismo Alakärppä conducted a study into an AR application that detects nature elements using visual markers, the goal of this study was to encourage the use of AR in schools. The primary limitation of the study was the lengthy process involved in the technical creation of the visual markers themselves. It is unclear whether this lengthy process has any correlation with the small volume of AR toys out there (Alakärppä, Jaakkola, Väyrynen and Häkkilä, 2017). Writers at the ARPost put emphasise on the amount of AR toys currently reliant on in-phone applications or expensive head and eye wear technology (Mileva, 2020). Research into self-contained AR toys (inclusive of its own interface) is scarce but could possibly offer a solution to the decreased time children now spend playing with toys before getting 'bored' (Prist, 2019).

Toy Hacking

This research has found that toy hacking is the process of transforming a non-technological toy into a technological one which is commonly done with mechanical toys as a means of teaching. Scholar Valentina Chinnici investigates the possibilities by exploring toy hacking as a way for pre-pubescent children to enter a new stage of their life. The concept involves a child entering a Makerspace and metaphorically "killing" their toy amongst their peers to then revive it with a technological advancement. Since this paper is heavily concerned with 'rites of passage' for pre-teens, it is not explicit in whether this concept can be applied to the life stages of much younger children. That said, the paper does mention scope for younger children to be involved in the 'hacking' process as there is no technical knowledge needed (Chinnici, 2013). Other research refers to adapting toys as retrofitted, in a 2016 conference paper Rong-Hao Liang et al. introduces GaussRFID, a kit used to 'reinvent' toys using portable magnetic field cameras which use sensors and replicate a 3D visual on screen. Liang conduced a 2-day toy hacking workshop involving 31 undergraduate students who provided feedback in favour of toy hacking as a practically enjoyable experience (Liang, Kuo and Chen, 2016). While children become gradually immersed in technology, the length of time spent playing has reduced as children becoming increasingly bored with what traditional toys have to offer. In a 2014 article Laura Richardson wrote about a future in which children can create their own toys, toys that will adapt and respond to their individual interests and abilities (Richardson, 2014). Is it possible that toy hacking can facilitate a space for children to create their own toys in their own image?

APPROACH

Research through design or practice-based design research is an approach that uses background research to develop a new product that can be tested against an existing concept or bring to light new ideas. The research conducted during this project sought to test the following hypothesis "If children can interact actively with a digital toy, they will feel less lonely". The researcher most cited was Kieran Woodward who looked at creating interactive TUI's that sit within toys/objects to capture and communicate emotion between children or lonely individuals. The features used by Woodward inspired the idea of implementing additional technical elements to existing children's toys, specifically, motion sensors (Woodward, Kanjo, Brown and Inkster, 2020). This research along with the research by Ismo Alakärppä inspired the idea behind an AR toy that children could engage with actively as well as digitally (Alakärppä, Jaakkola, Väyrynen and Häkkilä, 2017). The figure to the right depicts the project journey through a double diamond process evidencing the brief development stage that helped formulate a new hypothesis. How this process affected the outcomes of this research will be discussed in the following pages.

DOUBLE DIAMOND

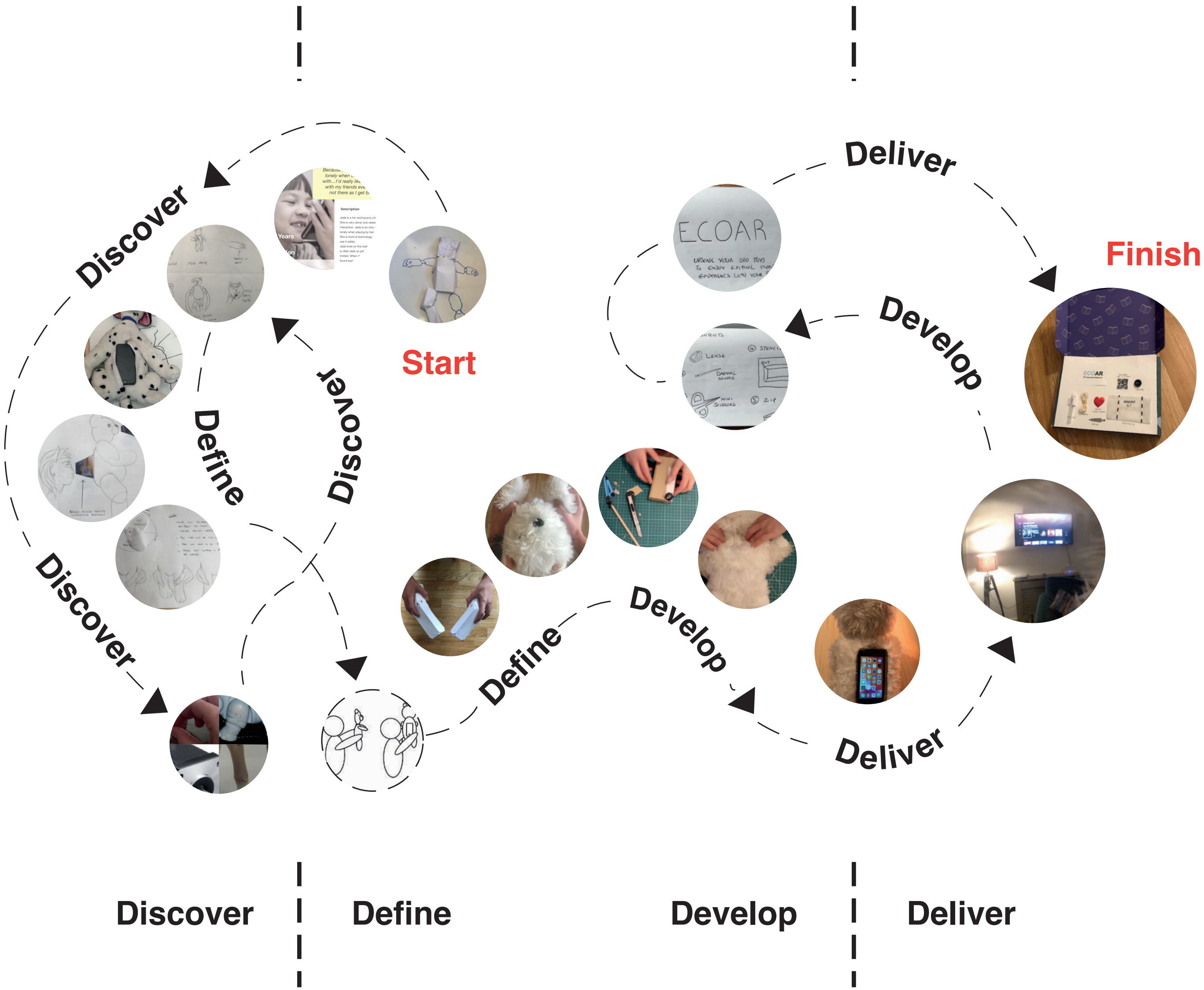
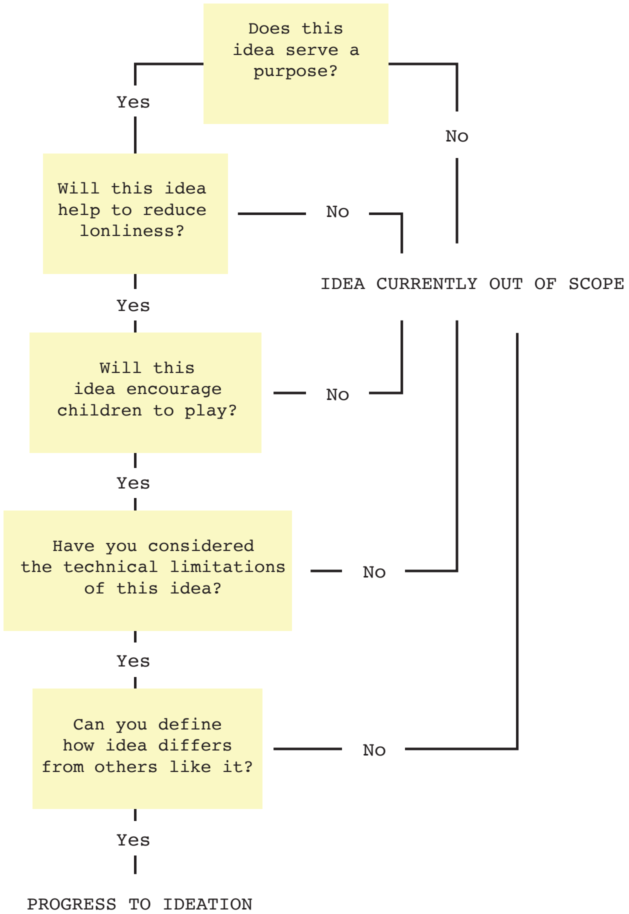


Figure 1

USER-CENTERED DESIGN METHODS

A user-centered design approach has been followed from the beginning of this project to ensure that all design decisions have the end user in mind. One beneficial technique that was used was a list of user-centered questions that was referred to during each ideation phase. Each idea was tested against the set of user-centered questions, the rules were as follows:



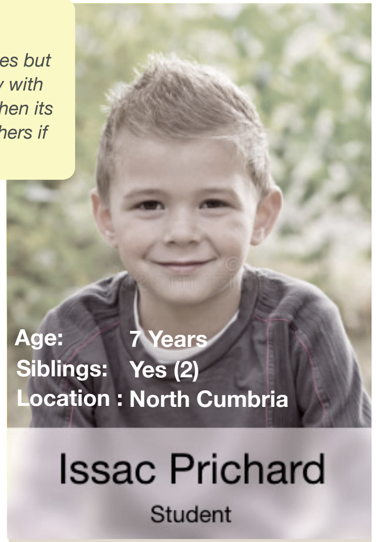
This technique assisted in keeping the project priorities concise and minimized wasted time.

USER STORIES

This technique assisted in keeping the project priorities concise and minimized wasted time. Another useful technique was user stories, each story helped the researcher delve deeper into the mindset of the parent and child which in turn produced the necessary needs and requirements listed (appendix A). The user stories also bring the end users to life. For example, stories such as, ‘As a child I want to play with my friends so that I don't feel lonely at home’ created an empathy pathway to the user which kept them at the forefront of the design.

Motivation

I really like electronics and games but I find it hard sometimes to play with others because I get nervous when its to loud…I'd like to play with others if a safe space.



Description

Issac is a quiet child and gets overwhelmed easily around other children which makes him withdrawn. Issac often gets lonely but struggles to connect or ask to others to play. He loves electronics and his dads iPhone is his favourite ‘toy’.He has a lot of friends nearby but prefers to play indoors. Issac has 2 older sisters who are his best play companions.

Needs/Goals

- I like to play with my mum because children can scare me by being too loud
- Better toys electronic toys so I don't get bored
- A toy I can play with over and over again but differently

Challenges/Frustrations

- Not having anyone to play with and feeling like don't have friends
- Other chidren are to loud
- I like to play with my mum and dad and sisters, other chidren scare me
- I need to be challenged

Motivation

Because I'm an only child I get really lonely when there's no one to play with…I'd really like to be able to play with my friends even when they're not there as I get bored easily.

Description

Jada is a fun and bouncy child with mild ADHD. She is very clever and needs a lot of social interaction. Jada is an only child and often gets lonely when playing by herself.She is fond of technology but is too young to use it safely. Jada lives on the main road of a rainy city that is often dark so playing outside the house is limited. When she can play outside she is often found exploring the back garden.

Needs/Goals

- I want to play with my friends even when they are not around
- I'm an only child so I need interactive play
- I want to be able to learn and play at the same time
- I like to play inside and outside

Challenges/Frustrations

- Not having anyone to play with and feeling lonely
- Being bored of my toys and in need of more interaction
- Not being being able to play outside the house or garden

PERSONAS

The personas represent two seven-year-old students with their own unique qualities, needs and requirements. Each persona was a central point of reference throughout this project– most specifically during the iteration of the prototype design. As no child participants were recruited for this project, the use of child personas was essential in steering the project towards the goals of children.

SKETCHES AND DISCOVERY

‘ Measure twice, cut once

One of the many benefits of the double diamond framework is its capacity for continuous iteration, however this can be time consuming. To save time this project took on a rough and ready approach to the initial designs by sketching them out onto paper and whiteboard.

The initial design for the AR toy was a robotic bear with ‘ball and socket’ arms and legs (Figure). However, it had been noted in the revised literature that soft toys provide vast amounts of space inside them, are easily manipulated, widely available and cheap, thus the design quickly took on a softer shape.

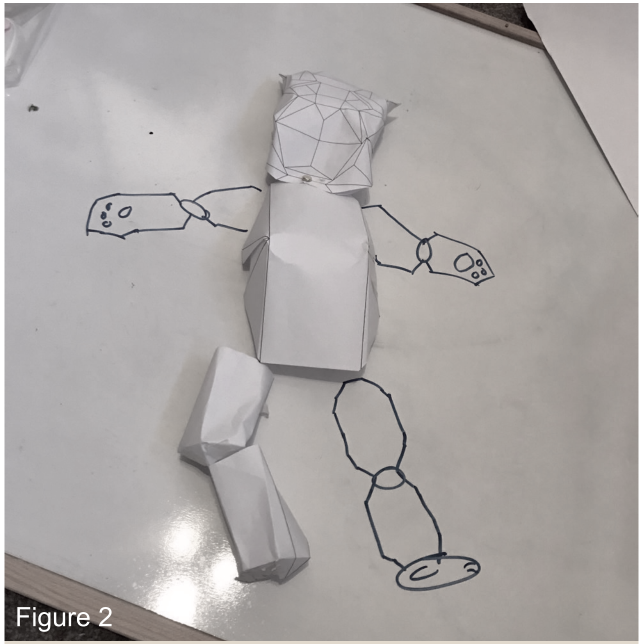


Figure 2

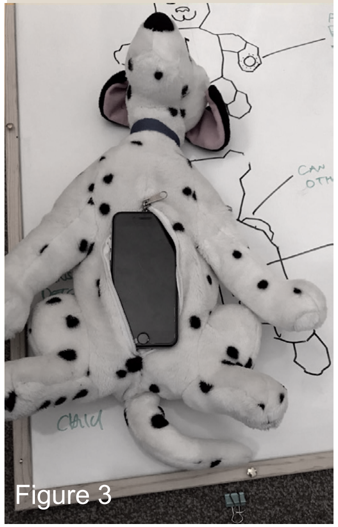


Figure 3

A small amount of market research was conducted to help understand how a phone might sit inside the soft toy. The figure above helped to gauge the appropriate size and introduced the new possibility of including a zip to hide the device holder when not in use. .

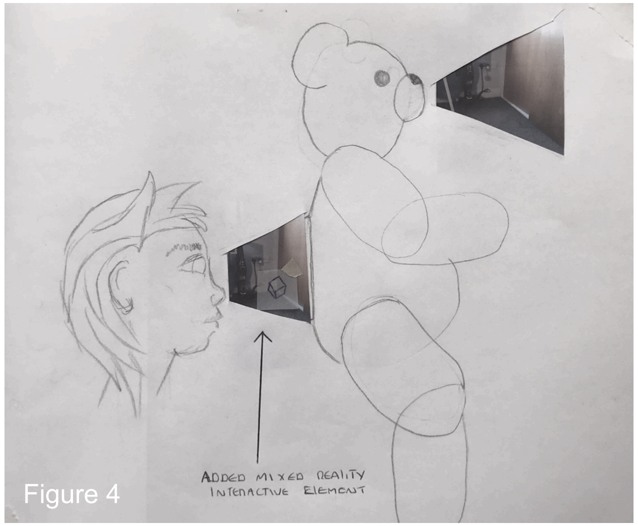


Figure 4

In the sketch above the child is looking into the phone and out through the eye of the soft toy. Whilst reflecting on this sketch it occurred that putting the camera in the eye would not be suitable as the two viewpoints would not line up correctly making interaction with the AR application problematic.

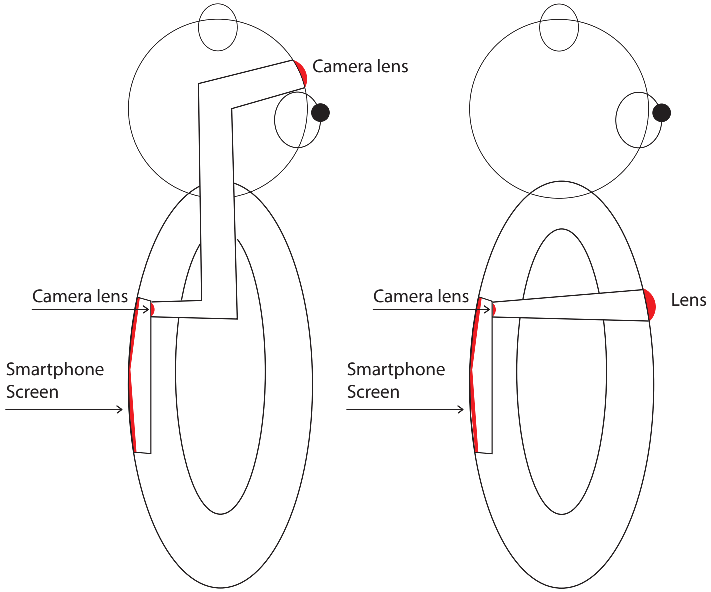


Figure 5

Further investigation also revealed that most smartphones do not have the capabilities to connect to external cameras (in the cases that do, third party software is needed). A solution to this problem is evidenced in figure 3 which depicts a lens sitting in line with the phone camera. This design iteration removes the need for an external camera and allows the lens and camara to align.

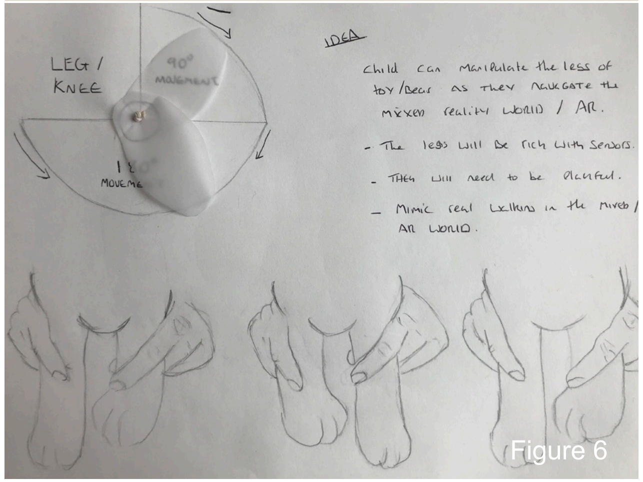


Figure 6

A primary feature brought forward from the user stories was the need for active interaction and movement. The figure above demonstrates how this interaction could be achieved through rotating and manoeuvring the legs of a toy. As children learn through touch and mimicking the actions of others, it was important to choose a natural mapping for the interaction to occur. Moreover, the action of walking can easily be translated as a movement in the AR application via sensors.

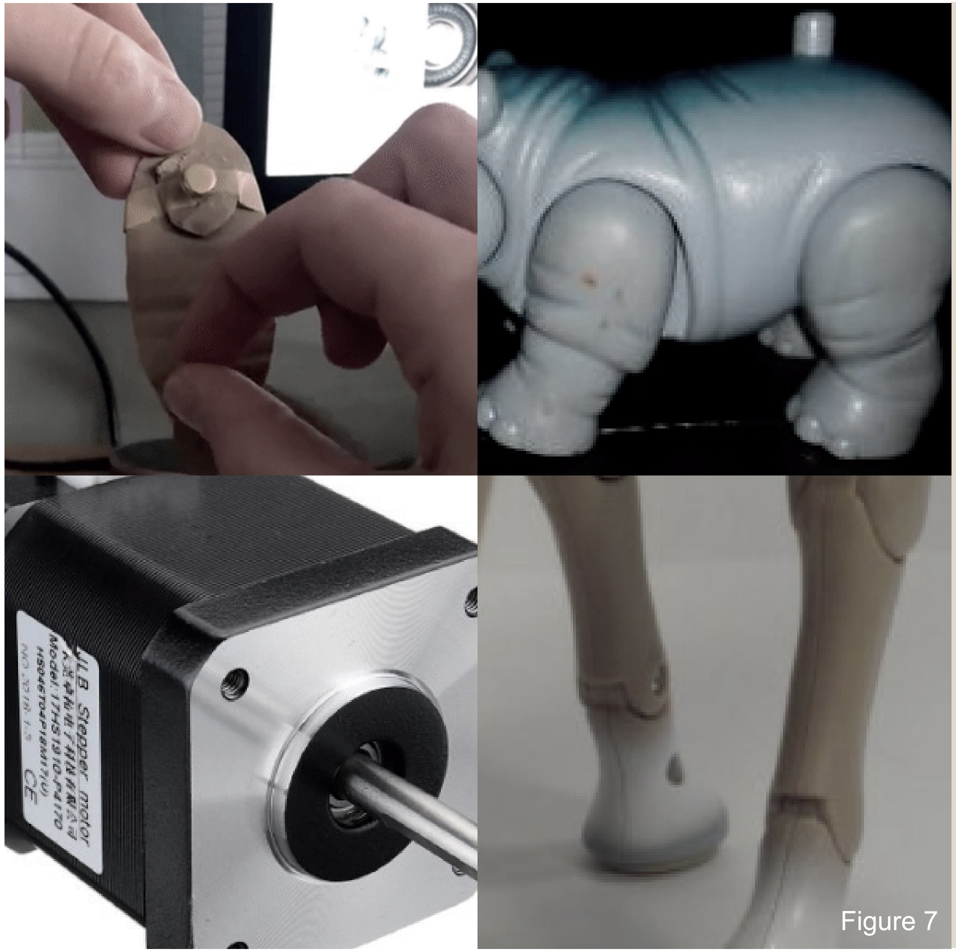


Figure 7

PROBLEM IN FINDINGS

Problems with ergonomics occurred during the persona scenarios; it was the intended idea that a child would move the legs of the toy and that this would be replicated in AR, however, research showed that the average hand span of our persona children would be about 4.4 inches which means they would find it difficult to hold the toy at eye-level and manoeuvre the legs of the toy at the same time. Further research investigated the possibilities of automated movement using cogs, buttons, or a motor. However, it was concluded that automating movement would be counter-productive to the goal of encouraging active interaction, it would also increase the technical requirements of the toy.

IDEATION

After diverting attention away from the legs, the prospect of using the arms to encourage physical interaction looked probable. By embedding sensors in the arms of the toy, the child should be able to use the arms to interact with the augmented reality components simultaneously.

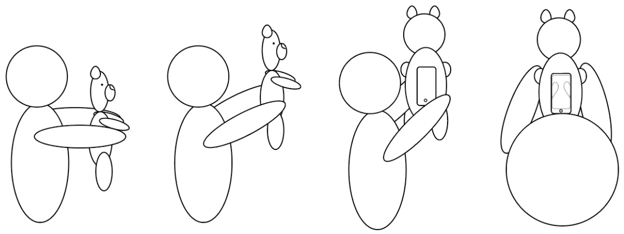


Figure 8

PROTOTYPE AND DEFINE

The prototypes depicted within this page represent the defining stages of the project. The purpose of the prototypes was to a) test the flexibility when preforming tasks such as pointing and picking up and b) test the range of vision available now the lens was in place.

Creating a physical high-fidelity prototype highlighted new questions regarding weight, size and toy shape. These questions later inspired a survey that was sent out to collect data on popular toy types and gain insights into child-toy relationships.

Figure 9

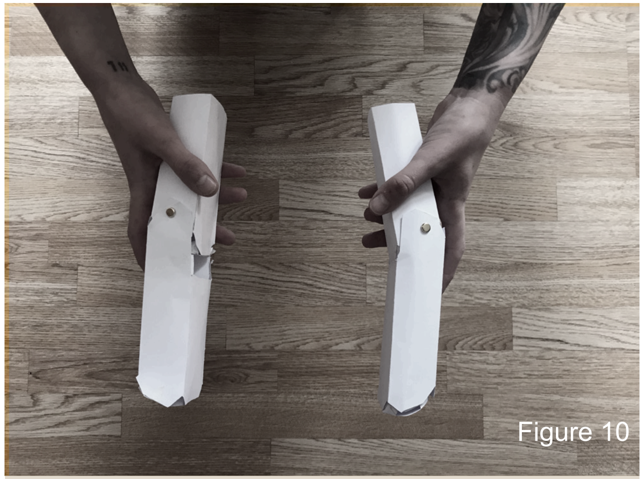


Figure 10

Figure 11

The data showed that of the 17 respondents, 11 said their favourite toy was a teddy bear. This data, along with the knowledge that a soft toy has optimal space for TUI's, created enough justification to continue to the high-fidelity development stages with a light medium sized teddy bear large enough to fit the average smart phone (5.5in).

DEVELOPMENT

Materials: Cardboard, Glue Gun, Pencil, Protractor, Ruler, Craft Knife, Scissors, Darning Needle, Thread and Lens. The development of the AR bear was carried out during a 3 hour workshop that involved the following stages.

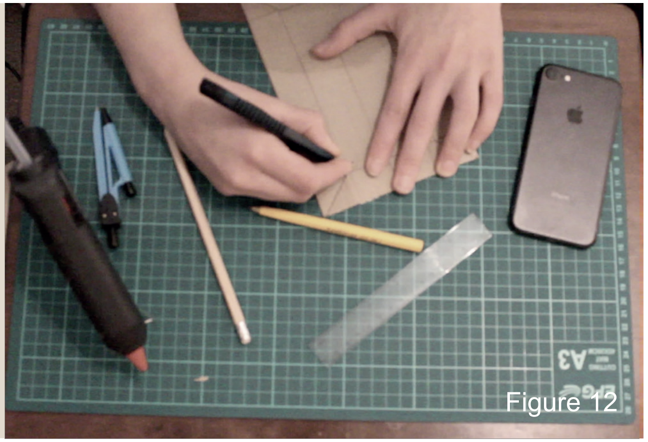


Figure 12

Phone Container

The phone container was made from cardboard and designed to fit an iPhone 6 in a 'snug' position. A circular hole was cut to allow the iPhone camera to peer outward. This process was successful and created a good working visual representation for the prototype, however, it was time consuming and awkward due to the stiffness of the cardboard. Further research would be needed to determine a more subtle material for future iterations to avoid tears in the prototype.


Figure 13

Lens

Adding the lens to the toy was less challenging, the process involved making a small incision for the lens to sit in. However, once the lens was in, it became difficult to align it with the cardboard phone container. After various attempts the decision was made to attach the lens to the phone container as the soft material would be easier to manipulate.


Figure 14

Body

The final stage of the high-fidelity prototype was to remove all the toy stuffing and insert the phone container with the attached lens - This was then sewn into place.


Figure 15

TESTING

Due to concerns over visibility and safety it was essential to conduct a usability test. The test itself was simple, it involved the researcher walking around a room with the toy in both hands and the phone at eye level– with its camera on. Furniture was then placed around a room to test if the researcher could see the furniture in their peripheral vision whilst still looking through the phone camera. Past research has proven that peripheral vision is the most important field of vision need when spotting new objects (Weinschenk, 2020).

Figure 16

Figure 17

Results

The test proved that the peripheral vision during the task was sufficient for an adult to avoid knocking into newly place objects in a room. However, this research cannot determine whether a child would be able to do the same. Nielsen's Severity Ratings have been used to define other usability issues – Ratings can be found in appendix B.

Reflection

The development process highlighted two new areas for discovery.

1) Toy Hacking as an activity

As evidenced above the steps involved in creating this prototype were straight forward and required no technical understanding, put simply, a child could do it.

2) Collaborative Experience

Children and parents can work together and create a lasting and memorable bonding experience through toy hacking

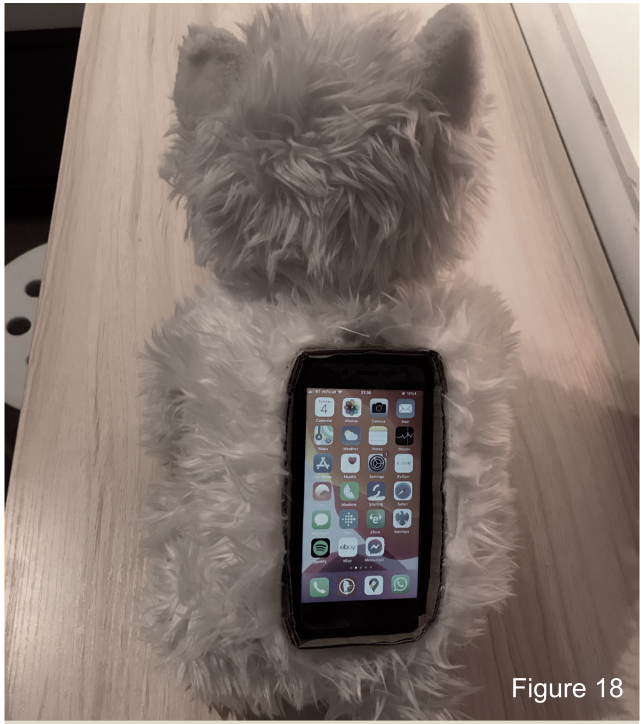


Figure 18

IDEATION

The following ideation embraces these new areas of discovery and aims to use them as a solution to the research problem. Research into collaborative experiences also created new scope to investigate whether creating child-parent bonding experiences could resolve issues surrounding loneliness in very young children.

Due to the abstract nature of 'designing for experience' it was necessary to mock-up a prototype to help materialise any new concept. Using the tools and documentation saved from the development of the AR toy, a kit was ensembled to represent the toy hacking activity. The toy kit has been temporary named ECO-AR to reflect the use of upscaled toys and AR technology.

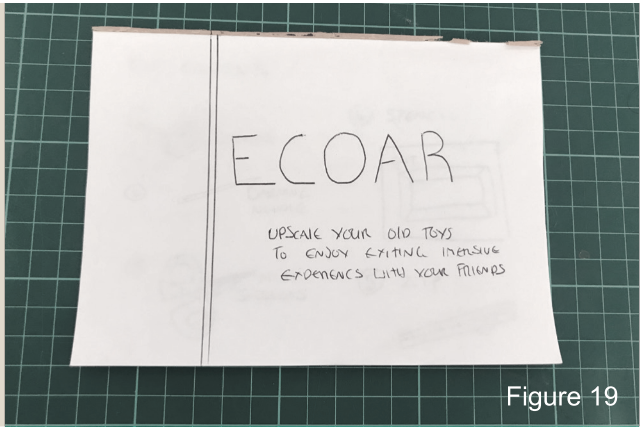


Figure 19

The ECO-AR prototype includes all the materials used to develop the hacked toy depicted on the previous pages. Sensors are essential to the kit; however, the technological development of sensors is out of the scope of this research.

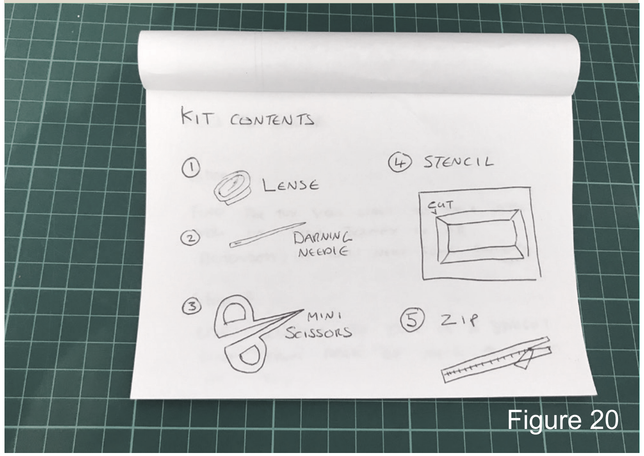


Figure 20

Further research would be to determine what utensils and materials would be needed to hack a toy completely. At this point in the project, it is assumed that all technology including sensors will be pre-programmed and interchangeable.

Figure 21

SURVEY DATA AND FINDINGS

This research involved gathering primary data via a 10-question questionnaire. The incentive behind the questionnaire was to gain an understanding of child-toy relationships, toy popularity and preferred activity.

Sample

The questionnaire was sent via Microsoft Teams to be completed by anyone who has children of any age. Each participant was advised to ask their child if they did not know the answer themselves. The questionnaire returned 17 results.

Findings

*Participants refers to the children of the adult completing the survey.

The results revealed that 11 out of the 17 participants had a favourite soft toy they still have (See Appendix B). Soft toys were more common in female children and generally used for comfort and sleep aid (See Appendix C). Parents took on the role of supervisor for females and advisor for males (See Appendix D). Finally, the results showed that most children gave up playing with their favourite toys between the ages 4-7 and became interested in technology between the ages of 5-9. 94% participants have a favourite toy they do not play with.

DISCUSSION

The ECO-AR kit comes with endless possibilities in terms of its content. The focus is on the currently untapped area of hacking soft toys with a scope to build future kits for dolls, action figures and mechanical toys. In terms of user experience, most published toy hacking guides require you to already have the correct tools, utensils, materials and know-how before you start. They also appear to be solitary activities to be undertaken alone. Considering new research suggesting that children are becoming socially withdrawn, this highlights a gap in which hacking soft toys as a collaborative activity can sit. Currently the ECO-AR kit idea involves a premade kit and a simple step-by-step guide to hacking a soft toy with pre-programmed sensors. The survey results show that most children already take part in play or recreational based activities or arts or crafts based activities, therefore it was important to reflect this craftiness in the design. The survey data also indicated that children lose interest in their toys from as young as four years old, whether this has any relation to the particular social lives of individual children is unclear, however, it does highlight a need to create a playful, engaging, and collaborative activity to maintain interest. Furthermore, the survey data also revealed ‘supervisor’ as the most common role taken up by parents which could suggest that parents are less inclined to get involved in their children’s play activities. The Child Development Institute released an article highlighting the cognitive benefits of play, stating that because children crave the attention of their parents, strong bonds are formed during their playful interaction. Finally, although the accompanying AR application has not been thoroughly discussed at this stage in the research, it will later play a pivotal part in creating a lasting joyful experience that will enable children to partake in collaborative games with both parents and peers. The prototype developed from this research opens doors for a new kind of bond to occur between children and their parents, where both child and parent take on the role of student.

FURTHER RESEARCH

Due to the outcomes of this research the volume of further research needed is high. To justify any further development additional primary research will should be gathered from the public to establish the need for this product. There should also be a broader and deeper investigation into any supporting literature which supports or rejects collaborative AR toy hacking as an appropriate solution to curb loneliness and strengthen parent-child bonds. Following this, a technical investigation is required to determine the level of programming needed to create pre-programmed sensors and the development of an AR application. Once a working prototype is built it will be subject to health and safety testing before being tested on the public. It is expected that there will be many iterations of this product before it is ready, making it difficult to predict what the end product will be. However, it is likely to be a technology driven experience fuelled by fun, friendship, and craftiness.

Figure 22

The AR App

The development of the accompanying AR application has not yet been developed.

A low-fidelity prototype can be found using the QR code below.

Further research would be required to truly estimate the technical requirements of the application as well as cost.

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Appendices

Appendix A

9	Critical
3	Important
1	Desirable

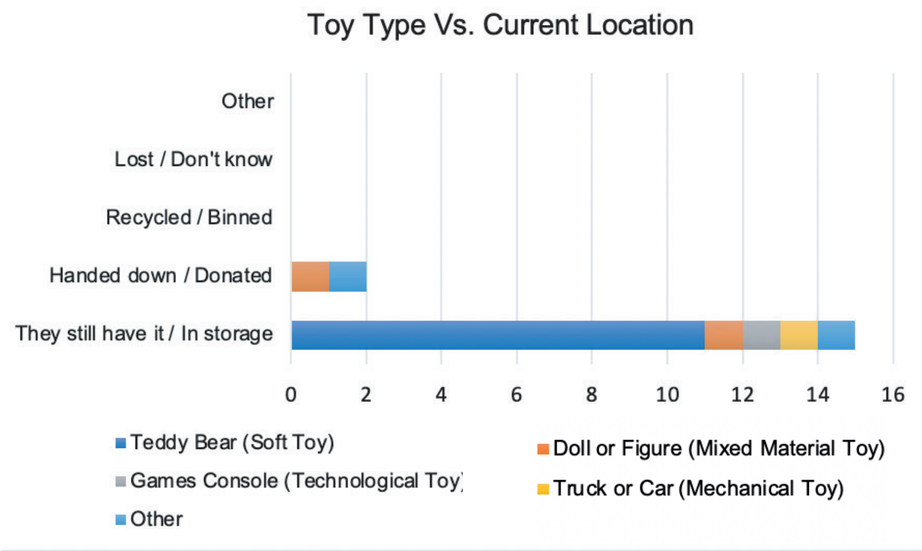
Importance	User Story	Requirement
9	As a child I want to play with my friends so that I don't feel lonely at home	Must be collaborative (Multi player, Add Friend)
9	As a child I want to also play by myself so that I can still have fun on my own	-
9	As a child I want to learn when I play so that I can feel proud	Education based activates
3	As a child I want to play with a soft toy so that I can cuddle it at night	Removable technology
3	As a child I want to play indoors so that I can still play when its dark	Indoor games and activities
1	As a child I want to play outdoors so that I can play when its sunny	Outdoor games and activities (water/damage resistant)
3	As a child I want to be-able to talk to my friends so that I don't feel lonely	Speaker and Microphone
1	As a child I want to play with others in a safe space so that I can feel comfortable	Advanced Security plus Password Protection
1	As a parent I want to be-able to see my child playing so that I don't have to worry	-
1	As a parent I want my child to be able to play indoors so that I can work as they play	-
3	As a parent I want to have some control over how my child interacts with electronic toys so that I can safe guard them	Parent access to settings
3	As a parent I want to be-able to monitor what my child does online so I can assure it is age appropriate	“”
9	As a parent I want to be assured that the technology my child interacts with has been appropriate tested so I can feel assured it is age appropriate	User tests

Appendix B

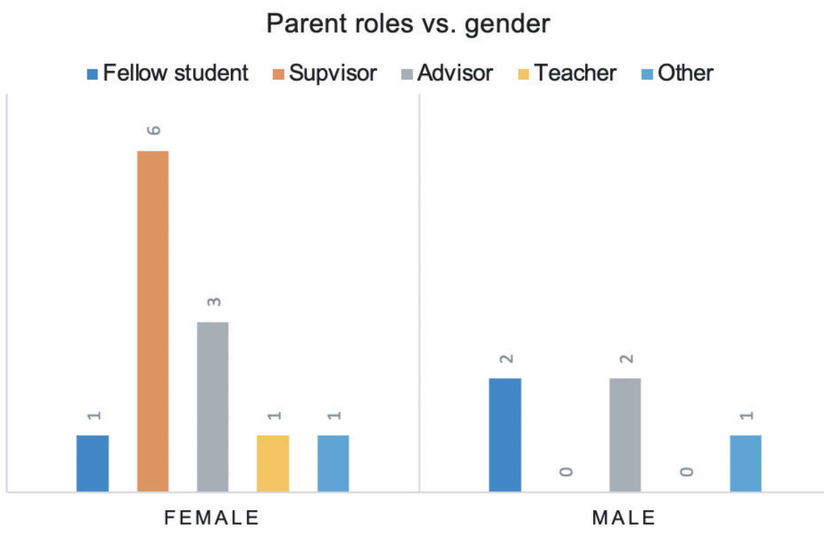
0	I don't agree that this is a usability problem at all
1	Cosmetic problem only: need not be fixed unless extra time is available on project
2	Minor usability problem: fixing this should be given low priority
3	Major usability problem: important to fix, so should be given high priority
4	Usability catastrophe: imperative to fix this before product can be released

Severity Rating	Usability Problem	Recommendation
3	Fur on toy obstructed external lens	Use short fured toys
4	Toy arms are to short to see in phone camara view	Use wide angle lense
4	Possibly risk of falling	Further tests needed
3	Poor sound qulity (muffling sound)	External speaker

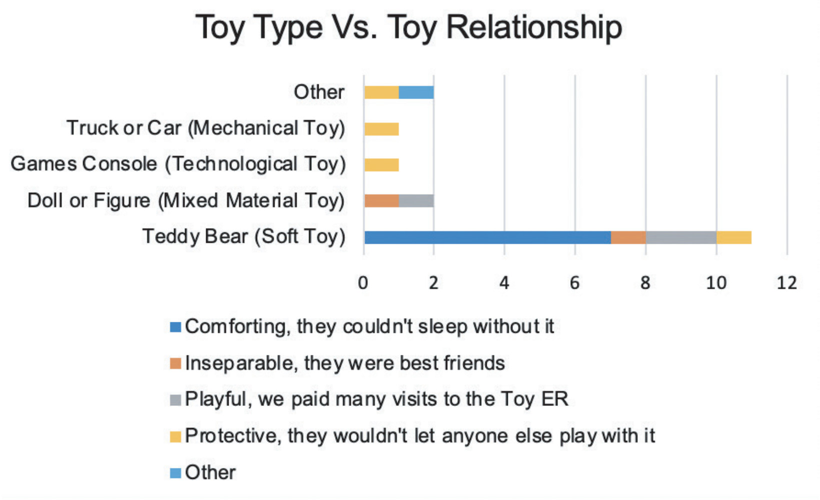
Appendix C



Appendix E



Appendix D



Appendix F