Toward a Technology to Overcome Anxiety in Children with Autism

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Abstract

Anxiety is very common in children with Autism Spectrum Disorder (ASD), which not only raises serious difficulties for these children in social situations, but has a high impact on the quality of their life, sometimes leading to depression and self-harm. For some children with autism, the presence of unfamiliar people, crowded places or social contexts that overload their senses can provoke strong and continuous anxiety, in some cases resulting in complete refrain from social interactions.

Previous research revealed that mindfulness-based coping strategies, such as counting or breathing exercises, can be effective in reducing anxiety in children with ASD. Also, technology proved to be highly appealing to individuals with ASD, and promising in teaching them skills and strategies to cope in difficult situations.

Therefore this project explores how technology can be best designed to present children with ASD strategies to cope with their anxiety. The technology employs Minecraft, a popular video game very much enjoyed by children, which has been used successfully as an educational resource for children with autism. From the knowledge of the researcher, Minecraft was never utilised to directly address anxiety in children with ASD.

A high-fidelity prototype was iteratively developed based on the ASD guidelines for designing technology and Human-Computer Interaction (HCI) principles, as well as empirical data. A participatory approach was adopted, and children (including one child with ASD), experts in HCI, ASD and Education were involved in the design and evaluation of the prototype. The results from the evaluation were very promising, revealing that the game (CalmCraft) was suitable, engaging, and enjoyable for children with ASD and has good potential to present strategies to help them cope with anxiety.
Acknowledgements

I would like to thank my supervisor Dr. Aurora Constantin who provided great guidance throughout the project. I would also like to extend my thanks to Dr. Helen Pain for her help in organising studies with children throughout this project.

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Chapter 1

Introduction

1.1 Autism Spectrum Disorder and Anxiety

Autism spectrum disorder (ASD) is a group of lifelong developmental disorders characterised by deficiencies in two core domains: social communication and interaction, and social imagination [14]. Due to the increase in awareness of autism and improvements made to the diagnostic criteria, ASD is estimated to occur in 1 out of 59 children [52], which is three times higher than it was estimated 20 years ago [4].

There are multiple psychiatric disorders that co-occur with autism, the most common being anxiety [61]. Anxiety is a feeling of fear or apprehension about a future event [14]. Studies indicate that around 40% of children with autism had at least one anxiety disorder diagnosis, social anxiety being one of the most commonly reported [61]. Social anxiety in individuals with ASD has been associated with socio-communication impairments, poorer social skills and functioning, and diminished social motivation [57]. Although there is no ‘cure’ for either autism or anxiety, studies proved that early medical and educational interventions can improve the quality of life of diagnosed individuals [65][14].

1.2 Project Goals and Research Questions

The main goal of this project is to research how technology can be best designed and developed to help children with ASD overcome social anxiety. Based on previous studies, technology appears to have an important role in supporting individuals with autism overcome their difficulties. As studies show, children with autism spend significant time playing video games, twice as much as typically developing children. The approach tackled in this project is to develop a technology using the widely played sandbox game Minecraft [7], to simulate social situations and present the player with coping strategies for social anxiety. To achieve this, the following research questions are addressed:

RQ1: What are the current strategies being employed to help children with ASD experiencing anxiety?
RQ2: What are the common aspects of social situations that might provoke anxiety in children with autism?

RQ3: How can a Minecraft game be designed to present strategies to cope with anxiety in children with autism?

RQ4: To what extent does the new educational game support children with autism prepare to face anxiety in social situations?

• RQ4.1: Are the game activities suitable for children with autism?
• RQ4.2: Is the game perceived as engaging by the target population?
• RQ4.3: Is the game perceived as enjoyable by the target population?
• RQ4.4: To what extent might the game be successful in presenting strategies to cope with anxiety to children with autism?

1.3 Structure of the Dissertation

The research project is divided into seven chapters and the remaining content is structured as follow:

Chapter 2: This chapter presents the literature review on autism and anxiety, with a particular focus on social anxiety experienced by children with autism. It then investigates the interventions for autism and methods to cope with anxiety used by practitioners. The chapter ends with the methodology and motivation of the project.

Chapter 3: This chapter focuses on the pre-design stage and includes a workshop with three typically developing children and one child with autism. It then discusses the Human Computer Interaction (HCI) and ASD-specific design principles that are followed through the project. The chapter concludes with an initial set of design implications.

Chapter 4: This chapter begins with the description of the low-fidelity prototype, implemented based on the initial set of design implications. The chapter then presents the evaluation study with 3 experts in HCI and ASD of the low-fidelity prototype and discusses the further design implications followed in the implementation of the high-fidelity prototype.

Chapter 5: This chapter presents the game developed in Minecraft Java Edition 1.16.5 based on all requirements gathered. It begins by describing technical decisions and their justifications. It then presents and explains all the relevant game elements and activities involved.

Chapter 6: This chapter presents the evaluation of the implemented game in three different studies: a usability study with 6 Informatics students, an evaluation with 3 TD children and an evaluation with 4 experts in HCI, ASD and game testing.

Chapter 7: This chapter answers the research questions based on the results from the evaluation studies, discusses the limitations of the project and presents different directions for future work.
Chapter 2

Literature review

This chapter discusses how anxiety and autism affect the individuals diagnosed and presents strategies and technologies employed in treatment procedures. The chapter ends with the motivation of the project and the description of the methodology. This chapter aims to answer **RQ1**: *What are the current strategies being employed to help children with ASD experiencing anxiety?*

### 2.1 Autism Spectrum Disorder

#### 2.1.1 Description of ASD

Autism spectrum disorder (ASD) is a group of lifelong developmental disorders characterized by deficits in two core domains [14]:

- social communication and interaction - this includes difficulty in social-emotional reciprocity, deficits in nonverbal communicative behaviors used for social interaction and struggle in developing, maintaining, and understanding relationships with others.

- social imagination - indicated by restricted and repetitive patterns in their behaviour, interests and actions.

Autism is often described by a ‘spectrum’, meaning that it manifests with different types and degrees of severity. While all people with autism share similar difficulties, their condition will affect them in various ways, making the group of diagnosed individuals a very heterogeneous one [17]. In the 5th Edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), Aspergers syndrome, Pervasive Developmental Disorder - Not Otherwise Specified (PDD-NOS) and Autistic Disorder are categorised in the group of Autism Spectrum Disorders [14].

#### 2.1.2 Comorbidities

Altered sensory perception such as atypical visual, auditory, tactile, olfaction and gustation processing have been proven to be directly linked with the ASD diagnosis, as up
to 95% of parents having children with autism reported some sort of unusual sensory behaviour in their child (e.g. avoidance of intense visual stimulation, overreactivity to touch, underreactivity to pain, overreactivity to smell, face processing abnormalities) [51][59]. All these lead to deficits in social communication, the integration of multisensory stimuli being crucial for complex social information perception [59].

Another widely studied and common behaviour in autism is the obsessive desire to sameness and routines, together with rigid and atypical interests such as intense interest in trains [47]. This type of behaviour is a measure of withdrawing form the unpredictability of the real world, which can be frightening for individuals with ASD. It is also believed that individuals with autism have a higher risk of developing mental health conditions, anxiety and depression being the most common ones [34]. Anxiety is further investigated in three consecutive sections starting from Section 2.2.

### 2.1.3 Prevalence and Impact of ASD

In the last few decades, the number of people diagnosed with ASD has increased significantly; this does not mean that nowadays there are more people with ASD than before, but rather that awareness has notably increased. Overall, ASC is estimated to occur as 1 in 100 [40], with a UK prevalence estimate of 1.6% [52].

From an economical point of view, the undiscounted lifetime cost of supporting an individual with ASD without intellectual disability is estimated at £3.1 million, and a 50 percent higher cost at £4.6 million is noted for individuals with autism that also have intellectual disabilities. Although these costs vary widely depending on multiple factors such as the severity of the condition, place of residence, hospital services or the need for private accommodation, studies showed that early and effective interventions during childhood can help reduce the intensity of support needed in adult life [36].

### 2.2 Anxiety Disorders

Anxiety is a feeling of fear or apprehension about a future event. Anxiety disorders include features of excessive fear, anxiety and related behavioral disturbances. Characterised by difficulty in concentration, restlessness, sleep perturbation and fatigue, anxiety disorders represent one of the major psychiatric disorders [14].

Anxiety was defined by Freud as an emotional state that included feelings of apprehension, tension, nervousness, and worry accompanied by physiological arousal. He observed that anxiety was adaptive in motivating behavior that helped individuals cope with threatening situations and that intense anxiety was prevalent in most psychiatric disorders [58].

### 2.3 Anxiety in Individuals with Autism

It is very common for individuals with ASD, ranging from all categories of ages, to experience anxiety. Due to the high variation of profiles in the spectrum, it is still
debatable whether anxiety is best conceived as a derivation or co-morbidity of ASD. Adults in the spectrum are taught to have a higher risk of developing co-occurring mental health conditions, anxiety and depressive disorders being the most frequent [34]. A pooled estimate of 27% for any current anxiety has been reportedly found in adults with ASD [32], a substantially higher than expected percentage based on non-ASD population estimates of 7-13% [45].

Constant anxiety can be extremely aching and it can have a big impact on quality of life as it affects people both psychologically and physically, for people with autism sometimes leading to depression or even self-harm. Studies indicated that around 40% of young people in the spectrum had at least one anxiety disorder diagnosis, social anxiety being one of the most commonly reported [61].

Social anxiety in individuals with ASD has been associated with socio-communication impairments, poorer social skills and functioning, and diminished social motivation [57]. If present from early stages of life, social anxiety can be a major impediment in the lifelong process of constant development.

### 2.4 Anxiety in Children with Autism

As we have seen above, 40% of children with ASD fulfill diagnostic criteria for an anxiety disorder [61], and an enormous 84% have subclinical anxiety symptoms [63]. In a recent analysis of 12 studies investigating rates of anxiety disorders in more than 1200 children, adolescents and adults, Kent and Simonoff [35] collected and reported the prevalence rates of both common anxiety disorders and ASD-related anxieties discovered in children with autism. The following percentages shows the ranges of rates obtained by combining findings from the studies reviewed. The common DSM-5 anxieties reported are:

- specific phobias (31%–67%): fears of needles, injections, blood, germs, doctors, insects or animals
- social anxiety (4%–29%): being socially evaluated, being rejected, letting people down, being different, having no friends, public speaking
- obsessive-compulsive disorder (OCD) (5%–37%)

The ASD-specific anxieties reported include:

- specific phobias: fears of chocolate buttons, men with beards, toilets, fears of specific foods
- anxious reactions toward stimuli generally considered enjoyable by children: happy birthday song, bubbles, Christmas
- sensory-related worries: too loud, bright, or busy places, auditory/tactile-related anxieties, being touched

Some of the ASD-specific anxieties may likely originate from sensory hypersensitivity and associated sensory processing difficulties, which in turn may be intensified in situations of uncertainty, such as change, transition, or overload [37]. Children
face increasingly complex social situations, very different from the normal perception, leading them and other young people around them to become more aware of their differences. This can increase their anxiety and may result in social pressure and even complete refrain from social interactions.

### 2.5 Strategies to Cope with Anxiety

Many researchers and practitioners focus substantial amount of their work to investigate and evaluate diverse techniques to cope with the roots of anxiety and its effects on individuals. An analysis of six studies on individuals with autism manifesting anxiety or depression symptoms show significant positive results in reducing their symptoms by making use of mindfulness interventions [22].

Mindfulness is the fundamental attentional stance underlying all streams of Buddhist meditative practice [29]. Mindfulness-based stress reduction (MBSR) represents an established program consisting of several mindfulness practices, including both formal and informal mindfulness exercises. Among those practices, some of the most widely used by practitioners are breath-focused attention exercises and counting exercises [29].

In a recent study towards an application to help children with autism cope with changes, Varnava et. al. [62] gathered several mindfulness techniques from practitioners and relevant literature with the aim of incorporating them in the application as strategies to help overcome anxieties related to different types of changes. The results were very promising, showing that coping strategies such as counting, guided breathing or listening to a favourite song can help reduce anxiety in children with autism.

### 2.6 Autism Interventions

Despite that a lot of research has been done on autism, there was no medical treatment found that can 'cure' it, mainly due to its nature. However, over the years researchers proved that early identification and intensive interventions on children with autism lead to great improvement in reducing the negative effects of their condition's core symptoms [24]. These interventions include behavioral interventions, developmental interventions, and cognitive-behavioral interventions. [24]. Older studies (1987 [39] and 1993 [43]) on early intensive behavioral intervention showed improvements in cognitive and educational functioning in about 47% of the children involved.

A study done in 2010 by Zachor and Itzchak [65] on a group of 78 participants aged 15-35 months, examined the effects of two intervention approaches on outcomes in cognitive, language, and adaptive skills, after one year of being involved in the program. The first type of intervention consisted in personalised goals delivered with a staff:child ratio of 1:1. The second type of intervention integrated several treatment approaches including Developmental Individual Difference Relationship (DIR) [30] and the Treatment and Education of Autistic and Related Communication Handicapped Children (TEACCH) [44], with a staff:child ratio of 5:7. After one year, improvement
was measured regarding change in autism diagnostic category, cognitive abilities and adaptive skills, positive outcomes being recorded in 76 out of the 78 children involved. The results of this study indicated no major difference in the magnitude of gains for each intervention approach chosen, but emphasized the importance of early detection and beginning of treatment [65] [33].

2.7 Technology-Based Interventions

Over the past years, along with the raise in autism awareness and research, the use of technology for ASD treatment has also increased significantly. Technology-based programs proved to be effective in addressing social, communication, behavioral, and adaptive skills in those with ASD and are progressively gaining recognition among researchers and practitioners [31]. Some of these technologies make use of virtual reality (VR), augmented reality (AR), robotics or music technologies, showing the wide range of opportunities technology can be exploited to tackle ASD treatment.

Many autistic individuals are visual thinkers, meaning that they can process information easier when they can visualise it by making use of pictures or words [38]. Therefore, they show great engagement with technological assistive tools as it captures and maintain their attention. Additionally, computer-based technologies can be easily adapted to meet sensorial needs of the individuals. For example, those with auditory or color sensitivity can adapt the tool to appropriate levels for them, and those experiencing fine motor skills difficulties can make use of keyboards or touch-screen in order to reduce the frustration of handwriting or drawing [38].

Computer-based interventions prove to be especially effective in treatment of children with ASD as they show a natural affinity for technology [60], as also the environment and context these technologies provide are predictable, engaging, motivating and rewarding for them [64].

Compared to typically developing children, teenagers and adolescents with autism spend twice as much time playing video games [42]. One reason this may be the case is that while playing, children rehearses and puts in practice, without the fear of being wrong, the skills and tasks implied by the game that they will later use in more formal contexts [15]. Games revealed to be a natural environment to stimulate different cognitive processes, promote stress relief and can act as a mood and anxiety management system [15][42]. One game which, after relevant appropriation, proved to have assistive properties as well as therapeutic uses is Minecraft [50][48].

2.7.1 Minecraft as an assistive technology

Minecraft [7] is an open-ended virtual world with no particular goals or play requirements [27][28]. It can be played as either a single player or a multiplayer game. If played single, the game provides to the player their own unique\(^1\) virtual world. As

\(^1\)content is create at the outset of a game, when the “new world” is created, and the placement of terrain and objects in the world are determined by an algorithm, rather than designed by a human [56]
a multiplayer game, it allows for social interaction between players through text chat and avatars. Players can ‘mine’ blocks that imitate real life materials (i.e. wood, sand, iron, diamond etc.), and use them to build or craft new objects. Although Minecraft tries to provide an inclusive, safe and creativity stimulating environment, some individuals with disabilities are still blindly excluded due to the nature of their condition not fitting with the characteristics of the game. However, by means of appropriation, Minecraft can be customised to accommodate special needs. Appropriation covers many activities including customisation, adaptation, plugins that add new content to the game or modify default aspects, or simply using artifacts with different purposes than initially designed [50]. One successful example of using these activities along other DIY techniques to appropriate Minecraft for individuals with autism is Autcraft [2].

As stated on the server’s official website, “Autcraft is a whitelisted Minecraft server for children (and adults) that have autism and their families.” [2]. Over the years, Autcraft community members actively worked to create an inclusive, beneficial and safe environment for children with autism, where everyone can not only be who they really are, but they are being valued for that. Ringland et al. showed that children being actively involved in the community learned how to self-regulate in a variety of ways, including mood regulation and sensory regulation, as well as how to manage engagement with others [50][49][48]. On top of that, parents and caregivers shared - on the server’s forum and on the public social media platforms maintained by the community members (i.e. Facebook page, Twitter account) - the amazing achievements of the individuals they are taking care of (e.g. some children became social in school for the first time, talking about Minecraft with their classmates, others learned how to correctly spell words by seeing others’ example in the game etc.), endorsing the beneficial aspects presented by researchers.

Appropriation can also play an important role in reducing the stigma corresponding to the use of assistive technologies [50]. Stigma can arise from aesthetically ugly devices, misconception about an individual’s ability, or social isolation for being categorised as disabled [55]. Thus, many experts involved in designing and developing technologies for individuals with autism shifted their focus from particular, heavily customised technologies to "mainstream", less stigmatized and more prevalent technologies that can be easily adapted to accommodate special needs.[25][55]. Since its launch in 2011, Minecraft’s player count increased continuously. As suggested by statistics web portals (Figure 2.1), in October 2018 the game was counting around 91 millions active players monthly, but until May 2020 the numbers climbed to an impressive estimation of 126 millions.
2.8 Motivation

Children with autism face increasingly complex social situations, very different from the normal perception, leading to constant social anxiety. Social and communication skills play a very important role in the development of the individual, thus children with autism need to be supported in coping with social anxiety. Previous studies [62] show that coping strategies [29] can be effective in reducing their anxiety when presented in a gamified manner. Moreover, previous research [48] pointed that games like Minecraft are appealing and effective in creating a safe and enjoyable environment where children with autism can play, but also learn. From the knowledge of the researcher, Minecraft was never used before to directly address social anxiety in children with autism.

The aim of this project is to develop a game in Minecraft that simulates social situations which might be worrying for children with ASD and presents to them strategies to cope with social anxiety in a gamified manner. Based on the previous positive findings [50] from the Autcraft [2] Minecraft server for individuals with autism, the approach proposed is considered feasible.

After analysing the four stages of cognitive development from Piaget’s Theory [41], the target population was set to include individuals in the “Concrete Operational Stage”, which consists in children between 7 and 11 years old. During this stage, children begin to thinking logically, understand concepts and start to reason from specific information to a general principle [41].

2.9 Methodology

This project followed the methodology presented in Figure 2.2, which is an adaption from (Scaife & Roggers, 2001) [54] and was inspired from the work of (Alabdullatif, 2016) [13]. This type of methodology allowed both children and experts to act as informants through the development of the project.

Stage 1: Background Research

The first stage consisted in reviewing the relevant background research on both ASD and anxiety, understanding the problem that trying to be solved and starting to sketch potential ideas of applications. Techniques and technologies for both autism and anxiety were researched in order to come up with an initial set of high-level requirements for the project.

Stage 2: Workshop to Inform the Design

In this stage, a workshop with 4 typically developing (TD) children and one child with autism was carried out in order to further define the requirements of the game. TD children were used as proxies for children with autism and aid in informing the design of the application to be implemented.

Stage 3: Designing and Prototyping

The aim of this stage was to implement a low-fidelity prototype based on the outputs collected form the previous two stages. The prototype was then evaluated with experts
in Human-Computer Interaction (HCI), ASD and Education to refine the design implications gathered so far and identify potential usability issues early in the development.

**Stage 4: Implementation**

At this stage the implementation of the high-fidelity prototype was carried out based on the refined requirements from the previous stage. The game was implemented in an iterative manner by first building the baseline and adding features to comply with the set of requirements.

**Stage 5: Evaluation**

In this stage the high-fidelity prototype was evaluated with experts, TD children and Informatics students. The evaluation focused on determining the usability of the game, its suitability for presenting coping strategies to children with autism and the suitability of the game activities for the target population, and aimed to find any issues to be tackled in future work.

Figure 2.2: Structure of the Methodology of the Dissertation
Chapter 3

Pre-Design Studies

This chapter describes the second stage of the project, "Workshop to Inform the Design", which includes two workshop sessions that were carried out to inform the design and discusses the initial set of game design elements for the low-fidelity prototype. This chapter aims to answer **RQ2**: *What are the common aspects of social situations that might provoke anxiety in children with autism?* and partially answer **RQ3**: *How can a Minecraft game be designed to present strategies to cope with anxiety in children with autism?*

### 3.1 Design Workshop

#### 3.1.1 Aims

The overall goal of this workshop was to gather game ideas and components in order to inform the design of the low-fidelity prototype. To achieve this, specific aims were defined:

- Determine in what social situations children may get anxious.
- Determine techniques and activities that may reduce anxiety in those situations.
- Gather ideas for a storyline in the game
- Identify what in-game rewards motivates children

#### 3.1.2 Environment

In order to follow the regulations imposed by the ongoing COVID-19 pandemic, the workshops took place virtually, on Microsoft Teams, through video conference.

#### 3.1.3 Participants

Five children participated in this workshop. Initially two children were scheduled to participate in the first session but one withdrew. In the second session two pairs of siblings participated, joining the conference together through the same device. At least
one parent/guardian was nearby for each participant. P1 was a child with autism and P2, P3, P4, P5 were typically developing (TD) children.

<table>
<thead>
<tr>
<th>Session</th>
<th>Participant Number</th>
<th>Participant Age</th>
<th>Participant Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>P1</td>
<td>6</td>
<td>Male</td>
</tr>
<tr>
<td></td>
<td>P2</td>
<td>12</td>
<td>Male</td>
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<td>2</td>
<td>P3</td>
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<td>Female</td>
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<td></td>
<td>P4</td>
<td>13</td>
<td>Male</td>
</tr>
<tr>
<td></td>
<td>P5</td>
<td>13</td>
<td>Male</td>
</tr>
</tbody>
</table>

Table 3.1: Design workshop participants

### 3.1.4 Materials

The materials used for the workshop enumerates: Consent form (Appendix E.5) and Information Sheet (Appendix E.2) for parent/guardian, Consent form and Information sheet for children (Appendix E.1), electronic device (laptop, tablet, smartphone), blank sheets of paper, coloured pens/pencils, additional audio-recording device for backup, script for the researcher.

### 3.1.5 Procedure

The workshop was conducted online via Microsoft Teams [6] and the sessions were recorded using the ‘Record Session’ functionality in Teams. The principal researcher (PR, the author of this dissertation) and another researcher participated to the workshop. The two researchers worked in parallel. one leading the activities and the other taking relevant notes.

The parents were contacted through email, where information sheets and consent forms for both parents and children were attached. If a child decided to participate, both consent forms were required to be signed and returned prior the session. The workshop consisted in a set of predefined activities designed to fit the aims presented above.

**Icebreaker (5 Minutes):** The icebreaker consisted in a drawing activity, in which everyone in the meeting participated. The task was to make two drawings, one for something that makes them feel happy and another for something that makes them sad. The purpose of the first activity was to get the children comfortable with the workshop setting and to warm them up for the upcoming drawing activities.

**Activity 1: Think of difficult situations (10 Minutes):** Before kicking off with the first activity, the children were presented a fictive person, named ”Alex”, and were told that Alex is a kid that gets extra worried when he is around people he does not know, or in situations where he does not feel completely comfortable in. They were asked, and reminded by the researchers before each relevant activity, to refer to Alex when thinking on their answers.

In the first activity children were asked to think of three situations in which Alex might get stressed or scared. They were advised to draw and write anything they found
useful for presenting their ideas, and the researchers provided a vague example, to help children understand better what they are expected to do.

Activity 2: Find solutions (10 Minutes): In this activity children were tasked to think of three methods or techniques to help Alex cope with the situations brought up in the previous activity. Children were informed that they can refer to any stressful situation mentioned, not only those presented by themselves. Researchers provided an example before the start of the activity.

Activity 3: The story (15 Minutes): For this activity, children were asked to come up with a fantastic story, based on both a scary situation and a solution they came up with in the previous activity. They were encouraged to draw characters, an environment, a map and anything else that would help them present the story. Researchers provided a sample storyline.

Activity 4: Rewards (5-10 Minutes): For the fourth and last activity of the workshop, children were asked to design rewards for a potential application or game. They were asked to think of both rewards to get at different stages in the game as well as rewards for the finish of the game that would act as celebration for completion.

3.1.6 Data Collection and Analysis

Data collected consisted of: video recordings, notes taken by the researchers and the electronic copies of the children’s drawings sent by parents via email. The recordings were reviewed and the data was transcribed. The transcriptions together with the notes and drawings were analysed using Thematic Analysis [20], a method of analyzing qualitative data by grouping similar data by topics, ideas or patterns, commonly referred as themes. The procedure followed was taken from Braun and Clarke [19] and consisted in 6 steps: familiarize with data, generate initial codes, search for themes, review the themes, define and name the themes, report the results. The Thematic Analysis led to several themes which are discussed in the next section.

3.1.7 Results

Based on the data analysis presented above, the following results emerged:

Social Situations: This theme revealed a series of social situations in which children become anxious. All children mentioned that within the school environment there are various worrying situations. For example, child P4 considers that going to a new school (Figure 3.1.a) or joining a class with a new teacher make them anxious. He commented: "...going to a new school or going to your school but there is a new teacher with a different teaching style, that can be stressful."

Two children, P2 and P5, mentioned about either going to the dentist or to the hairdresser as being activities that might get children nervous. P5 commented: "...at the hairdresser...the sound of clippers...and how it’s tickling your head."

Activities related to practicing sports can also produce anxiety as mentioned by P2 and P3 (Figure 3.1.b). Child P3 generally remarked: "If you do a new sport you could
be nervous because there might be different people that you don’t know...or you don’t know how to play.”

![P4’s drawing of school](image1.png)

(a) P4’s drawing of school

![P3’s drawing of school and a sport as anxiety provoking environments](image2.png)

(b) P3’s drawing of school and a sport as anxiety provoking environments

Figure 3.1: Children’s drawings

Strategies to Cope with Anxiety:

After identifying scary social situations, children had to come up with ideas of ways to relax in those situations. Four of the five kids mentioned talking to a parent or other family members to calm yourself, or communicate with people you are familiar with, if they are present in those situations. In terms of coping strategies, P1 suggested that counting form 1 to 10 can help in reducing anxiety: "Count in your head from 1 to 10...that’s a good idea.”. P4 mentioned relaxing in a quiet environment: "Spend some time in a quiet place.”. P5 pointed towards another coping strategy, the breathing exercise: "Think about something you like...and do some breathing (exercises)”.  

Game Storyline

The workshops were also a good opportunity to gather ideas for the story of the game. In this activity, children came up with various fantastic stories, some with very specific details, such as P4’s story: "Alien explorer crash landed on a new planet...to repair the ship he has to work with people. He finds a village and works with the people to find the parts, some more difficult than others”. Although the overall stories created by the children were vast, a summary of the concepts collected is presented in Table 3.2 below.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Quoted answer</th>
<th>Game Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>P2</td>
<td>&quot;...track your way and collect coins&quot;</td>
<td>collectables along the game path</td>
</tr>
<tr>
<td>P3</td>
<td>&quot;... in the first level... for the second level&quot;</td>
<td>multiple levels</td>
</tr>
<tr>
<td>P5</td>
<td>&quot;... if you get it correctly you move to next level&quot;</td>
<td>multiple levels</td>
</tr>
<tr>
<td>P4</td>
<td>&quot;you work with people...and there’s also your friend there”</td>
<td>feature multiple characters</td>
</tr>
</tbody>
</table>

Table 3.2: Game Concepts emerged from children’s stories
An interesting observation regards P1, the child with autism, who was not very talkative for most of the activities, but at some point he mentioned about playing Minecraft, so the researcher tackled this opportunity to find more about specific Minecraft features that children do or do not enjoy. From this, the following Minecraft-specific settings emerged: fall damage, fire damage and hostile mobs (monsters) should all be disabled in the game.

Rewards: Children suggested general types of rewards such as stars or smiley faces, as P2 stated: “you can get smiley faces...or stars, two or three depending on how well you do”. P3 and P4 suggested to have collectables through the game path: ”...collect coins which you use for upgrades” & ”...there are coins on the ground...”. P5 mentioned about having a set of achievements to unlock through the game as also a bigger reward at the end: ”Usually in games you have a list of achievements...and something cool like fireworks at the end.”.

3.2 Design Principles

3.2.1 HCI Design Principles

To determine the initial set of design implications, it is essential to take into account the principles used in HCI and follow them as guidance in the design process. The most general and widely used principles are the 10 Nielsen’s Usability Heuristics [46] and act as a rule of thumb for designing interactive tools. The list with the 10 principles and their explanation can be found in Appendix B. For the rest of the paper, where relevant, the HCI principles will be referred to using IDs (e.g. HCI-P2).

3.2.2 ASD Design Principles

Additional to the HCI principles discussed above, a set of principles designed to accommodate for individuals with autism were also followed through the design and implementation of the game. The set of ASD-specific design principles were collected by Laura Bartoli (2014) [18] and can be perceived as general guidelines in designing applications for children with autism. The relevant principles to this project are:

ASD-P1: The goal should be unique and specific.
ASD-P2: The game should allow progression through multiple levels.
ASD-P3: Instructions should be explicit and provided everywhere necessary.
ASD-P4: The game should be predictable and repeatable.
ASD-P5: Rewards appealing for children should be offered after good performances.
ASD-P6: The game environment should not be overwhelming.
ASD-P7: Navigation should be straightforward.
ASD-P8: Text should be simple, clear and easy to read.
ASD-P9: The game should promote the development of imitative capability.
### 3.3 Design implications

Bringing together findings from the literature review in Chapter 2, the results from the design workshop in Section 3.1 and the HCI/ASD Design Principles outlined in Section 3.2, the initial set of design implications (Table 3.3) was created and followed in designing the low-fidelity prototype.

<table>
<thead>
<tr>
<th>Design Implication</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>The target population is children with ASD between the ages of 7 and 11</td>
<td>Literature Review [41]</td>
</tr>
<tr>
<td>The game is developed in Minecraft</td>
<td>Literature Review [50,48], P1 from Design Workshop</td>
</tr>
<tr>
<td>Clear instructions are given where necessary</td>
<td>ASD-P3, HCI-P10</td>
</tr>
<tr>
<td>The game is intended to be played by the children, with minimal to no intervention from practitioners/carers</td>
<td>ASD-P7</td>
</tr>
<tr>
<td>The language is simple and direct</td>
<td>ASD-P8, HCI-P8</td>
</tr>
<tr>
<td>A &quot;Calm&quot; level bar, showing the calm level of the character, is always visible</td>
<td>HCI-P1</td>
</tr>
<tr>
<td>The game features characters resembling real life people (teacher, hairdresser, etc.)</td>
<td>ASD-P9, HCI-P2</td>
</tr>
<tr>
<td>Collectables are placed along the game path</td>
<td>P3 &amp; P4 from Design Workshop</td>
</tr>
<tr>
<td>The game has multiple environments, each simulating a social context: classroom, barbershop, soccer field</td>
<td>All children in Design Workshop</td>
</tr>
<tr>
<td>The game features ‘Calming Rooms’, each presenting a different coping strategy</td>
<td>Literature Review [22], ASD-P9, All children in Design Workshop, ASD-P9</td>
</tr>
<tr>
<td>The coping strategies are: relax in a quiet place, counting exercise, breathing exercise</td>
<td>Literature Review [22], All children in Design Workshop, ASD-P9</td>
</tr>
<tr>
<td>Tasks are clear and straightforward</td>
<td>ASD-P1</td>
</tr>
</tbody>
</table>

Table 3.3: Initial Design Implications
Chapter 4

Low-fidelity Prototype

This chapter presents the low-fidelity prototype (Section 4.1) and its formative evaluation with experts in HCI, ASD and Education (Section 4.2). This chapter aims to further answer RQ3: How can a Minecraft game be designed to present strategies to cope with anxiety in children with autism?

4.1 Prototype Description

The development of the application was iterative and thus, a low-fidelity prototype was implemented first, since it is a commonly used technique in iterative design due to the process of creating it being fast and inexpensive. The purpose of the prototype was to be evaluated with HCI, ASD and Education experts, to further update the set of design implications gathered so far.

The prototype was developed in Balsamiq [3], a wireframing tool which allows the design of graphical interfaces, as well as linkage between interfaces in order to simulate how the user navigates in the game environment. Several advantages of using Balsamiq were identified: it allows easy customisation of wireframes by drag-and-dropping artifacts, it is less time consuming and closer to the real software simulated than hand drawn mockups, and it is rough enough to encourage users to make modifications, even major ones. The main downside of using such a wireframing tool came from the fact that all free movement a user can perform in a Minecraft world could not be replicated in the graphical interfaces designed in Balsamiq, thus the prototype focused only on the main interactions that would change the state of the game. To compensate, during the evaluation of the prototype the experts were made aware of this limitation and asked to keep this in mind when formulating their feedback.

**Game Concept:** The general idea of the game, called ”CalmCraft”, is to simulate social situations that are stressful and reduce the calm level of the player’s character. The calm level is represented by a ’Calm’ level bar, initially full, which is present on the top of the screen through the entire game. In each stressful situation the ’Calm’ level of the character is reduced, due to either a specific action such as getting close to a character or just exploring the environment. The player is notified about the change
and the instructions appearing on screen will suggest that they should go into a calming room to regain the calm level of their character. Each situation will give access to a different calming room, each presenting a separate calming strategy.

The low-fidelity prototype features one social context, i.e. going to school, and one calming room, i.e. the "Quiet Room". The reason other social situations or calming rooms are not featured in the prototype is that the purpose of the expert evaluation was to assess in detail the mechanics and suitability of interactions that both Minecraft and this design impose, and those aspects would replicate the same in other levels of the game. Additionally, given the limitations of Balsamiq, the design in the actual game of each calming room or social situations would be very different, thus the focus was put on replicating the flow of actions as accurately as possible. Where no specific action, such as opening a door or pressing a button, is implied in the current wireframe, linkage to the next wireframe is done via a round button with the "+" symbol on it, as seen in Figure 4.1.

**Instructions:** In terms of guidance for playing the game, text instructions appear on the screen at relevant times, letting the player know what they should observe or perform in the current environment, or if any change (e.g. the calm level was reduced) occurred. Figure 4.1 shows an example of such text instructions, more specifically, the initial instructions regarding the tasks of the game.

**Tasks:** The purpose in the game is to collect apples and diamonds while keeping the 'Calm' level as high as possible. The two types of collectables serve different purposes:

- Apples, an easy to find and low-value resource in Minecraft, are used to pave the game path, hence highlighting the route to be followed.
- Diamonds, a more valuable item in Minecraft, are used less often and are placed near key elements of the game (e.g. important entrances, buttons or characters).

**The flow of game interactions:** In Figure 4.2 is presented the change in the calm level of the character when going into the classroom. In Figure 4.2.b, the game instructs the player that they should use the "waystone", a type of artifact which allows the player to teleport between locations where an instance of it is placed, to access the calming room. The concept of teleporting using waystones
was later dropped and replaced with a different method, presented in Chapter 5, due to the lack of customisation options.

The calming room featured in the low-fidelity prototype was inspired from the field notes of Ringland et. al. [50] while researching the behaviour of individuals with autism on the Autcraft server [2]. In the game, researchers came across holes in the ground which were used by some players for a "sensory break" when they were feeling overwhelmed. Based on this concept, the "Quiet Room" was designed as being a dark, silent place where the player should only relax while the calm level is slowly regained. Figure 4.3.a shows some of the instructions given in this room.

![Figure 4.3.a](image)

(a) Inside the “Quiet Room”

Figure 4.3: The calming room & The text reward after regaining the calm

Figure 4.3.b shows the text reward given after the player successfully uses the calming room. Previous research [23] revealed that this kind of reward is suitable for children with ASD, as it acknowledges task completion and progression in the game. It was also pointed that rewards should be incremental (e.g. firstly "Good job", then "Amazing job"), as children with ASD prefer the reward topic to remain the same, but the reward instance to be incremental as you progress in the game. Additionally, the same research [23] suggested that children with ASD need a ‘bigger’ reward at the end of the game. Alternatives for a final reward as well as other aspects of the low-fidelity prototype, such as if the current way of displaying instructions is suitable for individuals with ASD, or whether the game should have a linear storyline or levels unrelated to one another, were discussed during the expert evaluation of the low-fidelity prototype described in the next section.

### 4.2 Prototype Evaluation with Experts

The low-fidelity prototype described in the previous section was evaluated with experts on HCI, ASD and Education. This step was particularly important before implementing a high-fidelity prototype in order to discover any usability issues in the current design. It was also a good opportunity to discuss and assess with the experts design alternatives, as well as suitability of the proposed activities for the target population.

#### 4.2.1 Aims

The following main aims were set for this study:
• Evaluate the suitability of the current design for the target population (children with ASD aged 7-11 years old).
• Determine the best way to display instructions in the game.
• Determine the most suitable type of storyline (linear story or stand-alone levels).
• Determine an appropriate reward system.
• Determine the most suitable mechanism of exploring the calming rooms.

4.2.2 Environment
In order to follow the regulations imposed by the ongoing COVID-19 pandemic, the studies took place virtually, on Microsoft Teams [6], through video conference.

4.2.3 Participants
The participants were three experts in the fields of HCI, ASD and Education. To ensure anonymity, each participant is referred to using a participant number.

<table>
<thead>
<tr>
<th>Participant Number</th>
<th>Position/Occupation</th>
<th>Area of expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>Professor in Education</td>
<td>Experience in ASD</td>
</tr>
<tr>
<td>E2</td>
<td>PhD in HCI and ASD</td>
<td>Experience in HCI and ASD, developing technologies for children with ASD</td>
</tr>
<tr>
<td>E3</td>
<td>Researcher in HCI</td>
<td>Experience in HCI, developing technologies for children</td>
</tr>
</tbody>
</table>

Table 4.1: Expert participants for the low-fidelity prototype evaluation

4.2.4 Materials
The following materials were used to conduct the studies: Information Sheet and Consent Form for Experts (Appendix E.6), Computer or mobile device to join the Microsoft Teams meeting, Script for the researcher, Notebook for researcher’s notes, Additional audio-recording and playback device for backup.

4.2.5 Procedure
Each expert was contacted via email and the information sheet was attached. The invitation emails were sent in collaboration with another researcher, but each researcher held their study individually. Each session was run with one participant at a time, but the same procedure was followed. The sessions lasted between 30 and 45 minutes, depending on the follow-up questions and discussions with each expert.

For each session, the 'Cooperative Evaluation' method was used, a variation of the 'Think Aloud' method, where the user takes part as a collaborator and not only a participant [26]. Therefore, the experts were encouraged to ask questions (e.g. why,
what if) while going through the prototype in order to clarify the users behaviour. At the beginning of each session, the participant was informed about the project and its aims. Only one of the experts had experience in Minecraft, thus the other two were more comfortable with the researcher sharing his screen and going through the prototype while pointing out the relevant knowledge necessary to understand how the game works.

After the expert familiarised with the prototype, the researcher asked them a series of questions:

- Do you think Minecraft is suitable to teach calming strategies to children with autism?
- Is the current way of displaying instructions suitable for children with autism?
- What type of storyline you think would be more suitable in this context, a linear one or stand-alone levels?
- What type of rewards would be appealing to children in this context?
- How do you think would be best to get the player to explore calming rooms; give them the options to choose from or introduce them one by one?

In each session, following the answers to the previous questions, a discussion on best practices and suggestions was initiated. The emerged notes from these discussion, together with the answers from the set of questions are discussed in the 'Results' section.

### 4.2.6 Data Collection and Analysis

After the sessions with experts were complete, the recordings were reviewed, transcribed and combined with the notes taken during each session. The emerged data was inspected using Thematic Analysis [20] and the procedure followed was similar to the one described in Section 3.1.6. The resulted themes are presented in the next section.

### 4.2.7 Results

The experts were positive regarding the general idea of the game and the proposed way of integrating features. They pointed out many essential improvements and suggestions, however some of them were considered for Future Work due to the limited time for implementation and their complexity. From the thematic analysis presented in the section above, the following results emerged:

**Suitability of the current design:** One of the main focuses of this study was to check if the chosen software for implementing the game (i.e. Minecraft), together with the proposed mechanics and actions in the game, are adequate for the target population. All experts were optimistic regarding the potential beneficial aspects this type of game would bring to children with autism, E1 specifically remarking: "Playing in Minecraft...you could see that as a simplification of the social interaction...and regarding autistic child feeling overwhelmed about face to face interaction, the degraded social interaction within the game environment may be more manageable for them.”
When explained that Minecraft was intended to be used to reduce the stigma associated with assistive technologies, the experts were very positive about this aspect, E1 stating: "Yeah that is a very good point!"

**Instructions in the game:** As discussed in section 3.2 regarding HCI/ASD principles, instructions play a crucial role in guiding the player to successfully complete the game tasks. Experts were presented with the options available in Minecraft for giving instructions:

- Display text on the screen based on either player’s location or them interacting with an object.
- Add poster-like signs with text in any relevant place.
- Write instructions in books (items that the player need to specifically use).

After discussing all the options with the experts, all agreed that the first option should be the one to use, E1 and E3 also suggesting that the second option can be used in any relevant situations. About the first option, E2 stated: "It is a good idea, it is done frequently in games for children with autism.". E1 remarked that on-screen instructions are prominent and not long for the children to grasp: "Well it is obviously prominent, eye-catching...looks like enough words for a child to pay attention”.

**Storyline and Non-Player Characters (NPCs):** The two main options for the storyline of the game proposed and discussed with the experts were to either have a linear story that would link the exploration of the social situations from one to another, or to have a central place from which each standalone level, consisting in one social situation and a calming room, could be accessed. E3 remarked that a linear story would make the game repetitive: "A linear storyline would be the least impressive because a player would have to do the same thing every time they access the game.”. E2 pointed the benefits of having a flowing story, but also remarked its lack of customisation potential: "...there is a benefit to having a story, social stories proved their benefit...however I don’t see how could you customise that”.

All three experts opted for having standalone levels, mainly due to customisation purposes. E1 stated: "...possibilities of customisation and adding more to the story, that is a good idea”. E3 also pointed a good approach for how the levels can be still included in a general story, namely to receive tasks from the NPCs: "I would say levels...[and you] would be to receive tasks from the characters in the game...Having some challenges in between the exploration of the situations would be nice”.

**Exploring the Calming Rooms:** For this aspect of the game, experts were also presented two possibilities: teleportation to a calming room to be automatic and defined by the game in order to ensure exploration, or to let the player specifically perform an action to visit the calming room. All experts chose the second option, highlighting the necessity of having a specific action to perform in those situations. E2 remarked: "To try and calm yourself down is something you need to take action to do...To achieve that, you need to have something that lead them to use the calming room”.

**Rewards:** In terms of rewards, experts proposed different ways to recompense the children for progressing in the game, including the text rewards that acknowledge pro-
gression described in Section 4.1. E1 emphasised: "...you can have the game congratulate the child after successfully regaining their character’s calm...anything that gives the sense of achievement.”. E2 suggested a reward system based on the collectables gathered through the game: "They can buy accessories or gear with the stuff they collected.”. E3 mentioned having a final and more impressive reward for finishing the game: "...you can have some fireworks at the end of the game”.

4.2.8 Discussions

Overall the experts were positive towards the proposed design, especially about using Minecraft for educational purposes. Following the expert evaluation of the low-fidelity prototype, the list of design implications discussed in Section 3.3 was further updated. The additional features, along with their justification based on HCI/ASD principles (Appendix B & Section 3.2.2) and feedback from the experts, are presented in Table 4.2 below.

<table>
<thead>
<tr>
<th>Design Implication</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructions are clear and provided on-screen where relevant</td>
<td>All experts, HCI-P1, ASD-P3</td>
</tr>
<tr>
<td>Standalone levels are accessed from a central place</td>
<td>E1 &amp; E3, ASD-P2</td>
</tr>
<tr>
<td>NPCs can dialogue with the player, giving tasks and instructions</td>
<td>E2</td>
</tr>
<tr>
<td>Calming Rooms are introduced one at a time and the player access them voluntarily</td>
<td>All experts</td>
</tr>
<tr>
<td>Have incremental text rewards after completing each level</td>
<td>All experts, literature review [20], ASD-P5</td>
</tr>
<tr>
<td>Have a reward for finishing the game (i.e. fireworks)</td>
<td>E3, ASD-P5</td>
</tr>
<tr>
<td>Have cosmetic items that can be purchased by spending the collectables gathered</td>
<td>E2, ASD-P5</td>
</tr>
</tbody>
</table>

Table 4.2: Additional Design Implications
Chapter 5

High-Fidelity Prototype

This chapter firstly presents the technical details involved in the development of the game. It then describes the environment and interactions of the game, as perceived by the player.

5.1 Technical Decisions and Justifications

The world: The world\(^1\) was initially generated as a flat, plain terrain with no default structures or entities present. Settings at the time of generating the world included: disabled fall and fire damage, disabled logs appearing in the chat, disabled default achievements, programmed a setting for collectable items (apples and diamonds) to never disappear. These settings ensured compliance with the suggestions gathered from the child with autism during the design workshop and with HCI principles regarding "error prevention" and "aesthetic and minimalist design".

Buildings and Structures: The world was then populated with structures that simulate real life environments such as a classroom, a barbershop or a school soccer field, all being suggested in the design workshop (Section 3.1). Rather than manually building each structure, several websites \([12]\) \([8]\) were researched, containing large collections of worlds created and publicly shared by Minecraft players. The most suitable structures were identified, cropped, adapted by the researcher, then appended to the project world. The rigorous process of selecting each structure was driven by the HCI principle on "match between system and the real world".

Plugins: In order to achieve all the desired features, several plugins \([9]\) that add functionalities to the game had to be set up and integrated. Some of the most important ones were the plugins adding: customisable non-player characters (NPCs), personalised dialogues for NPCs, better-than-default teleportation functionalities, customisable holographic text displays and personalised game achievements. The supplementary functionalities added by the plugins facilitated the development of many features suggested either in the design workshop or in the expert evaluation of the low-fidelity prototype,

\(^1\)As also presented in Section 2.7.1, a 'world' is an individual instance of a game in Minecraft
such as: having custom and interactive characters, personalised achievements linked with gathering collectables or a consistent and comprehensive way of teleportation.

**Activities and Interactions:** As Minecraft is mostly developed in Java [11], there are several function calling commands that can be executed using the Minecraft chat. Those commands trigger various interactions in the game, such as change in the value of the ‘Calm’ level bar, display of text on the screen or teleportation to specified coordinates. To achieve the desired game behaviour in certain stages, two types of function files (example in Appendix D.1, Fig D.2) containing Minecraft commands were coded: function files with commands to be executed at the same time in the game and function files that schedule the execution of one or more function files. Together, those files are generally referred to as a datapack. The datapack developed for this game contains around 60 function files and schedules.

To execute the relevant functions at a given stage, ”command blocks” (Appendix D.1, Fig.D.1) have been used, a special type of block in the game that can store a command which can be triggered either specifically by pressing a button or automatically given the location of the player.

**The server:** In order to remotely evaluate the game with experts and children, the Minecraft world had to be converted into a server and hosted online, to facilitate users’ access. After setting up all the necessary files, the PR hosted the server on his personal device. Initial tests revealed poor server performance due to low computation power of PR’s device, thus it was decided to use a third-party hosting service. The chosen service [1] was selected due to their high reliability score and being GDPR compliant.

**Customisation and Modularity:** After analysing the feedback from experts, it was decided to develop the game in a modular manner by having standalone levels, which are accessed from a central ‘Hub’ (Appendix A, Fig.A.1.b). Each level consists of exploring a social situation (e.g. the classroom) and a calming room, the two not being particularly linked to one another, thus ensuring further modularity. With this design, both social situations and calming rooms can be added or removed from the world, without disrupting the narrative of the game. Hence, the game can be customised to fit individual preferences.

In terms of character customisation, Minecraft does not allow in-game customisation, but it offers the option to add a new graphic appearance to your character, called a ‘skin’, in the game launcher screen. Therefore, users can be pointed to any third party web application [10] where they can create and edit a skin or simply choose from one of the thousands already created on the website.

### 5.2 High-Fidelity Prototype Description

The prototype, entitled CalmCraft, tries to simulate social situations that the game defines as being worrying for the character, by reducing the value of the ‘Calm’ level bar after either a specific interaction or simply after exploring the environment. Then, the instructions appearing on screen together with the dialogues with NPCs suggest to teleport into a calming room to regain the calm level of the character. Each calming
room aims to present one of the strategies to cope with anxiety discussed in the literature review or suggested during workshops. The tasks in the game are to collect the apples and diamonds placed around the game path and to keep the Calm level bar as full.

At the start of the game, the player is located in a neutral space where only an NPC is present and text instructions appear on the screen (Appendix A, Fig.A.1.a). The purpose of this space is to present the player with the tasks and initial instructions of the game without having any distractions around. The player can then press a button to teleport into the ’Central Hub’, the place where the levels of the game can be accessed from (Appendix A, Fig.A.1.b). The teleportation functionality is consistent through the game and it consists of buttons with holographic text above them stating the destination it transfers the character to.

5.2.1 The Social Situations

**The Classroom:** In this environment, the player is firstly teleported at the top of a waterslide (Appendix A, Fig.A.1.c) which they have to ride to the bottom, where the entrance to the classroom is. This element was added to make the overall environment more fun and appealing for children, as suggest by one of the experts. In the classroom, the player can explore around, gather collectables and interact with the NPCs. Before getting to interact with either ’Your Best Friend’ or the ’Teacher’ NPC, the game reduces the Calm level bar value and notifies the player about the change (Figure 5.1). Both NPCs mentioned previously have dialogue lines remarking your state and suggest to use the calming room, as proposed by one of the experts during the low-fidelity prototype evaluation.

**The Barbershop:** Another social context mentioned by children in the design workshop is the ’Barbershop’. In the game, inside the ’Barbershop’ (Appendix A, Fig.A.1.e) the player can dialogue with two non-key NPCs and with the hairdresser, as the instructions suggest. The hairdresser points to the ’scissors collection’ room, where a diamond is paced. Inside this room, the game triggers the calm level drop, text instructions inform the player about the change (Appendix A, Fig.A.1.f) and suggest to teleport to the calming room.

**The Soccer Field:** Another situation that children mentioned as being anxiety provoking was about practicing a sport, potentially new for them. In the game, a soccer field is simulated (Appendix A, Fig.A.2.a), having NPCs running around the field and a coach on the side that can be interacted with. Here, the

![Figure 5.1: Text alerting calm reduction in the Classroom](image1)

![Figure 5.2: Dialogues with the Coach](image2)
player is encouraged to explore around and collect the apples and diamonds. Before getting to talk with the coach, the game defines the environment as being worrying and reduces the calm level (Appendix A Fig.A.2.b). When interacted with, the coach also points out that you do not look very calm and suggests to go to the calming room (Figure 5.2).

5.2.2 The Calming Rooms

The game features three calming rooms, two of them incorporating strategies to cope with anxiety that were researched in the literature review but also mentioned by children and agreed by experts. The third one is an updated version of the ‘Quiet Room’ described in the low-fidelity prototype (Section 4.1).

The "Cozy-Counting Room": This environment emulates a comfortable room, having a couch, armchairs and a fireplace. The coping strategy featured in this room is the counting exercise, which was researched in Section 2.5 and also suggested in the design workshop (Section 3.1). The player is advised through the instructions to press the button on the table to start the ‘relaxing counting exercise’. After doing so, a slow counting from 1 to 10 runs on the screen (Figure 5.3), at the end of which the Calm level bar is set back to maximum and the player is congratulated for regaining the calm (Appendix A, Fig.A.2.c).

The "Jump-and-Breathe Room": Inside this structure, special effects are applied to the player’s character so that they can jump very high and fall back to the ground slowly. The coping strategy presented in this environment is the breathing exercise, which is integrated in two steps as follows: the player jumps and while falling they should breathe in, then it jumps again and while falling, breathe out. The game proposes to perform the exercise a few times until the calm level is regained. The text presenting the room and giving relevant instructions is set to execute only the first time the room is accessed, such that the player is not spammed with the same information every time they wish to use this calming room, therefore instructions to perform the breathing exercise are displayed as holographic text on one of the walls (Appendix A, Fig.A.2.d/e/f).

The "Sensory Breakout Room": As mentioned above, this room is an adaptation of the initial concept of 'Quiet Room' described in Section 4.1. Rather than just having a dark and silent room, which might induce more anxiety than calm, this room was designed to have
a lights switch (Figure 5.4), but even when the main lights are off (Appendix A, Fig.A.2.g) there is still some ambient light in the room. As one of the suggestions during design workshop was to listen to a song when feeling worried, a jukebox was added along with a chest with disks containing Minecraft songs, so the child can play one of these songs if they do not enjoy the quiet. The calm level is regained over time, as the player should only relax in this room.

5.2.3 Rewards

The high-fidelity prototype features three types of rewards, two of them having incremental instances through the gameplay and the third is a reward for finishing all the levels.

Text rewards: The text rewards researched and used for the low-fidelity prototype are also utilised in high-fidelity prototype, but in a slightly different manner. The player is still congratulated after regaining the calm level, but the text reward is similar every time (e.g. Appendix A, Fig.A.2.c), as this action does not denote progression in the game.

The incremental text rewards, which were researched by Constantin et al. [23], are used after the player finishes exploring a level and returns to the ‘Hub’ to access other levels, as suggested by one of the experts. Figure 5.5 shows the three text rewards appearing in the middle of the screen after finishing each relevant level.

Achievements: In Minecraft, achievements are rectangular pop-ups appearing on the top right corner of the screen when the player accomplish a task (e.g. collect your first diamond). All the achievements of a player can be seen in the ‘Achievements’ menu accessed after pressing the ‘Esc’ key. In CalmCraft, default achievements are disabled and incremental achievements linked with collecting apples and diamonds are coded and integrated. The six achievements obtainable, three for each type of collectable item, can be seen in Appendix A, Figure A.2.i.

The Fireworks: Two proposals given by experts were to have rewards that can be obtained by spending some amount of apples or diamonds collected and to have a bigger reward for finishing the game, such as fireworks. These two ideas are combined in the current prototype. After exploring all the levels, the player is asked if they wish to spend five of the diamonds collected for a fireworks show (Appendix A, Fig.A.2.j). Due to time limitations, the reward system suggested by E2 in the low-fidelity prototype evaluation (Section 4.2.7) was not implemented, but for future development it is aimed to have multiple options to spend the items collected, such as cosmetic items or buddy NPCs (e.g. a dog, a parrot) that follows the player in their journey.
Chapter 6

High-fidelity Prototype Evaluation

This chapter presents the three evaluation studies of the high-fidelity prototype: a usability study with Informatics students, an evaluation study with TD children and an evaluation study with experts. This chapter answers the fourth research question RQ4: To what extent does the new educational game support children with autism prepare to face anxiety in social situations?

6.1 Usability Study

The game was firstly evaluated by Informatics students of the University of Edinburgh during the Project Day event.

Aims: The aim of this study was to evaluate the usability of the game in terms of user satisfaction.

Participants: Although many individuals showed interest in the game, only six Informatics students aged between 20 and 24 completed the questionnaire.

Materials: The materials used for this study were: an online questionnaire (Appendix C.3) in Google Forms, pre-recorded demo video of the whole game played by the researcher, script for the researcher, presentation poster of the project (Appendix D.2).

Procedure: The study was run during the Project Day event which unfolded virtually on Gather.town [5]. Given the virtual setting of the event this year, participants were not able to directly interact with the game, therefore a demo was pre-recorded and presented to the participants. The researcher was sitting at his virtual desk on Gather.town [5]. If students were interested in the project, the researcher shared his screen and played the demo video while explaining all the relevant knowledge about the game and the project. At the end of the presentation, students were sent the link to the online questionnaire in the chat of the Gather.town.

Data Collection and Analysis: Data were collected using the online questionnaire (Appendix C.3) consisting in the ten questions of the System Usability Scale (SUS). The SUS questionnaire was originally developed by John Brooke in 1996 [21] and it is a valid and reliable questionnaire which contains ten statements, the odd-numbered
statements being positively formulated and the even-numbered statements being negatively formulated. Each statement has a five-point Likert scale as options for answers [53]. The overall score of a participant is obtained by combining the ten scores using the formula in Appendix C.2. The scores range between 0 and 100. The scores are then interpreted on a set of acceptability ranges together with an adjective rating scale (Figure 6.1) proposed by Bangor et. al. [16].

Results: The graph with the overall score of each participant can be seen in Appendix C1, Figure C.1.a. The scores ranged between 75 and 85 with a mean value of 81.25. Following the adjective scale (see Figure 6.1) the mean overall score fall between the “Good” and “Excellent” adjectives. It it worth noting that the ratings given by participants were influenced by the lack of direct interaction with the game, one participant verbally commenting: "It’s nice but I’m sure it’s even nicer to (actually) play it...the demo was quite fast (paced) and (there were) a lot of details to grasp.”.

6.2 Evaluation with Children

6.2.1 Aims

The main aims set for this study were: 1. Determine if the tool was perceived as engaging and enjoyable by the target population; 2. Determine likes and dislikes from children perspective; 3. Determine if the game was easy to play; 4. Determine whether the game is useful to support children in real situations (i.e. if they would use the calming strategies introduced by the game); 5. Gather suggestions for further improvements.

6.2.2 Participants

Three TD children participated in this study, two of which also participated in the design workshop (P2 and P3). For this study it was particularly challenging to find participants as they were required to have Minecraft purchased and installed on their computer.

<table>
<thead>
<tr>
<th>Participant Number</th>
<th>Participant Age</th>
<th>Participant Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>11</td>
<td>Male</td>
</tr>
<tr>
<td>P2</td>
<td>12</td>
<td>Male</td>
</tr>
<tr>
<td>P3</td>
<td>9</td>
<td>Female</td>
</tr>
</tbody>
</table>

Table 6.1: Details of the children participants in the evaluation
6.2.3 Materials

The materials used for this study were: Information sheet (Appendix E.4) and Consent form for parents (Appendix E.5), Information sheet and Consent form for children (Appendix E.3), computer with Minecraft Java Edition 1.16.5 installed, script for the researcher, back-up audio-recording device, notebook for taking field notes.

6.2.4 Procedure

To follow the regulations imposed by the ongoing COVID-19 pandemic, each session took place virtually, on Microsoft Teams [6], through video conference. Parents were contacted prior the study through email where both information sheets were attached. If the child decided to take part, parents were sent both consent forms and were asked to return them signed prior the study. Each session was run individually with one child at a time. At the scheduled time, parents were contacted on Microsoft Teams [6] and after ensuring everything worked properly, the child joined the conversation. The researcher explained the relevant details about the game, then assisted the child in adding the game server in Minecraft on their computer. The researcher presented to the child the tasks of the game, to explore the environment collecting apples and diamonds while keeping the ‘Calm’ level bar as full. Children were asked to play the game in full-screen and were let known that, through the game, they were not supposed to build, craft or break anything in the game environment. While the child was playing the game the researcher was spectating their character on the server, taking relevant notes of their behaviour. After finishing the game, children were asked the following set of questions: 1. Two stars and a wish - two features that were liked and one feature you wish to be improved; 2. Which calming room you liked the most and why? 3. From 1 to 5, where 1 is very bad and 5 is very good, how enjoyable/easy/engaging was the game? 4. Can you think of any real life situation where you would put in practice one of the coping strategies presented? 5. Do you have any suggestions for improvements?

6.2.5 Data Collection and Analysis

Data collected consisted of video recordings of the sessions and notes taken by the researchers during children gameplay. After all the sessions concluded, the recordings were reviewed and the data were transcribed. The transcriptions together with the notes taken were analysed using Thematic Analysis [20]. The Thematic Analysis led to a series of themes which are discussed in the next section.

Although the same procedure was followed with every child, the game was randomised in terms of how the levels were ordered in the ‘Hub’, as well as to which calming room each social situation was pointing. This was done to check whether the modularity of the game’s story was implemented properly.
6.2.6 Results

This section presents the themes resulted from the thematic analysis of the emerged data.

Favourite Features: P1 really enjoyed the "Jump-and-Breathe" calming room, exclaiming "Oooo, WOOOW!" after jumping the first time. P2 and P3 liked the final fireworks. P2 stated: "I enjoyed to pay 5 diamonds for the fireworks". Beside the fireworks, P3 also enjoyed picking up apples and diamonds as highlighted: "I liked to collect apples and diamonds...you need a good eye for spotting them."

The additional features added to make to game more enjoyable proved to be useful as P1 and P2 liked the waterslide placed before getting to the classroom, P1 asking "why does this classroom have a waterslide, that's the best classroom ever!", P2 stated "Uuu, waterslide, nice!". Also the funny dialogue line of one of the NPC in the classroom, having a cat skin, was read out loud by P1 and P2: "'I have a cat costume’ hehehe" and "'I have a cat costume’ hahaa".

Fun: P1 and P3 rated the game as a 5 out of 5, when asked how fun was the game to play, P3 stated: "5, very fun". P2 rated it as a 3, remarking: "I'll give it a 3, I feel like the missions didn’t have enough content".

Easy to play: All participants rated the game a 5 in terms of easiness. P3 mentioned: "Easy to play...if you know how to play Minecraft it’s very easy to play" and P2 remarked that if a player is new to Minecraft it would be worth mentioning the basic mechanics: "Easy to play around, although for someone that never played Minecraft you could start with “move around with W,A,S,D and look around with mouse” or something like that”.

Engaging: P1 and P3 rated the game as a 5 in terms of how engaging it was. P2 rated it as a 3 from the same reason regarding the lack of activities: "3 because it was not enough content". A graph showing children’s ratings for enjoyability, engagement and ease of use can be seen in Appendix C.1.b.

Favourite Calming Room: Although was very enthusiastic about the "Jump-and-Breathe" room, P1 chose the "Sensory Breakout Room" as his favourite. After playing a song at the jukebox and playing with the lights switch, P1 stated: "Uuu, this is nice" and at the end of the session remarked: "My favourite (calming room) was the one where you could turn off lights, because you can make it really dark and listen to Minecraft music."

P2 and P3 both enjoyed the "Jump-and-Breathe" room the most mainly because of the jumping high and falling slow activity. P3 highlighted: "The jumping one. Because you jump higher than you normally do and it’s a lot of fun.”

Usability Issues: One usability issue that was discovered in this evaluation when both P2 and P3 returned to the ‘Barbershop’ for more exploration after regaining the calm, then tried to access the ‘Central Hub’ from there but no teleport button was available, P2 asking: “Oh, I have to go back to the calming room to go to the Hub?”

Another inconvenience pointed out by both P1 and P3 was that the NPCs running
around on the soccer field did not have dialogues implemented. P3 stated: “Oh, they don’t have anything to say I guess”.

**Improvements and Suggestions:** P1 and P2 mentioned that they were expecting to go back to the NPC at the beginning of the game, the one giving the tasks, to give it the apples they collected, P1 highlighting: “I wanted to go back and give the apples to the woman at the start”. P2 also suggested to have a reward after retrieving the apples: "...you should be able to give Lili (the NPC) the apples and she gives you a cake”.

Another suggestion from P2 regarded the Calm level bar and what should happen if the Calm level gets too low: "Bad things should happen...like you can get bad Minecraft effects like nausea or blindness". P2 mentioned that the game should feature more options to spend the collected items: "To be more engaging...have a shop or something to spend the apples and diamonds."

When asked for a wish regarding the game features, P1 stated that more levels should be added to the game: "...add a 4th level and...more levels, lots of levels.". Following P1’s remark, the researcher asked him what could be in the fourth level in terms of potentially scary social situations, P1 stating: "Maybe something to do with Coronavirus. The fact that you can’t go outside, you’re stuck inside all the time”.

**Coping strategies in practice:** When asked if they can think of any real situation where the coping strategies presented in the calming rooms can be put in practice, P2 stated a specific situation: "After playing (name of scary game) in VR". P1 stated that he usually does other activities to calm himself but highlighted that the strategies presented might also work: "Well the way I calm myself is by playing games or reading a book ... but those (strategies) presented were also nice.”

P3 mentioned that the breathing exercise would be helpful for relaxing, but also linked the breathing exercise with the jumping activity from the game: "If you are stressed, like at the end of this day of school you can go home on your bed and do some breathing and think about jumping in that room.”. This suggests that the game might be successful in teaching children coping strategies.

### 6.3 Evaluation Workshop with Experts

#### 6.3.1 Aims

The aims set for the expert evaluation were: 1. Determine if the game is appropriate for the target population; 2. Determine the appropriateness of the game for presenting coping strategies to children with autism; 3. Identify any usability issues; 4. Gather suggestions for improvements.

#### 6.3.2 Participants

In this study four experts took part, one being a game testing expert and the other three being researchers in HCI and ASD. E2 also took part in the evaluation of the low-fidelity prototype presented in Section 4.2.
## Chapter 6. High-fidelity Prototype Evaluation

<table>
<thead>
<tr>
<th>Participant Number</th>
<th>Position/Occupation</th>
<th>Area of expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>Former Game Tester</td>
<td>Experience in Minecraft, developing games for children</td>
</tr>
<tr>
<td>E2</td>
<td>PhD in HCI and ASD</td>
<td>Experience in HCI and ASD, developing technologies for children with ASD</td>
</tr>
<tr>
<td>E3</td>
<td>MSc in HCI and ASD</td>
<td>Experience in HCI and ASD, developing technologies for children with ASD</td>
</tr>
<tr>
<td>E4</td>
<td>Post-PhD in HCI and ASD</td>
<td>Experience in HCI and ASD, developing technologies for children with ASD</td>
</tr>
</tbody>
</table>

Table 6.2: Expert participants in the high-fidelity prototype evaluation

### 6.3.3 Materials

The materials used to run the study included: Information Sheet & Consent Form (Appendix E.7), computer with Minecraft Java Edition 1.16.5 installed, back-up audio-recording device, notebook for taking notes during the sessions.

### 6.3.4 Procedure

Each sessions took place virtually, on Microsoft Teams [6], through video conference. Experts were contacted through email with the Information Sheet & Consent Form was attached. If they decided to take part they were asked to sign and return the Consent Form prior the session. Each session was carried separately, but the same procedure was followed. For each session, the ‘Cooperative Evaluation’ method was used, a variation of the ‘Think Aloud’ method [26], where the user takes part as a collaborator and not only a participant. Therefore, the experts were encouraged to ask questions (e.g. why, what if) while going through the prototype in order to clarify the users behaviour. At the beginning of each session the researcher explained any relevant details about the game and assisted the participant in adding the game server in Minecraft on their device. he researcher described to the participant the same tasks for the game as in the children evaluation in Section 6.1, i.e. to explore the environment collecting apples and diamonds while keeping the ‘Calm’ level bar as full. Experts were asked to play the game on full screen and the same rules applied as in the children evaluation, i.e. they were not supposed to build, craft or break anything in the game. While the participant was playing the game the researcher was taking notes on their comments, questions and behaviour. After finishing the game, experts were asked the following questions: 1. Is the game appropriate for the target population? 2. Was the game intuitive and clear enough to play, and how would that be for the children, in your perception? 3. Is there anything that the target users might find too complicated through the game? 4. Might the game be effective in presenting coping strategies to ASD children? 5. Did you spot any usability issues? 6. Any suggestions for improvements?
6.3.5 Data Collection and Analysis

Data collected consisted of video recordings of the sessions and notes taken by the researchers during expert gameplay. After all the sessions concluded, the recordings were reviewed and the data were transcribed. The transcriptions together with the notes taken were analysed using Thematic Analysis [20]. The Thematic Analysis led to a series of themes which are discussed in the next section.

6.3.6 Results

This section presents the results of the thematic analysis on data collected from the expert evaluation study.

Appropriateness for the target population: All the experts stated that the current design was clear and intuitive enough for the target population. E3 mentioned that the game was easy to play even for someone that never played Minecraft before: "It’s easy to play, it was easy to play for me as a first time Minecraft player". E2 and E4 highlighted the suitable use of instructions and character dialogues: "...dialogues are simple but also the game does not depend heavily on them ... there is also a character every time that gives you instructions if you don’t know what to do" and "you give them step-by-step instructions both visually and textually".

E4 also highlighted the beneficial effect of using Minecraft to improve engagement from children with autism: "This is really nice, I like the overall idea and I like the idea of using Minecraft, individuals with autism love it!”. None of the experts pointed any issues when asked if they spotted anything unclear or hard to use through the game.

Potential of the game as an educational tool: One of the most important aims of this study was to check with the experts if the current design would be effective in presenting coping strategies to children, such that the strategies would be a takeaway to remember after playing the game. All experts were positive on this aspect, E1 commented: "I think you integrated the activities well enough ... for the main takeaway to be the calming strategies.”. E4 pointed that the effectiveness of this aim can only be tested with a separated study on this, but the game has potential in achieving it: The strategies are pretty straightforward … it’s hard to talk about effectiveness without doing a study but I can say it has potential … as it integrates Minecraft, something they (children with ASD) really like and educational elements that are easy to take away.

Environment customisation: Two of the experts remarked the modular way in which levels and calming rooms are placed and accessed in the game, E1 stating: "...good that you access the levels form this Hub...you can easily add new levels and also exclude the old ones by just removing the teleport button from here...”. E4 highlighted the beneficial effect for practitioners: "It’s also really good that practitioners can choose which levels to include.”.

Usability issues: E1 pointed the same issue brought up in the children evaluation, the fact that there is no teleportation option to the Hub from the ‘Barbershop’: “I think you forgot to put a teleport button to go to the Hub from here (the ‘Barbershop’).”.


E2 and E3 remarked that in the "Sensory Breakout Room", when the main lights are switched off, it was a little too dark, even with the ambient lights that are always visible, to see the switch button or the teleport buttons: "...it might be that my room (in real life) is very bright right now but I'm struggling to see the switch." and "It's a bit too dark in here now, where is the teleport button?".

E4 highlighted a potential issue in the "Jump-and-Breathe" room, concerning one of the impairments of children with autism, the repetitive behaviour: "You need to be careful about children with autism getting repetitive in this room as they might stay and jump around for too long...you can have a timer or some instructions after a while suggesting to leave the room."

Suggestions and Improvements: In terms of the overall gameplay offered by the game, all experts suggested that more activities should be added in each environment to increase the engagement and avoid the game becoming repetitive. E1 and E3 recommended to add mini-games through the environment, E1 suggesting "you can add common Minecraft mini-games...a parkour map with suspended blocks and you have to jump on them to reach a special collectable item" and E3 stated "...try to find a ball (plugin) at the soccer field so children can actually play some soccer."

Regarding new features, E1 pointed to a few more complex plugins that would allow better dialogues with characters and also missions from characters: "...there are some heavy-weight plugins (i.e. they require more server power) that add more complex dialogues to NPCs where the player can also answer back...or quests given by NPCs, and you can have a main quest and some side ones.". E4 proposed an interactive task that could be integrated in every calming room, to get the child to build something in the room, this way making the experience more memorable for them: "In the future you might be able to allow them to construct their own calming rooms...or at least small parts to build in the rooms...to have their own touch...they will remember the experience for a longer time."

One important aspect brought up by E3 and E4, which was also investigated by the researcher during the game development, regarded the 'Calm' level bar and by what amount its value is reduced in every social situation. E4 proposed that in the future there should be a practitioner settings panel where they could customise the calm level reduction to fit individual preferences: "you can have a practitioners settings panel for them to modify several parameters...such as the amount of calm level drop.". E3 suggested that children can be asked in advance to rank the social contexts in terms of scariness, but remarked that for the purpose of the project the current method is suitable: before the game...you can ask children to order social situations...how scary they are for them...and set accordingly the calm reduction...but for your proof of concept it works just fine to let the game decide.

6.4 Discussion

To evaluate the high-fidelity prototype three different evaluation methods were carried out. The first study aimed to evaluate the usability of the game in terms of user satisfaction from the perspective Informatics students, thus it aimed to partially answer
**RQ4.2: Is the game perceived as engaging by the target population?** Results from the SUS questionnaire pointed that the game situated close to the "Excellent" adjective rating for the overall usability, although these results cannot be considered conclusive given the low number of participants and that they did not directly interact with the game but watched a demo video.

The second study with 3 TD children had the main aim to answer **RQ4.2: Is the game perceived as engaging by the target population?** and **RQ4.3: Is the game perceived as enjoyable by the target population?**, but also to discover any usability issues and to gather suggestions for improvements. Two children awarded the game with maximum ratings for both engagement and enjoyment, and these ratings were backed up by their positive comments and exclamations while playing the game. The third child gave lower ratings for both aspects mentioned previously due to the insufficiency of activities in each environment, showing that the current environments can be improved. No major usability issues were discovered in this study other than the absence of direct teleportation option between one of the environment (i.e. the 'Barbershop') and the Hub. Children also answered positively when asked if they would use the coping strategies presented in the game in a real situation, on of them specifically linking the breathing strategy with the game activity of jumping. Overall, children were positive towards the game, although to get conclusive outcomes a long-term study involving more users, especially children with ASD, has to be carried out.

The main aims of the third study, the expert evaluation, were to answer **RQ4.1: Are the game activities suitable for children with autism?** and **RQ4.4: To what extent might the game be successful in presenting strategies to cope with anxiety to children with autism?**, as also to discover further usability issues and suggestions for improvements and future work. All experts stated that the game was clear and intuitive to play and pointed that instructions, both visual and textual, were clear enough and given everywhere necessary. They were very positive and optimistic regarding the educational potential of the game as they stated that the included coping strategies are well incorporated and easy to take away. Most of them highlighted the beneficial effect of using Minecraft, as children with autism show a natural affinity to games of this type. A couple of minor usability issues were discovered, i.e. not enough ambient light in one of the calming rooms and the absence of the same teleportation option discovered by children. Several suggestions for further development and improvement were provided, with a highlight on further customisation opportunities for both the player and for practitioners.

Overall, the evaluation studies revealed good potential for the game to achieve its purpose. In terms of usability, the conducted studies showed that the game is easy to use, engaging and enjoyable for the target population, although couple minor usability issues need to be resolved and more content has to be added in each environment. The game was considered appropriate by the experts involved as it successfully integrates Minecraft, a game very much enjoyed by children with ASD, with easy to grasp strategies to cope with anxiety. The coping strategies included in the game also seemed to be appealing and enjoyed by children when presented in a gamified manner. Future work should focus on increasing playtime in each environment of the game and developing further customisation options for players but especially for practitioners.
Chapter 7

Conclusions and Future Work

7.1 Research Questions

RQ1: What are the current strategies being employed to help children with ASD experiencing anxiety?

This question was answered by reviewing the relevant literature discussed in Chapter 2. The background reading firstly revealed several mindfulness-based strategies to cope with anxiety and the feasibility of incorporating them in a technology-based tool. It then discussed the effectiveness of technology in autism treatment, highlighting the affinity of children with ASD for video game. The literature review pointed towards Minecraft, which proved its therapeutic and assistive uses for individuals with ASD in previous researches.

RQ2: What are the common aspects of social situations that might provoke anxiety in children with autism?

To answer this question a design workshop with 4 TD children and 1 child with autism was conducted. Results emerged from this workshop revealed specific characteristics of social situations that make children nervous: the presence of non-familiar people, crowded places, completely new environments. The aspects brought up by children were backed up by the findings regarding anxieties of children with autism discussed in Section 2.4.

Moreover, these aspects were also discussed with experts during the evaluation of the low-fidelity prototype (Section 4.2), where further aspects were added and the beneficial use of Minecraft was pointed out.

RQ3: How can a Minecraft game be designed to present strategies to cope with anxiety in children with autism?

This question was answered by initially conducting a design workshop, discussed in Chapter 3, with 4 TD children and 1 child with autism to gather game elements appealing to children in the target age range. Findings from the design workshop were analysed in accordance with HCI and ASD design principles and the first set of design implications presented in Section 3.3 emerged. These implications were followed
to design the low-fidelity prototype described in Chapter 4, which was then evaluated with experts in HCI and ASD to further improve the set of design implications (Section 4.2.8) that was then used to implement the high-fidelity prototype.

RQ4: To what extent does the new educational game support children with autism prepare to face anxiety in social situations?

This question was divided into the four sub-questions presented below:

RQ4.1: Are the game activities suitable for children with autism?

This sub-question was answered in the evaluation with 4 experts in ASD, HCI and game testing of the high-fidelity prototype in Chapter 6. All experts perceived the activities as being well integrated and were happy with how the game unfolds, no major usability issues being pointed out.

RQ4.2: Is the game perceived as engaging by the target population?

To answer this sub-question, a usability questionnaire filled by 6 Informatics students and an evaluation study with 3 TD children were carried out. Results showed that students perceived the game as being engaging for the target population and the same outcome was noted from the study with children, although one participant argued that more activities should be added.

RQ4.3: Is the game perceived as enjoyable by the target population?

This sub-question was also answered in the evaluation study with children presented in Chapter 6. After playing the game, all children stated that they had fun playing it, this outcome being backed up by their positive comments and exclamations of excitement during the sessions.

RQ4.4: To what extent might the game be successful in presenting strategies to cope with anxiety to children with autism?

The fourth and final sub-question was answered by conducting the expert evaluation in Chapter 6. As all experts agreed, the game successfully integrated an appealing video game to children with autism, with easy to comprehend coping strategies, thus resulting in a game with high potential for its set purpose.

7.2 Limitations

Proof of concept: The implementation of this game is a proof of concepts and presents the possibility to implement and present strategies to cope with anxiety using Minecraft. Whether this game is effective in addressing anxiety in children with autism is outside the scope of this project due to the difficulty of recruiting children with ASD and the need of a long-term study. Also, due to the limited timespan, features regarding further customisation possibilities (e.g. practitioners settings panel) were disregarded from the implementation and considered for future work.

Limitations imposed by the virtual environment: Due to the current limitations imposed by the pandemic, it was more complicated to recruit both experts and children
to participate in the studies, particularly for the evaluation studies as the participants were required to have specific software installed on their devices. Also, some children that participated in studies through the project were outside the set target age range, but still acted as good informants for the proof of concept.

7.3 Future Work

After all evaluation studies concluded, the researcher analysed the outcomes in accordance with the design implications drawn up in Section 3.3 and Section 4.2.8, the HCI principles (Appendix B) and the ASD principles (Section 3.2.2) in order to categorise and rank the directions the project could take in future development. Firstly, all usability issues discovered need to be resolved, that is: add teleportation option from 'Barbershop' directly to 'Hub', improve ambient light in the "Sensory Breakout Room", add at least one line of dialogue to all NPCs without any, add a timer in the "Jump-and-Breathe" room to avoid potential repetitive behaviour. Also, as pointed by children and also experts, at the end of the game the player should be able to travel back to the character at the beginning to return the collected apples and get a reward for it.

Secondly, further customisation options for practitioners need to be developed, such as a settings panel where practitioners can easily customise various parameters in the game (e.g. amount of 'Calm' level drop in each environment, the range of the counting exercise, how much time is allowed to spend in the "Jump-and-Breathe" room).

Additional features considered for future development include: more complex dialogues between characters where the player can also respond, missions and quests given by characters through the game, mini-games such as jumping challenges to reach special reward or a ball plugin to play soccer, more options of rewards to buy with the diamonds collected (e.g. cosmetic items, buddy NPCs).

7.4 Conclusions

This project explored how a technology-based game can be designed and developed to help children with autism cope with anxiety. A Minecraft game has been developed in an iterative manner and then evaluated in a participatory approach, with children and experts in ASC, HCI and Education. Based on the results from the evaluation studies, the game provides the base of a functional game that can be fun, engaging, easy to use and able to present children with autism with coping strategies for anxiety. The contributions of this project are as follows:

1. Identification of a set of aspects of social situations that provoke anxiety in children with autism.
2. A design concept and the implementation based on empirical data and literature review of a game to present strategies to cope with anxiety in children with ASD.
3. Empirical evidence from the evaluation with children and experts in ASC, HCI and Education, that the game has potential to support children with ASD overcome social anxiety.
Bibliography


Appendices
Appendix A

High-Fidelity Prototype Screenshots

Figure A.1: High-Fidelity Prototype Screenshots
Appendix A. High-Fidelity Prototype Screenshots

Figure A.2: High-Fidelity Prototype Screenshots 2
Appendix B

HCI Principles

HCI-P1: Visibility of system status:

Appropriate feedback should be given to the users withing appropriate time so the users are always informed about their status.

HCI-P2: Match between system and the real world:

The interface should use concepts, language and real-world conventions that are familiar to the user.

HCI-P3: User control and freedom:

Users should be able to undo actions, exit from any sequence of actions, and not be forced into a series of actions.

HCI-P4: Consistency and standards:

Information that is the same should appear to be the same. Information that is different should be expressed differently.

HCI-P5: Error prevention:

Where possible, prevent errors from happening in the first place.

HCI-P6: Recognition rather than recall:

Show all the options available to the user rather than expecting them to remember them all. Do not require users to remember information from one screen another.

HCI-P7: Flexibility and efficiency of use:

Experts should have ways to use the interface faster or more efficiently. The design should have accelerators such as keyboard shortcuts to allow skilled users to move faster.

HCI-P8: Aesthetic and minimalist design:

The content and visual design should focus on the essentials. Ensure that the visual elements of the interface support the user’s primary goals.
HCI-P9: Help users recognize, diagnose, and recover from errors:

   Error messages should be expressed in plain language, precisely indicate the problem and constructively suggest a solution.

HCI-P10: Help and documentation:

   Documentation might be needed to help users understand how to complete their tasks, however it would be best if the system does not require any additional explanation.
Appendix C

Final Evaluation Materials

C.1 Graphs

(a) SUS - Overall scores of each participant and the average

(b) Children Evaluation - ratings form 1-5 for Enjoyability, Engagement and Ease of use

C.2 SUS Formula

- For each of the odd numbered questions, subtract 1 from the score.
- For each of the even numbered questions, subtract their value from 5.
- Take these new values which you have found, and add up the total score.
  Then multiply this by 2.5.

Figure C.2: Formula to calculate overall score of a participant

C.3 System Usability Scale questionnaire
### System Usability Scale

*Required*

1. Please rate your level of agreement with each of the following statements: *

<table>
<thead>
<tr>
<th>1 - Strongly Disagree</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5 - Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I think that I would like to use this system frequently.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. I found the system unnecessarily complex.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. I thought the system was easy to use.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. I think that I would need the support of a technical person to be able to use this system.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. I found the various functions in this system were well integrated.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. I thought there was too much inconsistency in this system.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. I would imagine that most people would learn to use this system very quickly.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. I found the system very cumbersome/awkward to use.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. I felt very confident using the system.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. I needed to learn a lot of things before I could get going with this system.</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Figure C.3: SUS Form**
Appendix D

Additional Files

D.1 Technical Aspects

Figure D.1: Settings screen of a Command Block

Figure D.2: Example of function file
D.2 Poster from Project Day

Towards a Technology to Overcome Anxiety in Children with Autism

Using Minecraft to introduce Self-Regulation Techniques to help prevent Social Anxiety in children with autism

Research Questions:
1. What are the current interventions for anxiety addressed to children with autism?
2. How should technology be best designed to support children with autism cope with anxiety?
3. To what extent does this technology support children with autism to cope with their anxiety?

Approach:
1. Literature Review
2. Design Workshop with children
3. Low-fidelity Prototype: Design & Evaluation
4. High-fidelity Prototype: Implementation & Evaluation
5. Summative Evaluation

Researcher:
Andreas Ghira
s1732228@ed.ac.uk

Supervisor:
Aurora Constantin
Aurora.Constantin@ed.ac.uk

Figure D.3: Project poster
Appendix E

Studies Materials

E.1 Children Information and Consent Form Design Workshop
**Designing and Testing Games to Help Children**
*(to be read aloud to the child)*

This page is for children. We will ask you to help design and test new computer games, take part in different activities, and answer a few questions. You can decide if you want to say “yes” or “no” to helping and can change your mind at any time.

**Who is organising the event?** This is Helen, Aljawharah, Aurora, Aimee, Sophia, Ethan, Andreas and Kaiwen. They want to make computer games that can help children. You can help them by providing ideas for new computer games, taking part in different activities, helping to test them, and answering some questions.

<table>
<thead>
<tr>
<th>Aljawharah</th>
<th>Helen</th>
<th>Aurora</th>
<th>Aimee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sophia</td>
<td>Ethan</td>
<td>Andreas</td>
<td>Kaiwen</td>
</tr>
</tbody>
</table>
How can I help?

Some children with autism can find that lots of different things can make them worried. They might find simple activities like talking to other people and changes to their usual activities harder than most children. Sometimes they find it hard to understand and manage what they are feeling. We would like to design some fun games to help these children with their worries, and we would like you to help us! We would like to hear your ideas for ways to make some of these situations less scary and we would like you to help us to make our games fun.

What will happen if I help?

You will get to take part in game design and testing workshops and participate in other activities. You will get to talk with other children about your ideas, and we might ask you to do some drawings to show us your designs.

You can tell Helen or one of the researchers if you want to stop doing any of the activities. You do not have to tell them why. Please tell them if you want to take a break. You can also say you do not want to be a game developer or tester anymore, and that is OK.

The researchers will ask if it is OK to make a video recording of you helping design the game and answering questions. This is because it is too hard for them to write down everything that happens. They will listen to and look at the recordings later to help them understand what you thought about the game.

What will happen after I am finished helping?

The things you make, do and say in the game testing workshops will help them. They will write about what they have learned and use it to design and evaluate their games.

Your mum or dad said it is OK for you to help us.

Do you want to be a game developer/tester? You can say “yes” or “no”. It is OK to say “no”. It will not hurt the researchers’ feelings.
Do you want to ask a question about being a games developer/tester?

It is OK to have more questions. You can ask the researchers as many questions as you want about being a game developer. Ask your mum or dad to help you call them on the phone or write an email with your question.
Child Consent Form

To be used as a guide for securing consent or refusal after the child has had a chance to get information about the study. The child may mark (or be helped to mark) this form, or the child’s consent/refusal may be video recorded.

I can choose to be a game developer.

I do not have to help if I don't want to.

I can decide to stop taking part or take a break if I want to, I do not have to say why.

It is okay if I change my mind later and say I do not want to be a game developer anymore.

It is okay if some parts of the game are hard for me!

There are no wrong answers to questions.

Anything I can do is very helpful.

Do you want to be a game developer? [YES] [NO]

Helen, Aurora, Aljawharah, Ethan, Andreas, Sophia, Aimee and Kaiwen will listen to/watch the recordings later. They will not show them to other people.
Is it okay to take video recordings?  YES  NO

Write your name:
_______________________________________________

THANK YOU ฯ!!
E.2 Parent Information Sheet Design Workshop
Designing Educational Games and Tools for Children with Autism

Information sheet for parents and guardians

This information sheet is for parents and guardians; it explains the research project at the University of Edinburgh, in which we would like your child to participate. It gives information about the project in the form of questions you might have and their answers. If you have further questions, we are happy to discuss them and give you more information.

This study was certified according to the Informatics Research Ethics Process, RT number XXXX. Please take time to read the following information carefully. You should keep this page for your records.

The researchers on this project and their contact details are as follows:

- Aimee Redbond: s1713640@sms.ed.ac.uk (Lead Researcher)
- Andreas Ghira: s1732228@sms.ed.ac.uk (Lead Researcher)
- Sophia Singh: s1623165@sms.ed.ac.uk (Lead Researcher)
- Ethan Soreide: s1741258@sms.ed.ac.uk (Lead Researcher)
- Kaiwen Xue: s1615893@ed.ac.uk (Lead Researcher)
- Dr. Aurora Constantin: aurora.constantin@sms.ed.ac.uk (Research supervisor)
- Aljawharah Alabdullatif: s1500319@sms.ed.ac.uk (Research advisor)
- Prof. Helen Pain: helen@staffmail.ed.ac.uk (Research supervisor)

University of Edinburgh, School of Informatics

Please return the parent consent form to one of the researchers if you give permission for your child to participate in the project.
Overview of the project

We are five UG4/Minf students from the University of Edinburgh working on educational games for children with autism as a part of our Honours projects. Each student pursues research in their chosen area and will develop their own game.

What is the goal of the project and the purpose of the workshops?

Many different circumstances can cause children with autism to suffer with anxiety. These include social situations, changes to their routines, and disruptive events such as the COVID-19 pandemic. The goal of our project is to design technology-based tools to help children with autism cope with and manage their anxiety in different situations.

Kaiwen: I am designing and developing a game to support children with autism to overcome anxiety during Covid-19 pandemic. This game is intended to be designed in collaboration with children. The purpose of this workshop is to conduct some activities with children with the purpose of understanding what makes them worried during Covid-19 pandemic and how they cope with their worries. In these activities, children will write and draw to express their ideas using either pen and paper or a software program, depending on their preference. These ideas will be used to build a game to help children with autism cope with anxiety during pandemic.

Aimee: I aim to develop an interactive app which will help children with ASC to cope with changes. The purpose of the app is to reduce the anxiety caused by changes, and to help children with autism to become more flexible and resilient when faced with changes in the future. The aim of the workshop is to guide the children towards identifying new situations which might cause them anxiety, discussing coping strategies for these changes, and designing ways to reward them for coping. The workshop will be useful for designing the app to suit children, and for building a tool that will help children adapt to changes.

Andreas: The aim of the project is to develop a technology that would help children interact in an online environment, facilitating the reduction of their anxiety levels in social situations. The purpose of this workshop is to gather information from children regarding social anxiety. The main aims are:
- Determine social situations where children might feel anxious
- Determine practices that help them cope with those situations

**Ethan:** I am aiming to create a tool or game for children with autism to help overcome, manage or understand their anxiety, especially regarding social situations. Similarly to Andreas, my workshop will consist of tasks that explore social situations and any worries related to these. These activities aim to establish what social settings can trigger any anxiety in children and why, as well as identifying any strategies or methods they have to overcome these.

**Sophia:** Dungeons and Dragons is a popular tabletop roleplaying game that has potential to be an effective tool for delivering therapy in an interactive and story driven game environment. I aim to build an online tool to help conduct dungeons and dragons games while incorporating mindfulness techniques to aid with anxiety. The workshop will guide the children towards creating interactive games and stories focused on calming activities like breathing and other mindfulness related activities. The workshop will be beneficial for designing the app and building interactive tools that the children consider calming and engaging.

**How can my child help?**

The game designing workshops will comprise a variety of activities which will help to inform the design of our prototype games and provide potential ideas to enhance fun and engaging gameplay for an educational game.

**Workshop Information**

**What happens during the workshop?**

Workshops will take place in small groups (3 – 4 children) online using Microsoft Teams. At least one researcher and one supervisor will be present for all workshops. Your child will get to engage in numerous game development activities, such as group discussions and drawing designs, and provide feedback and ideas for c. 30 minutes. In order to facilitate these activities, we would request that you provide
sheets of blank paper and colouring pencils for your child to use during the session. We may request that any materials created by your child during the session be uploaded for our review after the session. If your child is willing to talk to us about the activities, we will ask them a few questions. They will each participate in X (will edit depending on each workshop structure) workshops, if they are happy to do so.

**Video and audio recordings**

We would like to video record the session, to provide a record for later analysis and allow us to freely interact with your child during the session without worrying about taking notes. Microsoft Teams does not allow for solely audio to be captured, but the video recording will only be used to transcribe the audio from the session, and then will be deleted. The video would be seen only by us during the analysis. If you are not comfortable with your child being video recorded at all, then your child should not participate in this particular study. Although we will only be video recording for the purpose of transcribing the session, we would ask that your camera is switched on throughout the session, so that we can ensure your child is not becoming upset or distracted.

We ask parents to read this information sheet so you can make an informed decision about whether participation as a game designer is a good idea for your child.

If you say “yes” when returning the permission form, we will explain the game designer role to your child and ask them if they want to help. We will remind your child that they can stop being a developer at any time, without having to give any reason, and that we will always listen to them. We will check that the child agrees to be video recorded. This explanation will be based on the child information sheet included in this packet. We feel strongly that children should be given a real choice about whether to participate. Even if you say “yes” on the permission form, your child may still say “no” if s/he does not want to be a game developer. We will respect your child’s decision.
If you say “no”, we will not contact you again about this study and will not ask your child to be a games designer.

Will this project teach my child new skills?

This project is not a type of therapy or intervention. We will not be teaching children new skills or improving existing skills. The information we learn from this project may be used in future games/smart objects that could help children with ASC.

What happens when the project is over?

After the study has finished and we have analysed the information we collected, it will be used to evaluate and further develop the design of the game/smart object and eventually be presented in a final report. This report along with the data and transcripts may be shared or presented in scientific journals or conferences. We never share children’s names, schools or other personal information.

How will personal information be protected?

Confidentiality is extremely important to us and all data will be processed in accordance with Data Protection Law. Recordings and other information (such as forms with children’s names) will be stored safely on password-protected encrypted computers. Your consent information will be kept separately from your responses in order to minimise risk. Access will be limited to the people involved in the research (listed above). Recordings and other information will be identified only by participant codes or pseudonyms, and will be separated from identifying information (such as name). Your data may be archived for a minimum of 2 years.

Who paid for this research?

This study is part of the undergraduate work for the main researchers (listed above). It is indirectly paid for by the University of Edinburgh and the funding is not attached
to a specific project or to any outcomes of that project. Conducting this research brings no financial benefit to the researchers or to the university.

**Who can I contact?**
If you have any further questions about the study, please contact any of the lead researchers or the research supervisor Dr. Helen Pain.
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 any of the lead researchers or the research supervisor.

**General information**

Once again, this study is completely voluntary, and you and your child are under no obligation to take part. Even if you say yes now, you may withdraw your child from the study at any time and for any reason by contacting us. Your child may also withdraw at any time by saying that s/he does not want to be a game developer any more.

For general information about how we use your data, go to: edin.ac/privacy-research
Thank you for taking the time to read this.
E.3 Children Information and Consent Form Evaluation Study
Designing and Testing Games to Help Children
(to be read aloud to the child)

This page is for children. We will ask you to help design and test new computer games, take part in different activities, and answer a few questions. You can decide if you want to say “yes” or “no” to helping and can change your mind at any time.

Who is organising the event? This is Helen, Aljawharah, Aurora, Aimee, Sophia, Ethan, Andreas and Kaiwen (Kevin). They want to make computer games that can help children. You can help them by providing ideas for new computer games, taking part in different activities, helping to test them, and answering some questions.

<table>
<thead>
<tr>
<th>Aljawharah</th>
<th>Helen</th>
<th>Aurora</th>
<th>Aimee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sophia</td>
<td>Ethan</td>
<td>Andreas</td>
<td>Kaiwen/Kevin</td>
</tr>
</tbody>
</table>
How can I help?

Some children with autism find that lots of different things can make them worried. They might find simple activities like talking to other people and changes to their usual activities harder than most children. Sometimes they find it hard to understand and manage what they are feeling. We would like to design some fun games to help these children with their worries, and we would like you to help us! We would like to hear your ideas for ways to make some of these situations less scary and we would like you to help us to make our games fun.

What will happen if I help?

You will get to take part in game testing workshops and participate in other activities. You will get to talk with other children about your ideas, and we might ask you to do some drawings to work out your ideas.

You can tell Helen or one of the researchers if you want to stop doing any of the activities. You do not have to tell them why. Please tell them if you want to take a break.
You can also say you do not want to be a game developer or tester anymore, and that is OK.

The researchers will ask if it is OK to make a video recording of you helping design the game and answering questions. This is because it is too hard for them to write down everything that happens. They will listen to and look at the recordings later to help them understand what you thought about the game.
What will happen after I have finished helping?

The things you make, do and say in the game testing workshops will help them. They will write about what they have learned and use it to design and evaluate their games.

<table>
<thead>
<tr>
<th>Your mum or dad said it is OK for you to help us.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you want to be a game developer/tester?</td>
</tr>
<tr>
<td>You can say “yes” or “no”.</td>
</tr>
<tr>
<td>It is OK to say “no”.</td>
</tr>
<tr>
<td>It will not hurt the researchers’ feelings.</td>
</tr>
</tbody>
</table>

Do you want to ask a question about being a games developer/tester?

It is OK to have more questions. You can ask the researchers as many questions as you want about being a game developer. Ask your mum or dad to help you call them on the phone or write an email with your question.
Child Consent Form

To be used as a guide for securing consent or refusal after the child has had a chance to get information about the study. The child may mark (or be helped to mark) this form, or the child’s consent/refusal may be video recorded.

I can choose to be a game tester. I do not have to help if I don’t want to.

I can decide to stop taking part or take a break if I want to, I do not have to say why.

It is okay if I change my mind later and say I do not want to be a game tester anymore.

It is okay if some parts of the game are hard for me!

There are no wrong answers to questions. Anything I can do is very helpful.

Do you want to be a game developer? YES NO

Helen, Aurora, Aljawharah, Ethan, Andreas, Sophia, Aimee and Kaiwen will listen to/watch the recordings later. They will not show them to other people.

Is it okay to take video recordings? YES NO

Write your name:

THANK YOU !!
E.4 Parent Information Sheet Evaluation Study
Designing Educational Games and Tools for Children with Autism

Information sheet for parents and guardians

This information sheet is for parents and guardians; it explains the research project at the University of Edinburgh, in which we would like your child to participate. It gives information about the project in the form of questions you might have and their answers. If you have further questions, we are happy to discuss them and give you more information.

This study was certified according to the Informatics Research Ethics Process. Please take time to read the following information carefully. You should keep this page for your records.

The researchers on this project and their contact details are as follows:

- Aimee Redbond: s1713640@sms.ed.ac.uk (Lead Researcher)
- Andreas Ghira: s1732228@sms.ed.ac.uk (Lead Researcher)
- Sophia Singh: s1623165@sms.ed.ac.uk (Lead Researcher)
- Ethan Soreide: s1741258@sms.ed.ac.uk (Lead Researcher)
- Kaiwen Xue: s1615893@ed.ac.uk (Lead Researcher)
- Dr. Aurora Constantin: aurora.constantin@sms.ed.ac.uk (Research supervisor)
- Aljawharah Alabdullatif: s1500319@sms.ed.ac.uk (Research advisor)
- Prof. Helen Pain: helen@staffmail.ed.ac.uk (Research supervisor)

University of Edinburgh, School of Informatics

Please return the parent consent form to one of the researchers, or complete the form from the link sent to you if you give permission for your child to participate in the project.
Overview of the project

We are five UG4/Minf students from the University of Edinburgh working on educational games for children with autism as a part of our Honours projects. Each student pursues research in their chosen area and will develop their own game.

What is the goal of the project and the purpose of the workshops?

Many different circumstances can cause children with autism to suffer with anxiety. These include social situations, changes to their routines, and disruptive events such as the COVID-19 pandemic. The goal of our project is to design technology-based tools to help children with autism cope with and manage their anxiety in different situations.

Kaiwen: I have designed and developed a web game, the purpose of this game is to help children with autism overcome their anxiety and understand dentist meaning when they go to the dentist. Children will be asked to explore the game, complete some game tasks and provide some feedback on what can be changed, added or improved. A web browser (preferably Chrome) will be used to access the tool.

Aimee: I have developed an interactive web application which aims to help children with ASC to cope with changes. The purpose of the app is to reduce the anxiety caused by changes, and to help children with autism to become more flexible and resilient when faced with changes in the future. In this workshop, the children will be asked to explore the app, complete some simple tasks, and offer feedback based on their experience interacting with the application. In order to use the application, children will need access to a web browser such as Chrome, Safari, etc. I will provide the link to the application during the workshop.

Andreas: I have developed a Minecraft map that simulates social situations (going to school, going to the hairdresser, playing soccer) that children might find stressful in real life and I have designed calming rooms that tries to teach the player self-calming techniques (i.e. counting in your head from 1 to 10, breathing exercise, relaxing in a quiet place). Children will be asked to explore the game by following the instructions given on the screen and provide feedback on their experience. To play the game,
children will need Minecraft Java Edition (the Official version) installed on their computer.

**Ethan:** I have designed an interactive exploratory tool of what a child might experience when getting their hair cut. This emulates some of the anxieties one may feel at the hairdresser and rewards you for tolerance of the stimuli. Children will be asked to explore the app, complete some activities and then provide feedback on what can be changed, added or improved. A web browser (preferably Chrome) will be used to access the tool. A detailed walkthrough for this will be given for this prior to the evaluation.

**Sophia:** Dungeons and Dragons is a popular tabletop roleplaying game that has potential to be an effective tool for delivering therapy in an interactive and story driven game environment. Based off the design workshops from late last year, I have built a platform to help conduct dungeons and dragons games for autistic children. The workshop will help me test the tool and retrieve feedback on how it can be improved. A web browser (preferably Chrome) will be used to access the tool from a downloaded ZIP file. A detailed walkthrough for this will be given for this prior to the evaluation. Additionally, having a sheet of paper and some pencils will be useful.

**How can my child help?**

The game evaluation workshops will comprise a variety of activities which will help to inform the design of our prototype games and provide potential ideas to enhance fun and engaging gameplay for an educational game.

**Workshop Information**

**What happens during the workshop?**

Workshops will take place individually online using Microsoft Teams. At least one researcher and one supervisor will be present for all workshops. Your child will get to engage in the numerous different games that have been made and provide feedback and ideas for c. 30 minutes. In order to facilitate these activities, we would request that you provide sheets of blank paper and colouring pencils for your child to use during the session. We may request that any materials created by your child during the session be uploaded for our review after the session. If your child is willing to talk
to us about the activities, we will ask them a few questions. They will each participate in 3 to 5 workshops, if they are happy to do so.

**Video and audio recordings**

We would like to video record the session, to provide an audio record for later analysis and to enable us to freely interact with your child during the session, without worrying about taking notes. Microsoft Teams does not allow for solely audio to be captured, but the video recording will only be used to transcribe the audio from the session, and then will be deleted. The video would be seen only by us during the analysis. If you are not comfortable with your child being video recorded at all, then your child should not participate in this particular study. Although we will only be video recording for the purpose of transcribing the session, we would ask that your camera is switched on throughout the session, so that we can ensure your child is not becoming upset or distracted.

**We ask parents to read this information sheet so you can make an informed decision about whether participation as a game designer is a good idea for your child.**

**If you say “yes”** when returning the permission form, we will explain the game designer role to your child and ask them if they want to help. We will remind your child that they can stop being a developer at any time, without having to give any reason, and that we will always listen to them. We will check that the child agrees to be video recorded. This explanation will be based on the child information sheet included in this packet. We feel strongly that children should be given a real choice about whether to participate. Even if you say “yes” on the permission form, your child may still say “no” if s/he does not want to be a game developer. We will respect your child’s decision.

**If you say “no”,** we will not contact you again about this study and will not ask your child to be a games designer.

**Will this project teach my child new skills?**
This project is not a type of therapy or intervention. We will not be teaching children new skills or improving existing skills. The information we learn from this project may be used in future games/smart objects that could help children with ASC.

**What happens when the project is over?**

After the study has finished and we have analysed the information we collected, it will be used to improve the different games and eventually be presented in a final report. This report along with the data and transcripts may be shared or presented in scientific journals or conferences. We never share children’s names, schools or other personal information.

**How will personal information be protected?**

Confidentiality is extremely important to us and all data will be processed in accordance with Data Protection Law. Recordings and other information (such as forms with children’s names) will be stored safely on password-protected encrypted computers. Your consent information will be kept separately from your responses in order to minimise risk. Access will be limited to the people involved in the research (listed above). Recordings and other information will be identified only by participant codes or pseudonyms, and will be separated from identifying information (such as name). Your data may be archived for a minimum of 2 years.

**Who paid for this research?**

This study is part of the undergraduate work for the main researchers (listed above). It is indirectly paid for by the University of Edinburgh and the funding is not attached to a specific project or to any outcomes of that project. Conducting this research brings no financial benefit to the researchers or to the university.

**Who can I contact?**

If you have any further questions about the study, please contact any of the lead researchers or the research supervisor Prof. Helen Pain.

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 any of the lead researchers or the research supervisor.

General information

Once again, this study is completely voluntary, and you and your child are under no obligation to take part. Even if you say yes now, you may withdraw your child from the study at any time and for any reason by contacting us. Your child may also withdraw at any time by saying that s/he does not want to be a game developer any more.

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

Thank you for taking the time to read this.
E.5 Parent Consent Form
Parent Consent Form

* Required

1. Have you read the information sheets? *
   - Yes
   - No

2. Have you received enough information about the study? *
   - Yes
   - No

3. Do you understand that participation is completely voluntary and your child can leave the study at any time, without having to give a reason? *
   - Yes
   - No
4. Do you consent for your child to take part in this study? *

- Yes
- No
Details

By filling in the sections below, you indicate that you understand and accept the conditions of this study, including video recording. You agree that the researchers may explain this study to your child and invite him or her to take part as a game developer.

5. Full name of participating child: *

6. Child's date of birth: *

   Format: M/d/yyyy

7. Your relationship to the child: *

8. Your full name: *

9. Email address: *
10. Date: *

Format: M/d/yyyy

4/7/2021
E.6 Expert Information & Consent Form Low-fidelity Prototype Evaluation
Participant Consent Form

Toward a Technology to Overcome Anxiety in Children with Autism

Researchers: Andreas Ghira & Ethan Soreide
(s1732228@sms.ed.ac.uk, s1741258@sms.ed.ac.uk)

Supervisor: Dr Aurora Constantin
(acosta2@staffmail.ed.ac.uk)

In this interview, we aim to further our knowledge on the relevant topics of the project and get feedback on our project ideas so far. All data will be anonymised with pseudonyms (such as E1, E2, etc.). The interview will take place on Microsoft Teams. If you consent to being audio recorded, recordings will be stored safely on password protected computers. You may withdraw from this research study at any time without explanation and you can ask any data you have supplied to that point be withdrawn /destroyed. You can omit or refuse to answer to any question that is asked of you. All data from this study may be archived for a minimum of two years. Please feel free to ask any question related to this study at any time.

I confirm that I have been informed about this project by the researchers and that I have had the opportunity to ask questions, and that any questions I had were answered to my satisfaction.

Please Select: YES / NO

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.

Please Select: YES / NO
I consent to my anonymised data being used in academic publications and presentations.

Please Select: YES / NO

I understand that my anonymised data can be stored for a minimum of two years.

Please Select: YES / NO

I agree to take part in this study.

Please Select: YES / NO

Participant’s Signature:                                            Date:

_______________________                               ____________
E.7 Expert Information & Consent Form High-fidelity Prototype Evaluation
I have developed a Minecraft map that simulates social situations (going to school, going to the hairdresser, playing soccer) that children with autism might find stressful in real life and I have designed calming rooms that tries to teach the player self-calming techniques (i.e. counting in your head from 1 to 10, breathing exercise, relaxing in a quiet place). You will be asked to explore the game by following the instructions given on the screen, provide feedback on your experience and answer a few questions at the end. To play the game, you will need **Minecraft Java Edition 1.16.5** installed on your computer.

In this study, I am aiming to evaluate various usability aspects of the game that I have created. All data will be anonymised with pseudonyms (such as E1, E2, etc.). You may withdraw from this research study at any time without explanation and you can ask any data you have supplied to that point be withdrawn /destroyed. You can omit or refuse to answer to any question that is asked of you. All data from this study may be archived for a minimum of two years. Please feel free to ask any question related to this study at any time.

I confirm that I have been informed about this project by the researcher and that I have had the opportunity to ask questions, and that any questions I had were answered to my satisfaction.

**Please Select: YES / NO**
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.

**Please Select: YES / NO**

I consent to my anonymised data being used in academic publications and presentations.

**Please Select: YES / NO**

I understand that my anonymised data can be stored for a minimum of two years.

**Please Select: YES / NO**

I agree to take part in this study.

**Please Select: YES / NO**

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**Participant’s Signature:**

**Date:**