Supporting the Wellbeing of Children with Autism during COVID-19 Pandemic

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2022

Abstract

Autism spectrum disorder is a prevalent condition that frequently persists throughout a person's life and impacts their capacity for social interaction, behavior, and communication. This condition is present in 1% of the world's population. These people have a hard time integrating into society normally, especially children with autism. Additionally, in recent years, the breakout and spread of COVID-19 have had a significant negative impact on people's ability to lead regular lives, particularly for individuals with special needs. For such children with autism, the effects of this epidemic are even more severe. It makes it much more difficult for them to integrate into everyday social life. Children with autism must contend with additional difficulties in their already delicate and sensitive psychological circumstances. These difficulties have a serious impact on the autistic child's capacity for social interaction, social communication and social imagination. The difficulties faced by autistic children also affect their parents, who must manage their child's psychological stress in the face of the financial pressures of unemployment, salary reductions, and even bankruptcy brought on by COVID-19 [8].

Previous research [60] has shown that interventions are highly appealing to children with autism and produce good results in improving skills and mitigating impairments, and with the development of technology and the limitations of traditional interventions during the COVID-19 pandemic, technological intervention has gradually become popular. However, after reading the literature and searching the App Store, I have discovered that many of the existing technologies seek to directly affect autistic children, such as directly outputting knowledge or what they want to express into technology. They ignore the autistic children's acceptability of new things and the ability of human interaction and human-computer interaction. These interventions are also not very comprehensive, and some guidance measures have not been fully implemented.

Therefore, this research examines the problems that need to be resolved but for which there are no suitable solutions that children with autism face throughout COVID-19. Then a technology is created to assist children with autism in overcoming this obstacle. Finally this research investigates the use and significance of this novel technology by evaluation.

Iterative creation of a high-fidelity prototype was carried out using empirical data, serious game concepts, and technical requirements for ASD and HCI design. Children (including children with ASD), their parents or guardians, and experts in HCI, ASD, and Education took part in creating and testing of the prototype. The evaluation's findings were very encouraging; they demonstrated that the game is engaging and enjoyable

for children with autism, that it is appropriate for their requirements, that it has a good chance of preparing children for COVID-19's challenges, and that it offers new avenues for research and thought for professionals.

Research Ethics Approval

This project obtained approval from the Informatics Research Ethics committee.

Ethics application number: 260135

Date when approval was obtained: 2022-07-01

The participants' information sheets and consent forms are included in the appendix.

Declaration

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

(*Qi Zhang*)

Acknowledgements

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Chapter 1

Introduction

1.1 Autism spectrum disorders and COVID-19

Autism spectrum disorder (ASD) is a prevalent condition that frequently lasts a person's whole life and affects how they behave, interact with others, and communicate [51]. This condition affects 1% of people worldwide [38]. It can be difficult for these people, especially children with autism, to fit in with the rest of society. They are characterized by a lack of social interaction and communication as well as confined, repetitive habits, hobbies, or activities [11]. Frequently autism comes with co-morbidities, such as physical impairment [56].

COVID-19 pandemic epidemic has significant influences in recent years [66]. It has had a significant impact on how individuals throughout the world live their everyday lives, especially those who have special needs [23]. The epidemic had a big impact for children with autism. It significantly impairs the social communication and interaction [54] of autistic children as well as their social imagination [41]. Since the breakout of COVID-19, children with autism have lost out on opportunities for in-person social interaction due to school closings, suspension of extracurricular activities, and suspension of routine health treatment [61]. Additionally, due to daily confinement to their houses, their flexible thinking has been too strong harmed by their rather rigid daily routines and behavioral habits [10]. It would be too hard for them to think flexibly about issues that change and evolve on a daily basis. This makes it more challenging for these children to eventually re-enter and integrate into society since it exacerbates conditions that have previously been treated. Additionally, it makes it harder for them to accept and comprehend the new modifications that must be followed throughout COVID-19 and the justifications for these modifications [13].

1.2   Project Goals and Research Questions

This project's purpose is to identify the new problems and difficulties experienced by children with autism throughout COVID-19 and to look into the best ways to create and develop strategies to help them deal with those challenges. Previous studies [11] have shown that one of the best methods to assist children with autism is through intervention. With the advancement of technology, technology-based interventions have grown in popularity in recent years as a means of assisting children with autism in overcoming their challenges. By creating a technology based on the idea of serious game design(The goal of the game is to teach real life skills rather than recreation) [65] to handle the issues that need to be resolved during COVID-19 for which there are no appropriate solution, this project seeks to assist children with autism in facing their challenges. In order to achieve this goal, the following research questions are posed in this paper.

- **RQ1**: What are the most challenging difficulties that impact the wellbeing of children with ASD during pandemics?

- **RQ2**: How can technology support children with autism during COVID-19?

- **RQ3**: How well the new technology works and to what extent does it help children with autism face the challenges they encounter during COVID-19?

    - **RQ3.1**: Are the game suitable for children with autism?

    - **RQ3.2**: Is the game perceived as engaging and enjoyable by the target population?

    - **RQ3.3**: To what extent might the game be successful in alleviating the challenges faced by children with autism?

1.3   Structure of the Dissertation

The remaining content of this research project is organised as follows, with the remaining chapters being separated into 7:

Chapter 2: This chapter provides an overview of literature on autism and the difficulties experienced by autistic children throughout COVID-19. A brief review of autism intervention strategies follows, with an emphasis on tech-based interventions. An explanation of the design philosophy and motivation for serious games is provided

at the end of this chapter. This contributes to the answer of the research question RQ1 & 2.

Chapter 3: This chapter details the work carried out during the pre-design phase. It includes a workshop and questionnaires, followed by a discussion of the serious game design and HCI principles to be followed throughout the project to display a list of high level requirements and design ideas. This contributes to the answer of the RQ1 & 2.

Chapter 4: The first section of this chapter describes a low-fidelity prototype that was created based on the high level requirements and design ideas presented in chapter 2. The low-fidelity prototype is then evaluated by experts in ASD, HCI, and Education. Then a discussion of the general scope and specifics of the high-fidelity prototype implementation follows. This also contributes to the answer of the RQ2.

Chapter 5: This chapter describes the high-fidelity prototype implementation. It also includes the justification of the decision taken during the implementation phase. This chapter contributes to the answer of the RQ3.

Chapter 6: This chapter describes the final evaluation of the high fidelity prototype which involved children and experts in ASD, HCI, and Education. It presents the results in the evaluation and discusses them. It answers research question RQ3.

Chapter 7: This chapter provides responses to the research questions based on the findings of the assessment studies while analyzing the project's limits and the direction of future work.

Chapter 2

Literature Review

This chapter covers the effects of the COVID-19 breakout on children with autism as well as the educational interventions. An explanation of the project's motivation and methodology is provided as the chapter comes to a close. This chapter aims to answer **RQ1**: *What are the most challenging difficulties that impact the wellbeing of children with ASD during pandemics?* and **RQ2**: *How can technology support children with autism during COVID-19?*

2.1   Autism Spectrum Disorders

ASD covers Autism, Asperger's syndrome (it is a syndrome in pervasive developmental disorder (PDD)) and Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS) (a neurobiological disorder characterized by impairment in ability to interact with others and by abnormalities in either communication or behaviour patterns and interests) [38]. Two core manifestations would be exposed if a person has ASD: a shortage of social communication or interaction and repetitive behaviors [38]. In further detail, their social interactions and communications in multiple environments set them apart from others in several ways, for example, they have difficulties to express their passions or feelings; it is nearly hard for them to interact with other people due to their poor eye contact and body language integration, and inability to adapt to change also makes it difficulty integrate into a new environment and build friendships with others [38]. They prefer to repeat specific activities or sentences because of their entrenched interests, and they react to sensory input in an atypical way (indifference to pain or poor responses to certain sound frequencies) [38].

2.2 Effects of COVID-19 on children with autism

2.2.1 New challenges posed by COVID-19

Many experts have started to research the new challenges that COVID-19 provides for children with autism as a result of its breakout and proliferation [62]. For learning: children with autism are less effective learners and less likely to have the chance to connect with others due to school closures and the use of online courses, which negatively affect their learning results and social skills [13]. For daily activities: many autistic children have incredibly picky eating habits [9]. They would like some certain foods or brands for their diet. However, it was difficult to go shopping in market since people must stay at home during the COVID-19 pandemic, even found a specific brand of a specific food. Lack of familiarity with everyday foods could be incredibly stressful for children with autism [9]. Some children with autism need to spend enough time outside to release energy, or else they would start hurting themselves [61]. But during COVID-19 pandemic they have to find other ways for stress reduction due to the same reason. For mental health: they lack possibilities for everyday contact and outdoor time due to their prolonged isolation, that would bring emotional discomfort to children with autism [58]. COVID-19 also forces children with autism to adapt to the new environment out of the original education system and requires understanding and following several new rules [61]. They would also feel a lot of psychological pressure.

2.2.2 Effects of COVID-19

By summarizing the challenges that COVID-19 brings to children with autism, we can see that COVID-19 has a serious impact on children with autism in two main areas: social communication and interactions, and social imagination.

Children with autism are severely disturbed by COVID-19 in aspects of the communication and interaction. If there were no COVID-19, although children with autism had difficulties to build friendship or play with friends, they have to do these things due to normal daily lives, like extracurricular activities, group discussions or homework collecting [23]. Regular health care events organized by professionals or children's doctors can help encourage them in part by helping them connect with others [9]. However, children with autism lose these opportunities for social interaction because of the suspension of routine health services, quarantine regulations, and school closures. They can only take classes or communicate through the Internet, which reduces the

efficiency of normal social interaction [13]. Segregation policies prevent them from going out and socializing. There is evidence that online classes, virtual meetings, or medical events are far less effective than offline [61], and that online medical treatment [22] is nearly unable to be accepted for everyone with autism due to technical support and financial problem [10]. Children with autism spend too much time with parents or guardian making it difficult for them to practice social skills.

Children with autism also have an impaired social imagination, which is an awareness of personal experience about wider society [41]. The current situation is that children with autism are confined to attending online classes at home day in and day out, repeating the routine of sleeping and eating. These repetitive routines and behavioral patterns nearly keep them from thinking flexibly [13] which means they don't need to think dynamic routines such as what game to play with peers today or where to go to play after school. Worse still, the destruction of the social imagination and monotonous thinking set back again the already progressive social skills and language skills, and even exacerbate the conditions that had already been alleviated [13]. As a result, these children will have a much more difficult time re-entering society in the future. It is challenging to accept and comprehend the new requirements they should follow for COVID-19, as well as the justifications for these requirements [13], such as reasons for quarantine measures proposed by the government, reasons for vaccinating against COVID-19, or reasons for wearing masks in public. These are very different from their habits. With so many challenges, This project concentrate on assisting children with autism in understanding the new social norms they should adhere to throughout COVID-19, assisting them in adjusting to these norms, bringing variety into their monotonous life, and alleviating stress.

2.3 Coping strategies for ASD

2.3.1 Traditional interventions

How to help children with autism overcome their challenges has been extensively researched. Children's social behavior and communication can be significantly impacted by low-intensity interventions that instruct parents or guardians to engage with young children with autism, according to several well-conducted randomized controlled studies [64]. Thus, early on, parental involvement as a mediator and the inclusion of parents in the child's life could make the child more active [28]. And early intervention

during this time period also had a positive impact on the child's oral ability [28]. Subsequently, scholarly research has turned towards naturalistic behavioral developmental interventions [38], such as the best-known Applied Behavioral Analysis (ABA)[21]. It underlined that intervention for children with autism should proceed in accordance with normal developmental stages. Through one-on-one sessions with a teacher or professional, the child's social skills and social imagination were enhanced using the principles of learning [13]. Or other natural forms of interventions could be used such as music [57], language [30], songs [46], etc.

2.3.2 Technology-based interventions

Over the past several decades, an increasing number of technology-based interventions have been created, and an increasing number of children were adopting products connected to technology [36], and students with autism have been educated by technology for 35 years [18]. Colby [18] was one of the first to study technology-based interventions. Colby's team employed computer games for various difficulties to increase children's letter and sound sensitivity and assist children with autism to comprehend word building and expressiveness [18]. After more than ten years, Panyan [45] demonstrated how useful technology might enhance the attentiveness, focus, and social engagement of children with autism. Computer-assisted learning (CAL) [25] [49] and serious games are ways to increase the ability of technology to intervene with children with autism. CAL uses computer equipment to provide education and interventions for people with ASD [35]; serious games [13] are made to enhance psychological wellbeing of mental health and developmental disorders, or to learn general skills or information aside from play, not just for amusement [37]. Point Outwords [63], which is an application, supported computerised interventions and gave users access to an intuitive tablet through computer-assisted learning. When children with autism are unable to engage in outside activities because of the COVID-19 pandemic, it created mini games through various real scenarios involving various themes, such as some straightforward puzzles or scrabble words, allowing them to learn through play. Some movement games based on serious games, such as [17] [26] [31] [48], enable children to engage in light exercise or the joy of movement at home to relieve their physical and mental stress to a certain extent when they are unable to do outdoor activities. With the development of technology, artificial intelligence-based technologies such as voice recognition devices and VR [32] are also gradually being used to help children with autism [55]. [14] [33] analyse

data demonstrating how spoken language software and speech-generating gadgets assist spelling in students with autism [40]. In the Apple App Store, there is an app Replika that utilizes artificial intelligence to create a virtual friend that children with autism may interact with to improve their communication abilities. Children with autism can engage with individuals at home or encounter sights in public areas with the "Autism VR Experience" application also available in the Apple App Store.

2.4   Motivation

As COVID-19 remains a issue globally, countries took measures to control and curb its spread and there is little sign of an end to COVID-19 [62], so children with autism are still affected by COVID-19 and its control measures and children with autism need to be supported in COVID-19. According to previous research, coping strategies can be more easily accepted by children with autism when it is presented in a gamified form [20]. Therefore, this project is focused on designing and developing a game to help children with autism alleviate the new challenges and difficulties they face during the epidemic. This project aims to help children with autism cope in a COVID-19 environment and show them ways to cope with the problems posed by COVID-19 in a gamified way. Based on previous research [45], and the framework of 'serious game' [65], we found that there are few applications designed for children with autism during the epidemic using the 'serious game' approach. The proposed approach is considered to be feasible. After analyzing the four Piagetian stages of cognitive development [39], the target population was set at the 'Concrete Operational Stage', that means children aged 7-11 years, where children begin to think logically, understand concepts, and have an appropriate understanding of electronic devices, games, and experience in the COVID-19. These abilities represent that they can understand and adapt to what the project wants to help them, and have the foundation to play the game.

2.5   Methodology

The project followed the approach shown in Figure 2.1, which was adapted from (Scaife & Roggers, 2001) [53] and inspired by the work of (Constantin, 2018) [19]. This approach allows children and experts to act as informants in the development of the project. And the whole process will have user participation [52].

Stage 1: Background Research The first stage was to review the relevant background research on ASD and COVID-19 to understand the problems being attempted and to begin to sketch potential application ideas. Technologies for ASD and new technologies from the COVID-19 period were researched to come up with an initial set of high-level requirements for the project.

Stage 2: Design Studies In this phase, to further define the requirements for the game, a workshop was conducted with 4 typically developing (TD) children who were used as proxies for children with autism and helped to inform the design of the application to be implemented.

Stage 3: Prototyping This phase aims to implement a low-fidelity prototype based on the output collected in the first two phases. The prototype is then evaluated by experts in HCI, ASD, and Education to refine the design implications gathered to date and to identify potential usability issues early in development.

Stage 4: Implementation In this phase, the high-fidelity prototype is implemented based on the refined requirements from the previous phase. The game is implemented in an iterative manner, refining the functionality based on the requirements.

Stage 5: Evaluation In this phase, the high-fidelity prototype is evaluated by experts, TD children. The evaluation focused on determining the usability of the game, its suitability for providing help to children with autism, the suitability of the game for the target group, and identifying issues that need to be addressed in future work.
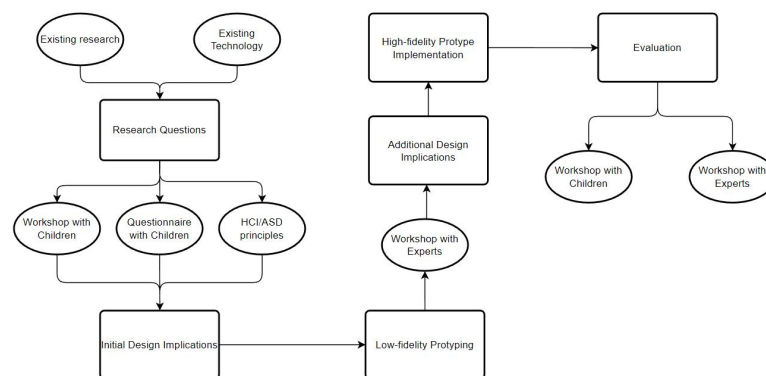
Figure 2.1: Structure of the Methodology of the Dissertation

Chapter 3

Pre-Design Studies

This chapter describes the second phase of the project, which is to understand better what problems children face during COVID-19 and to collect design ideas to identify some of the details of game. These included a questionnaire and a workshop to inform the design and lay the groundwork for the initial stages of designing a low-fidelity prototype. The purpose of this chapter is to answer **RQ1**: *What are the most challenging difficulties that impact the wellbeing of children with ASD during pandemics?* and partially answer **RQ2**: *How can technology support children with autism during COVID-19?*

3.1   Design Questionnaire and Workshop

3.1.1   Aims

The overall goal of this workshop were to:

- identify problems children faced during pandemic.

- find out what activities they prefer to do to overcome these problems.

- gather ideas for game elements: storyline, game activities, and rewards.

3.1.2   Environment

The workshops were conducted via Microsoft's Teams [4] or Zoom [6].

3.1.3 Participants

Four children participated in the study. First, the four children answered a questionnaire. Two children(P3, P4) participated in individual workshops. The details of them are shown in Table 3.1.

Participant Number	Participant Age	Participant Gender	Way of participation
P1	8	Male	Questionnaire
P2	7	Female	Questionnaire
P3	9	Female	Questionnaire and Workshop
P4	10	Female	Questionnaire and Workshop

Table 3.1: Design questionnaire and workshop participants

3.1.4 Materials

The materials used for the workshop were consent form and participant information sheet for parent/guardian, consent form and participant information sheet for children, consent form and participant information sheet for adult, electronic device (laptop, tablet, smartphone), blank sheets of paper, colored pens/pencils/crayons.

3.1.5 Methods and Procedure

The questionnaire was divided into four parts in total, including the Icebreaker session, the problems children faced during the epidemic, the relevant details of the game, and the game reward part.

We sent the questionnaire to the parent or guardian of the child by email. The parent or guardian showed the question to the child, and they wrote down the answers which come from the child in the corresponding position. Finally, the completed questionnaire was sent back. During the whole process, parents or guardians could ask any questions related to the questionnaire and this research at any time, principal researcher answered relevant questions by email or telephone.

The workshop aims to let children express their ideas in a richer form, and the questions raised were more interesting. Children could express their ideas more concretely

by drawing pictures, which made the data collected by the research more sufficient, so as to better design low-fidelity prototypes.

Workshops were conducted online through Microsoft Teams or Zoom software, and meetings were recorded using the software's recording function or recorded using the smartphone's recording function.

The parents were contacted via email - the parent and child information sheets and consent forms were attached. If the child decided to participate, both consent forms were signed and returned prior to the meeting.

The following activities were performed by children to meet the above aims by the workshop:

Icebreaker (5 minutes): The task was to talk about where they would like to travel after the pandemic is over. The purpose of the first activity was to acclimate the children to the workshop environment in preparation for the upcoming chat or painting.

Activity 1: Problems faced during pandemics(7 mins): Children were shown a fictional character named "Robin" before beginning the first activity, and they were informed that Robin is a young kid who struggles to fit into a new environment or to adjust to certain changes, and that the backdrop environment was now experiencing COVID-19. The researchers instructed them to consider Robin while they deliberated their responses before to each pertinent activity. Children were encouraged to brainstorm [7] three things and/or rules that Robin would find challenging or challenging to adjust to during COVID-19 for the first activity. They were instructed to express themselves through drawing or writing. To assist children better comprehend what they should be considering, the researchers displayed a hazy example.

Activity 2: Let's help Robin (7 mins): Children were required to think about strategies or approaches to assist Robin in dealing with the situations described in the previous activity for this workshop. If they could not think any good idea, they could also come up with a game that can make Robin's situation easier, and the researcher would ask the suggested game further questions about the characters or the setting of the background. The researchers also provided an example before children started thinking.

Activity 3: Let's design a game for Robin (7 mins): The students were then informed that Robin is a young kid who enjoys playing video games. In this activity, children were asked to come up with a fantastic story or describe a story that interests them based on their preferences and solutions they came up with in previous activities. They were encouraged to draw characters, environments, maps, and anything else that helps them present the story. The researchers provided a sample storyline.

Activity 4: Rewards (5-8 mins): In the final activity of the workshop, children were asked to design a reward for a potential app or game. They were asked to consider rewards earned at different stages of the game, as well as rewards as a celebration of completing the game. The researchers provided an example of a known game's reward pattern.

At the end of the workshop, the researchers thanked the children for their help and complimented them on their suggestions. After asking the child if they has any other thoughts or questions. The researchers emailed certificates of thanks and asked parents to take photos of their children's drawing and writing ideas and email them to the researchers.

3.1.6   Data Collection and Analysis

Data collected included: questionnaires answers, audio recordings, researcher's notes, and electronic copies of children's drawings emailed by parents. Records are reviewed and data transcribed. Transcript data, notes, and drawings were analyzed using Thematic Analysis [16], a qualitative data analysis method that summarizes the collected content to distill some themes and other research models [29]. After getting familiar with the code, category, and theme of the method, the following steps are taken from Braun and Clarke's [15], including 6 steps: familiarizing yourself with your data (already converting the audio recording into text), generating initial codes (because the analyzing children's ideas should rely more on data than theory, so use inductive coding), generating themes/theme development (summarize codes and group them into potential themes), reviewing potential themes (separate codes that are not relevant to our research question), defining and naming themes, producing the report. Thematic Analysis [16] leads to several themes discussed in the next section.

3.1.7   Results

According to the method of qualitative analysis described above, themes are defined as follows:

Problems Faced during Pandemic: This theme revealed a range of social situations that children find difficult. All the children mentioned the inconveniences during COVID-19. For example, child P4 thought that if the school is closed during the epidemic, it is very boring at home, and it is very inconvenient to be infected with COVID-19 when school re-opened. She said: "*. . . can't go to school when he needs to*

quarantine, so he may fall behind. "(Figure B.2.c) P3 told a case of her friend:"... *so she can't come to class. She needs to stay at home, so she missed a lot of time we played.*"(Figure B.1.a)

Three kids, P1, P2, and P4, pointed out that getting vaccinated is a difficult thing to get used to, and the conditions after getting vaccinated were troublesome. For example, P2 said about her own experience: "*I had a fever after the last vaccination. Not only was the vaccination very painful, but the subsequent symptoms also made me very uncomfortable.*"

In addition, P3 and P2 proposed to be in public places as a place for the game activities(such as supermarkets, and movie theaters) is very inconvenient, P3 gave an example: "... *cinemas are closed, and he can't enjoy watching movies with popcorn.*"(Figure B.1.a) And both P3 and P4 also pointed out that wearing a mask is a difficult situation. As P4 says: "... *to wear face masks during the pandemic to protect ourselves from the virus. He might feel uncomfortable when he wears face masks, especially in summer.*(Figure B.2.c)"

Strategies to Cope with Problems: After identifying the problems children may face during COVID-19, they were asked to come up with ways to deal with them. Most of the problems could be solved through online apps and web system. For example, inconvenience in public places (such as supermarkets, and movie theaters) can be solved through online viewing or online shopping. P3 says: "... *watch movies on TV and it will be cheap, and the important thing is they can talk loudly. ... delivery service, it's so convenient, even the delivery uncle can bring things to my door.*" (Figure B.1.b)

Due to the problems caused by the closure of schools, some children felt that online classes can also achieve the purpose of learning, or they can chat with friends and teachers through chat software such as WhatsApp.

In addition to this, child P4 suggested a game named 'animal crossing' [1]. The game proceeds in an open-ended fashion and develops it into a community of anthropomorphic animals. Players can imitate things in our real lives like catching bugs, collecting fish and also have social interaction with other players online [67], P4 suggested: "... *play animal crossing so that he could imitate camping life in the game with his friends during quarantine. He can even go fishing in the game.*"(Figure B.2.b) The characters in the game are all cute little animals and this game has been proved to ease the stress [67].

Game Storyline: In this workshop, children came up with many interesting stories, such as P4's story: "*The story can happen in the forests with blue sky and clean spring. The characters can be lovely animals that live in this forest.*"(Figure B.2.a) Some of

the stories were referred to some animated movie, such as 'Finding Nemo', 'The Lion King', and 'Frozen'. Like the story proposed by P3: "*I love watching Frozen so the story can take place outside Frozen Castle. The character can be Elsa herself. There can be many stars in the sky, and Olaf can accompany us.*"(Figure B.1.c).

Game Concept: Table 3.2 is a list of key points raised by children in relation to game concept.

Participant	Quoted answer	Game Concept
P1	"Like it can imitate the growth process of. . . constantly pick up props in the game to develop the overall process."	Props are obtained as the game progresses
P2	"Each level has different characteristics, the first level can. . . the second level and then. . . "	multiple levels
P3	"I love watching. . . so the story can take place. . . "	reference animated movie's plot
P4	"The characters can be . . . that live in . . . ."	feature multiple characters

Table 3.2: Game Concepts emerged from children's stories

Rewards: Children suggested using general types of rewards like stars or fruits, as P4 said: "*. . . can get fruits as awards to feed the animals, such as strawberry and carrots. . . *" P3 suggested players use stars to buy skins by collecting stars: "*I feel like I can pick up stars in the game. I can redeem princess clothes and crowns with stars.*"(Figure B.1.d). P3 and P4 suggested that the game could eventually have some interactive animation effects:" *After completing a level, I want Olaf can interact with me.*", "*. . . for the final rewards, I'd like to see animals dance together happily.*"

3.2 Design Principles

3.2.1 HCI Design Principles

In order to ensure that the design of low-fidelity prototypes can be implemented, it is necessary to consider the principles that should be followed in human-computer

interaction, and design low-fidelity prototypes based on these principles. The most prevalent and widely used principle is Nielsen's 10 Usability Heuristics [44] as a rule of thumb for designing interaction tools. They are about how to design an HCI interface to provide a good user experience [34]. They are called "heuristics" because they are broad rules of thumb rather than specific usability guidelines [43]. A list of the 10 principles and their explanations can be found in Appendix A. For the following sections, the relevant HCI-ID will be used to refer to the principles (e.g. HCI-3 means the third HCI principle).

3.2.2 ASD Design Principles

Because this game is mainly designed for children with autism, we also have to consider what principles should be followed in the design of children with autism. The ASD-specific design principles presented below were collected by Laura Bartoli (2014) [12], and it can be considered a general guide for designing apps for children with autism.

ASD-1: The goal should be unique and specific.

ASD-2: The game should allow progression through multiple levels.

ASD-3: Instructions should be explicit and provided everywhere necessary.

ASD-4: The game should be predictable and repeatable.

ASD-5: Rewards appealing for children should be offered after good performances.

ASD-6: The game environment should not be overwhelming.

ASD-7: Navigation should be straightforward.

ASD-8: Text should be simple, clear and easy to read.

ASD-9: The game should promote the development of imitative capability.

Combining the findings of the literature review in Chapter 2, the results of the design workshop in Section 3.1, the HCI/ASD design principles outlined in Section 3.2, and some literature [50] [47] [59], an initial set of design implications which is Table 3.3 was created and it will be followed when designing low-fidelity prototypes.

Design Implication	Justification
The target population is children with autism between the ages of 7 and 11-Games should be understood and enjoyed by children at this stage.	Children at this stage already have relevant knowledge and experience with electronic products or games, and they have various life experiences (including school, friends, family, etc.) in the face of COVID-19.
Clear instructions are given if necessary-Include text in guides or games for hints	HCI-10, ASD-3
Provision of Choice-Design a variety of methods for passing levels	HCI-3,Literature Review [65]
The language is simple and direct-use suitable words	ASD-8, HCI-8,Literature Review [50]
Have a clear interface where everything that needs to be displayed or character status can be seen-the game page and button layout should be clear and simple enough	HCI-1, HCI-6,Literature Review [50]
Collectables are placed along the game path	P3 and P4 from Design Workshop,Literature Review [20], [65]
The game has storylines with multiple environments, multiple characters, multiple levels which are be predictable and repeatable and Individuation	ASD-2, ASD-4, ASD-6, HCI-3, All children in Design Workshop and Questionnaire
In the game, players will have corresponding prompts or encouragement if they fail to clear the level	ASD-8, HCI-9,HCI-8,Literature Review [50]
Tasks are clear and straightforward	ASD-1
Provide reasonable in-game rewards and final rewards	Literature Review [20], ASD-5, All children in Design Workshop and Questionnaire

The game interface is beautiful, and the buttons are easy to operate	HCI-7, HCI-8
No violence, bullying and other bad guidance	Literature Review [50]

Table 3.3: Initial Design Implications

Chapter 4

Low-Fidelity Prototype

This chapter presents the low-fidelity prototype (Chapter 4.1) and its formative evaluation with HCI, ASD, and Education experts (Chapter 4.2). This chapter aims to further answer **RQ2**: *How can technology support children with autism during COVID-19?*

4.1 Prototype Description

The design approach was iterative. First, a low-fidelity prototype was developed and then it was evaluated formatively. Prototypes were designed incorporating the requirements presented before and were based on the HCI and ASD principles.

The prototype was developed on Figma [3] [24]. This is a vector graphics editor and prototyping tool. The interface design and links between interfaces of the low-fidelity prototype were implemented by Figma. Figma has several advantages. From a design point of view, it is possible to design and use our own components and simulate the phone bezel. From a usability standpoint, Figma allows users to work cross-platform and work directly from the web. The main disadvantage of Figma is that it is mainly used for designing relatively static prototypes. Therefore, when evaluating prototypes, experts were told to ignore animations of characters in the prototype as much as possible.

Game Concept: This game, called 'Virus Revolution', focuses on the introduction of props to guide children with autism through the difficulties that occur during COVID-19 and to guide them to accept the changes that COVID-19 brings. The game simulates real life to a certain extent and is somewhat detached from it so that the children's social imagination can be exercised on a real-life basis. The game is a horizontal breakout game. The player controls the character by overcoming obstacles and avoiding 'virus'. The victory condition is to reach the end of the game safely with time left, where obsta-

cles and 'viruses' waste the player's time and hinder their progress towards the end of the game.

There are three buttons to press - 'Go', 'Jump' and 'Quarantine'. Figure 4.1 displays the buttons layout. The first two buttons control the player to move forward and jump to avoid obstacles and 'virus' respectively while the 'Quarantine' button can be used in this scene: a 'weak value' will be displayed if the player touches 'virus'. 'weak value' increases as the player moves or as time

Figure 4.1: Buttons display

passes, If the 'weak value' is too high, the character will not have the strength to move forward and will fail the level, the character can decrease the 'weak value' by clicking 'Quarantine'. This will last for a few seconds. Once you have quarantined yourself, the 'weak value' will disappear and the player will be able to move normally again. 'weak value' settings will be replaced by 'health value' after evaluation, which will be explained in the evaluation section. Figure 4.2 displays the 'weak value'.

The game uses this sequence of actions to mimic the way quarantine is performed when infected with COVID-19, thus leading children with autism to embrace this form. Each level of the game introduces a prop related to COVID-19 which represents a piece of knowledge that is intended to be introduced to children, such as a mask, vaccine, etc.

Figure 4.2: Weak Value display

Instructions and guides: To make the interface sufficiently brief, the prototype has almost no text tips on the official levels (but there is a description of the reasons for failure if you fail), instead text tips have been added to the 'Guide for beginner', which makes it possible to introduce and guide the game for beginners. In this function, players are first prompted with a storyline and enter a training level, where they are introduced to the game's interface, button functions, checkout screen, and props ...... so that they can learn the basics of the game and its objectives. Figure 4.3 displays the first page of 'Guide for beginner'.

Tasks: In 'Guide for beginner' the player is introduced to the storyline of the game where the player needs to find and defeat the 'Villain'. The 'virus' is the ' Villain 's servant who are used to hinder the player. So, the game's mission is to require the player
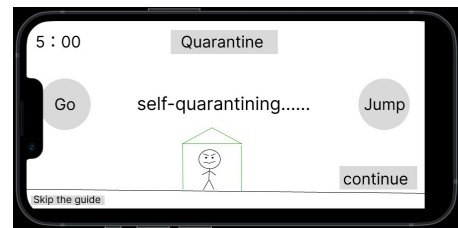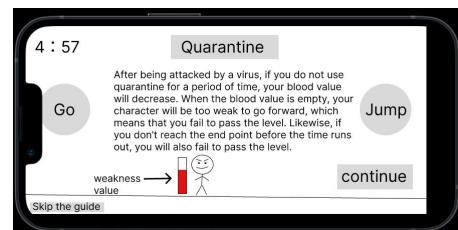
to go through each level and eventually defeat the 'Villain'. In the process, players can learn something about COVID-19 and thus face the problems it brings to them. There are pointing props in each level, and players can get coins by picking up pointing props. Coins can be used to buy some decorations from the shop, which is mentioned below.

Shop: In Pre-design we got a lot of storylines and character appearances that children liked, but we had a hard time fitting every single one of the mentioned storylines and characters into our game, so we put some character clothes, character accessories, game environments or animation effects into the shopping cart, allowing players to buy

Figure 4.3: Guide for beginner

their favorite character items with the coins they earn. This allows for maximum character diversity and environment variety.

Rewards: In addition to the coins mentioned above as rewards for the whole game, there are also final rewards at the end of each level which include a score, rating (number of stars), and comments. Figure 4.4 displays the rewards type. Previous research [20] has shown that this type of reward is suitable for children with autism, as it recognizes that the tasks in the game have been completed and that the child gets a sense of achievement. Children with autism prefer digital technology rewards [20], while ratings and textual rewards give the rewards a formal feel like a certificate. In addition to this, the literature [20] suggests that rewards should be progressive, for example, the number of stars increases from one to three and the textual rewards progress from 'Good job' to 'Amazing job'. [20].

This is because children with autism want the reward theme to remain the same, but the instances of reward should be progressive as the game is completed to a high level of excellence [20]. The final reward format, the appropriateness of the guides, and other aspects of the low-fidelity prototype are discussed in the next section of the expert evaluation of the low-fidelity prototype.

Figure 4.4: Rewards display

A lot of screenshots of this low-fidelity prototype are displayed in Appendix C.
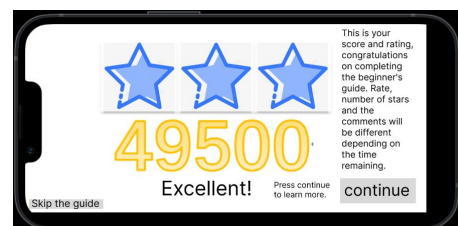
4.2 Prototype Evaluation with Experts

The low-fidelity prototypes described in the previous section were evaluated by experts in HCI, ASD, and Education. Experts are highly insightful in these areas, so they can help uncover any usability issues or things that need to be changed in the current design, creating a good foundation for high-fidelity prototyping. And experts in ASD helped with design ideas for children with ASD. It is also a great opportunity to discuss and evaluate various options with the experts and whether the proposed activity is suitable 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 autism aged 7-11 years old).

- Determine the suitable type of storyline (linear story or stand-alone levels).

- Determine an appropriate reward system.

- Determine suitable props can be added to the game.

- Gather design ideas.

4.2.2 Environment

The workshops were conducted via Microsoft's Teams or Zoom software.

4.2.3 Participants

The participants were three experts in the fields of HCI, ASD and Education. Their details are shown in Table 4.1. To ensure anonymity, each participant is referred to using a participant number.

Participant Number	Position/Occupation	Area of expertise
E1	Master in Education	Experience in ASD
E2	Postdoctoral Research Assistant in HCI and Education	Experience in HCI and Education, developing technologies for children with HCI
E3	Research Associate, University Teacher in HCI and ASD	Experience in HCI and ASD, developing technologies for children with ASD

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 adult participant (experts), computer or mobile device to join the Microsoft Teams meeting or Zoom meeting, script for the researcher, notebook for researcher's notes, additional audio-recording device.

4.2.5 Procedure

The participants were contacted via email with information sheets and consent forms. If they decide to participate, they were asked to sign and return the consent form prior to the meeting. Each session ran only one participant at a time but followed the same process. Sessions last 30 to 45 minutes, depending on follow-up tasks and questions with each expert.

For each session, a "Cooperative Evaluation" approach [2], a version of the "Think Aloud" approach [2], was used in which the user participates as a collaborator rather than just a participant that means experts were encouraged to ask questions (e.g. why, what, if) while the prototype was running to clarify user behavior. At the start of each meeting, the participants were informed about the project and its purpose. Researchers shared the low-fidelity prototype by sharing the web link of the prototype in Figma. Then researchers gave experts five tasks to do and asked questions after each task. The tasks were about the 'Guide for beginner', try three levels, and rewards. Experts were asked after each task: 'What did you like most in this/these guide/levels/rewards', 'What did you like least in this/these guide/levels/rewards', 'Do you have any suggestion for improving this/these guide/levels/rewards?' and 'How suitable you think this is for

a child between 7 to 11?' At each session, after answering the previous questions, researchers asked the experts if they have any other suggestions. Finally, the advice given by the experts and the answers given to the above questions are discussed in the following sections.

4.3 Data Collection and Analysis

After the expert evaluations, the recordings were reviewed, transcribed, and combined with the notes from each meeting. Thematic Analysis [16]were also used. The themes obtained will be presented in the next section.

4.4 Results

The experts were positive about the general concept of the game and the suggestions for integrating the features. They identified several important improvements and suggestions, some of which were considered for future work due to the limited time and complexity of implementation. Based on the thematic analysis presented in the previous section, the following results emerged:

Suitability of the current design: One of the main focuses of this study was to examine the relevant content of the game and whether the game's mechanics and actions were suitable for the target group. All experts felt that the game could help children with autism during COVID-19 and were optimistic about its suitability for children aged 7-11 years, with E3 feeling that *"it's very suitable."* and E1 noting in particular that *"younger children may not have experience with electronics, and slightly older children can understand the knowledge the game brings, so it's perfect for this age group of children with autism."* E2 felt that *"It's great to be as inclusive as possible, but the cognitive and developmental level of the target group should be made clear, and the issues should be addressed appropriately. "*

Design ideas and storyline: The guide for this game is like a little simple level, so the experts mainly offered insights into some game mechanics, button layout, and storyline. In terms of vocabulary used: E1 and E2 pointed out to some words that are inappropriate in the storyline: *"Almost no game uses 'devil', maybe you want to use 'villain' or 'anti-hero'.", "I think 'die' is too sensitive a word for autistic children."* E3 pointed out that for consistency in the HCI principles, word 'self-isolation' should be written consistently as 'Quarantine', and all experts pointed out that there may be a

bit too much text in the 'guide' for children to read. The text could be spread out on other pages or added as a voice-over. On game mechanics and button layout: Some experts considered that several terms are not clear enough and suggested alternatives. E1 felt that the 'weak value' were confusing and could be replaced with 'health value', and both E1 and E3 felt that in a normal game such 'health value' should be displayed horizontally rather than vertically. E2 said:" . . . *perhaps the 'Go' and 'Jump' buttons should be swapped.* " Cause the 'Quarantine' button was located at the top of the page and far from 'Go' and 'Jump' buttons, E1 pointed out that "*the 'Quarantine' button is hard to press, perhaps it could be placed on the left and right instead of the top.* "

Level settings: Some experts praised the design of the levels. E1 said: "*The third level is very clever in that the player has to be exposed to the virus and thus has to use 'Quarantine' to learn about it.* "E2 and E3 praised the game's special effects: "*The blue aperture is very well designed and makes me feel protected.* ", "*The levels are very educational and I liked the way the masks, and vaccination effects were presented.* " But E3 pointed out that the educational part of the game should be more visual: " *I think you need to make it more visual so you know at the end you say well done, blah, blah blah and you can draw the prop beside the conclusion.*" For more props could be used, E2 pointed out that a level of using 'medicine prop' could also be added: "*Can you add a level about 'medicine prop' whereby taking them, the player can increase the 'health value'.*". E1 also suggested to add a level about 'medicine prop': "*You could add 'medicine props', which would allow the player to shorten 'Quarantine' time or increase 'health value'.* " E3 suggested that the previous levels could be merged to create a more complete level.

Rewards: Experts liked the design of the reward system. E3 said: "*I like the style of reward system very well, players will always feel that stars are a very familiar reward.*" But E2 pointed out that the reward design of the settlement interface was too much: "*you can delete some of them. . . or use fireworks.*" and E3 offered a new idea: "*you have a shop and you also have an icon for your things for easily finding the decorations you owned. . .*".

4.5 Discussions

In general, the experts were positive about the proposed design and in particular found the game very educational. At the same time, experts also put forward some insights and improvement directions, such as the appropriateness of vocabulary, interface layout,

which props or levels can be added, and the improvement of the shop system. Following the expert evaluation of the low-fidelity prototype, the design implications were further updated based on the principles presented in the previous section and the experts' comments that are shown in Table 4.2.

Design Implication	Justification
Interface instructions and button layouts should be concise	All experts, HCI-1, ASD-3,ASD-7,HCI-6,HCI-8
Use more appropriate vocabulary and maintain consistency	All experts,ASD-3,ASD-8,HCI-4
Add 'medicines prop' or mix up more complete levels	All experts,ASD-2,ASD-9
Remove some rewards and add some special effects in the settlement interface	E2,ASD-5
Shop and inventory system needs improvement	E3,ASD-5
Health value mechanism needs improvement	E1,E2,HCI-1
Made the educational part of the level more intuitive	E3,HCI-2

Table 4.2: Additional Design Implications

Chapter 5

High-Fidelity Prototype

This chapter first describes the technical details involved in the development of the prototype and justifies the decisions taken. It then describes the details and improvements based on the suggestions and implications in section 3.1.7 and 4.4 made to the game in the high-fidelity prototype (the screenshots can be seen in Appendix D).

5.1 Technical Decision

The final high-fidelity prototype was developed on Unity [5], a real-time interactive content creation and operation platform and development engine. It can be used to create and manipulate a wide range of 2D and 3D content [27]. Here are the advantages of using Unity: 1. Cross-platform development: Unity can export prototypes to various systems, saving a lot of compatibility time considerations. 2. Integrated editing: Unity's user interface is well-designed, with a detailed object property editor, which can modify parameter values in real time while the prototype is running, easily create game scenes, and add scripts directly to components through code [42]. This saves a lot of time for game development.

5.2 High-Fidelity Prototype Description

This game, named 'Virus Revolution', helps children with autism to cope with the problems they face during COVID-19 by introducing props related to these problems. The task of the game is to pass each level in good health (which means player should arrive the 'end point' before 'health value' decreases to zero) and eventually defeat the 'villain' (which appears at the end of the last level, it is described in games storyline

and also a little challenge for children).

At the start of the game, if the player is new to the game, they can choose to click on the 'Guide for beginner' button to learn about the game and its mechanics. Alternatively, they can select the 'New Game' or 'Continue Game' button (both can be pressed at the game initial interface) to enter the game. The game is divided into 4 levels, the first 3 levels correspond to the 3 difficulties the children face during the epidemic and the 4th level incorporates the knowledge taught in the first 3 levels and adds 'a villain', which need to be defeated to pass the game. Figure 5.1 displays the level selection page. A shop with special effects, pictures of the environment, and 'medicine props' (which is a new prop mentioned by experts to add to the game, it is described in section 4.4 in experts sentences in 'Level settings' part) are part of the reward system (Figure 5.2.a). Each level is rewarded with progressive stars and reward comments (a kind of text rewards like 'Excellent!' or 'Nice'). Improvements to several major parts of the game are stated below, by taking into account the comments of the experts in Section 4.4.
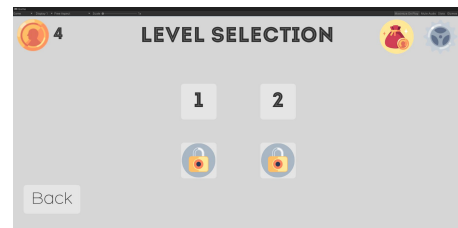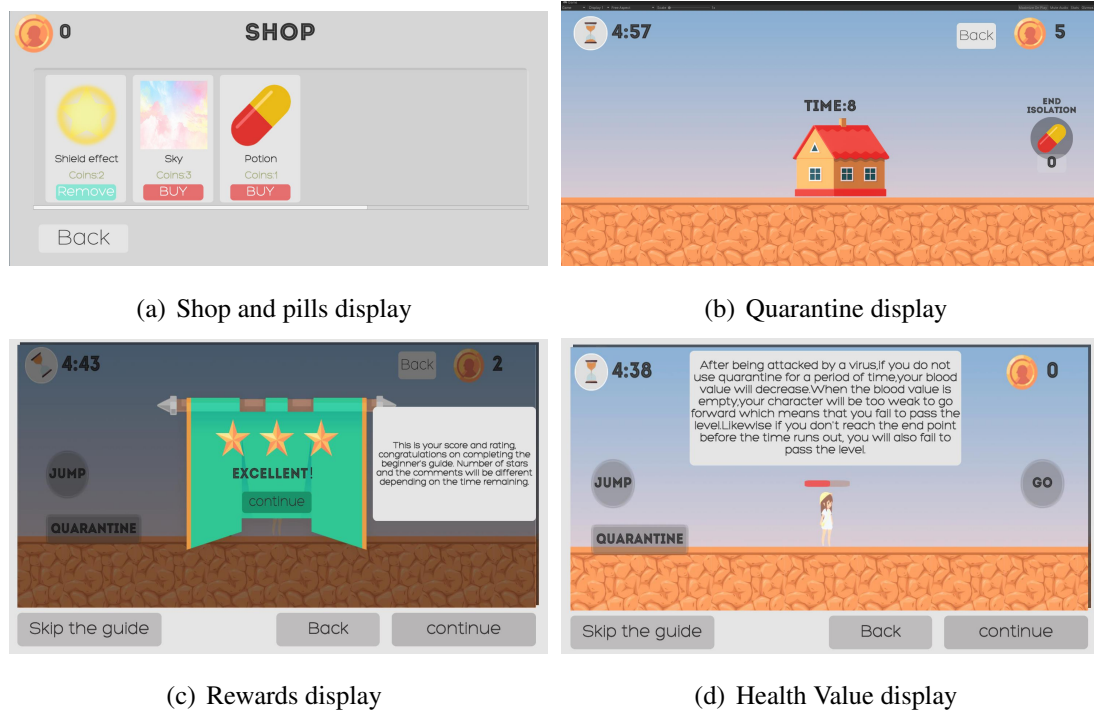

Figure 5.1: Levels display

5.2.1 Improvements for Guide for Beginner

To make the 'guide' more user-friendly, a 'skip the guide' button and a 'back' button to each 'guide' page was added. To make it easier for children to read the text, the text has been gradually popped up through printer effects, and inappropriate words such as 'die', and 'devil' were removed. To make buttons easier to press, the button layout was adjusted. To make it easier for children to understand, more obvious countdown cues when 'Quarantine' were improved. Figure 5.2.b displays the 'Quarantine' page. To make the mechanic more logical, 'weak value' was changed to 'health value' and to horizontal. Figure 5.2.d displays the 'health value' now.

5.2.2 Improvements for Game levels

There were too many rewards on the screen, so the score was removed and the star rating and comments were retained to make the screen less cluttered. Figure 5.2.c displays the score rewards page. To make the child feel more accomplished, firework effects were added after the final defeat of 'the villain'. To make the game more functional and

able to teach more, 'medicine prop' was added to the shop, which functions to speed up the end of 'Quarantine'. These are also improvements to the rewards section. To help children review what they have learned, a new level has been added which mixes the previous props . To make it easier for children to understand what they are learning, the educational interface has been made more concrete with the addition of props.

(a) Shop and pills display

(b) Quarantine display

(c) Rewards display

(d) Health Value display

Figure 5.2: Improvement for High-fidelity Prototype

5.2.3   Improvements for Rewards

In addition to the improvements mentioned in the Game levels section, to make the game more user-friendly, the shopping cart was changed to a shop, and purchased items could be selected or unloaded from the shop. It can be seen in Figure 5.1 and Figure 5.2.a.

Chapter 6

High-Fidelity Prototype Evaluation

6.1 Evaluation Workshop with Children

This chapter presents two evaluation studies of high-fidelity prototypes: a TD children evaluation study and an expert evaluation study. This chapter answers research questions **RQ3**: *How well the new technology works and to what extent does it help children with autism face the challenges they encounter during Covid-19?*

6.1.1 Aims

The main objectives of this study are to determine if : 1. the technology is engaging; 2. the game is easy to play; 3. the game helps children in real-world situations. Additionally, the evaluation intended to gather suggestions for further improvement.

6.1.2 Environment and Participants

The workshops were conducted via Microsoft's Teams [4] or Zoom [6] software. A total of 4 TD children participated in this study, 3 of whom also participated in pre-design(P2,P3 and P4). More information about the participants is presented in the Table 6.1.

Participant Number	Participant Age	Participant Gender
P1	10	Male
P2	7	Female
P3	9	Female
P4	10	Female

Table 6.1: Details of the children participants in the evaluation

6.1.3 Materials

The materials used for this study were: information sheet and consent form for children, information sheet and consent form for guardian, 'Unity', computer, or mobile device to join the Microsoft Teams meeting or Zoom meeting, script for the researcher, notebook for researcher's notes, additional audio-recording device.

6.1.4 Procedure

Before the study, parents were contacted by email with two information sheets, one for themselves and one for the child. If the child decided to participate in the study, the parents were given two consent forms and returned them before the study began. The researcher first sent the game to the parents via an attachment and explained the details about the game. The researchers handed out a list with 5 tasks. These tasks required the child to explore the 'Guide for beginner', to play the first three levels of the game and finally to explore the shop. While the children were playing the game, the researcher watched the children and took notes. After the game, the children were asked the following series of questions about what they liked most/least, how fun, easy and engaging the game was (these questions were asked on a scale from 1 to 5, where 1 is very bad and 5 is very good), how helpful they found the game. They were also asked to provide suggestions for improvements.

6.1.5 Data Collection and Analysis

The data collected included audio recordings and notes the researchers took during the children's play. After all sessions, the recordings were reviewed, and transcribed. Transcripts and notes were analyzed using Thematic Analysis [16]. Thematic analysis leads to a series of themes, which are discussed in the next section.

6.1.6 Results

This section presents the themes resulted from the thematic analysis [16] of the emerged data by children. Several of the children showed the same opinion about the final evaluation.

Favorite Features: P1, P2, and P4 all loved some of the effects, characters, or sounds in the game, especially the fireworks at the end of the game, P4 said excitedly:" *. . . the viruses are cute, and the villain at the end made me feel very challenging. . . like the final firework effect and sky background the most.*" P2 expressed the same preference for the characters and other elements: "*The girl is lovely, and the house is cute, I would be happy if I can quarantine in such a cute house. . . the interface and the music is good and it can release myself.*" In addition to this, P1 and P4 also expressed their enjoyment of the 'guide', which they felt was clearly expressed. "*. . . was able to describe every step very clearly, which enabled me to get a good handle on this game. . .*", "*made the 'guide' clear to me by showing me step by step what I should do.*" P3 thought the whole game was great and she loved the whole thing.

Easy to play: Each child gave full marks for this item and each child felt that the game was designed to be simple and clear. For example P1 said:" *. . . simple enough and the props are displayed clearly. . .*" P4 felt:" *. . . easy to do every level. . . get 3 stars on every level. . .*"

Fun and Engaging: P1, P2, P4 thought the game was interesting but the plot might be a bit simple so they all scored it 4. P1 said:" *. . . each level is a little short and the plot is a little simpler. . .*", P4 expressed her thoughts:" *. . . just started to experience this level and it ends. . .*", P3 scored 5 but felt that there were too few levels, more levels could be designed:" *. . . add more levels to make me play for a long time. . .*"

Usability Issues: P1 did not raise some usability issues, he thought it was all good overall. P2, P3 and P4 pointed out that there is too much text in the 'guide' and they did not want to see so much text appearing at a very slow pace. P2 mentioned:" *. . . too much text and appeared in such a slow speed. . .*" and P4 said:" *It shows up slowly and there are a few mistakes that make it feel like it's not particularly formal.*"

Improvements and Suggestions: P1 and P2 recommended making the 'guide' dynamic and P1 would like to have a more complex game plot:" *. . . was static and lacked some interest. . .*", P2 pointed the same view:" *. . . should be more complex and diversified to make the game experience better. . .*" P3 had no other suggestions while P4 offered ideas for variety in the game:" *. . . incorporate some small animal elements*

into this game, such as changing the character to a bunny rabbit, and changing the coins to carrots. . . "

Effective: All children found the game well designed, useful and educational. P1 said:" *The game has a strong practical significance. . . "*, P2 expressed:" *. . . it is educational. . . "*, P4 thought that:" *. . . it was useful, the teachings were clear and encouraging, they made me realize the importance of these items, which was great. . . "*.

6.2 Evaluation Workshop with Experts

6.2.1 Aims

The aims of the expert evaluation were set as follows: 1. to find out if the game is engaging for children. 2. to determine the suitability of the game for the target group; 3. to determine the appropriateness of the game for helping children with autism during pandemics; 4. to identify usability issues; and 5. to collect suggestions for improvement.

6.2.2 Environment and Participants

The workshops were conducted via Microsoft's Teams [4] or Zoom [6] software. In this study, five experts participated. They are researchers in HCI, ASD and/or Education. E1 and E3 also participated in the evaluation of low-fidelity prototype. More information about the participants is presented in the Table 6.2.

Participant Number	Position/Occupation	Area of expertise
E1	Master in Education	Experience in ASD
E2	Graduate of the School of Information, University of Edinburgh	Experience in ASD,HCI and Education, developing technologies for children with ASD
E3	Research Associate, University Teacher in HCI and ASD	Experience in HCI and ASD, developing technologies for children with ASD
E4	Graduate of the School of Information, University of Edinburgh	Experience in Education,HCI and ASD, developing technologies for children
E5	Graduate of the School of Information, University of Edinburgh	Experience in Education,HCI and ASD, developing technologies for children

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

6.2.3 Materials

The materials used for this study were: information sheet and consent form for experts, 'Unity', computer or mobile device to join the Microsoft Teams meeting or Zoom meeting, script for the researcher, notebook for researcher's notes, additional audio-recording device.

6.2.4 Procedure

The participants were contacted via email with information sheets and consent forms. If they decide to participate, they were asked to sign and return the consent form prior to the study session. Each session was held individually but followed the same procedures. In each session, a "collaborative evaluation" approach [2] was used which is a version of the 'Think Aloud' approach [2] in which users participate as collaborators rather than just participants. Therefore, we encourage participants to ask questions (e.g., why, if) when going through the prototype to clarify user behavior. The researcher first sent the game to the expert via an attachment and explained the details about the game. The researcher showed the expert the tasks. The tasks described by the researcher to the participants were the same as the child assessment in Section 6.1, i.e., let them play the

'Guide for beginner', play the first three levels of the game, and explore the shop. As the participants played the game, the researchers recorded their comments, questions, and behaviors. After the tasks, the experts were asked the following questions about: is the game suitable for children with autism, is the game intuitive and clear enough, and how important is it to the children with autism, could children with autism find overly complex content in the game, how engaging was the game, is this game effective in helping children with autism to face problems during COVID-19 pandemic and some usability issues. They were also asked to provide suggestions for improvements.

6.2.5   Data Collection and Analysis

The data collected included audio recordings and notes the researchers took during the experts' play. After the sessions, the recordings were reviewed, and transcribed. Transcripts and notes were analyzed using Thematic Analysis [16]. Thematic analysis leads to a series of themes, which are discussed in the next section.

6.2.6   Results

In contrast to the children's comments, the experts offered more professional and detailed advice.

Appropriateness for the target population: All experts agreed that the game was excellent for the target group. E5 was particularly excited regarding the suitability of the game for children with autism:" *Oh my gosh, I love it and it's really good . . . suitable for them.*"

Potential of the game as an educational tool: Every expert was positive about the game educational value. For example E3 said:" *. . . really love the character. . . I think it's really nice and educational as well.*" E2 and E4 also emphasized its uniqueness as an educational tool. E2 mentioned:" *It's compressed comprehensive. . . a gamified manner of learning children, about wearing a mask and the vaccine and most importantly, quarantining because I feel like a lot of games like this don't take this thing into consideration. . .*", E4 remarked:" *It's quite effective. I think it can help children with autism learn more about the virus. develop certain skills like decision making.* "

Engaging: E1 thought the game is very good and attractive. E2 also expressed a positive opinion about the game potential for engaging children with autism :" *It's engaging. I like that the levels are incrementally harder. You bring new things in each level, which obviously makes it makes it fun for the kids and engaging.*" E2

recommended:" *. . . adding for example multiple paths That would make the game replay able, that which is a quite important thing. You should make sure that your game has at least a few elements that would make it be played multiple times.* " which can make the game more engaging. Other experts also found the game fascinating. For example E3 said:" *I think it's very nice. I think the character is very cute. The environment looks nice. It's using a well-known game style which isn't difficult. . .* "

Usability issues: Experts raised several usability issues, the most controversial being the display of text in the 'guide section', which was also addressed in the low-fidelity prototype evaluation. The newly effects used for text did not work very well. Every expert had pointed out that having too many words on the same page could also be stressful for children with autism. For example, E5 said:" *Click on the screen for all the texts and display might like be a cause of like the stress for the children when they're playing the game.* "E3 also gave more specific advice:" *. . . see the text altogether and to have instead an option to have it read out loud. . .* "In addition to this, E1 and E2 also raised usability issues. E1 pointed out display issues with the shop and some detail issues in the 'guide section':" *It would be better to display the number of pills you owned. . . arrow are not exactly to the button. . .* " E2 identified some issues in relation to the play experience of children with autism:" *This screen is good because it's simplistic. . . gray cause discomfort for children with autism. . . stressful component for children you can reverse it have time increasing. . .* " Finally, E1, E2 and E3 all stated that the 'invincibility time' that 'vaccine props' can provide for characters should be displayed, like P3 said:" *. . . a number on that effect which shows how many time you have. . .* "

Suggestions and Improvements: Most of the experts were satisfied with the overall game effect, so only a few suggestions were pointed out. For the shop system, E2 said:" *Add the icon of the coin so the actual coin added near where it says coin. . .* ". E3 thought the icons and personalization could be optimized:" *. . . wouldn't have guessed that's the shop. . . you can buy a vaccine. . . customize all games like sky color, character. . .* " For the 'guide section', E4 and E5 pointed out that some explanations about the 'shop' and the 'end point' could be added" *. . . explain about the shop as well. . .* "," *Will you add the endpoint in this guide?*".

6.3 Discussion

The prototype was evaluated by children and experts in HCI, ASD and Education. These evaluations could be fully used to answer **RQ3**. For question **RQ3.1:** *Are the game suitable for children with autism?*, the experts gave a positive answer. All experts said that the game was clear and intuitive both in terms of contents and mechanics. For question **RQ3.2:** *Is the game perceived as engaging and enjoyable by the target population?*, the children rated the game very highly, with almost all of them scoring the game with full marks. This was supported by their positive comments and exclamations while playing the game. Some children felt that the levels were short and monotonous and some experts pointed out that more content should be designed and suggested ways to increase the replay ability of the game, suggesting that the current game could be extended and improved. The answer to question **RQ3.3:** *To what extent might the game be successful in alleviating the challenges faced by children with autism?*, was also positive, with children clearly stating that the game had positive impact on them and that they could learn about COVID-19 from it and accommodate to the changes as well as face challenges entailed by that. The experts were also optimistic about the educational potential of the game, as they felt that the knowledge included in the game was well integrated into the game and easy to be learned and applied by the children. Apart from this, we found some usability issues. The main one was about the presentation of the text in the game and other details of the game. We have also gained some improvements and suggestions that can be refined and improved.

Overall, the evaluation study showed good potential for the game to achieve its goals. In terms of usability, the research carried out showed that the game is easy to use, attractive and fun for the target users, although some usability issues need to be addressed. The experts found the game very suitable. When presented in a gamified way, children also seem to enjoy learning about the knowledge contained in the game. Future work should focus on increasing the amount of playtime in each game environment, improving the text display, and developing further customization options for players, especially practitioners.

Chapter 7

Conclusions and Future Work

7.1 Research Questions

RQ1: What are the most challenging difficulties that impact the well-being of children with ASD during pandemics?

This question was answered by reviewing the relevant literature discussed in Chapter 2 and the Pre-design section in Chapter 3. We could find that the children do have a lot of difficulties, and some of them have been resolved. The most challenging difficulty was summed up in that it was difficult for children with autism to suit some of the policies proposed for COVID-19 and understand the reasons of them, such as why they need to wear masks in public places, why they need to be vaccinated, etc. And through the literature, it was found that there were few applications designed for children with autism during the epidemic using the method of 'serious games'.

RQ2: How can technology support children with autism during COVID-19?

This question was answered by reviewing the relevant literature discussed in Chapter 2, as well as the pre-design in Chapter 3 and the low-fidelity prototype evaluation in Chapter 4. This technology included the knowledge provided by TD children and literature that needed to be understood and implemented during the epidemic, presented them in the form of serious games, which was a more specific and appropriate way found by literature, and low-fidelity prototype evaluation by experts to express this knowledge. It could teach children with autism about the epidemic in a suitable way to help them face the difficulties during the epidemic. Additionally, this technology also considered HCI principles, and ASD principles, and summarized some design implications. This helped children with autism as much as possible without causing them unnecessary trouble.

RQ3: How well the new technology works and to what extent does it help children with autism face the challenges they encounter during COVID-19? This question was divided into the following three sub-questions:

RQ3.1: Are the game suitable for children with autism? In Chapter 6, five experts and four children tested and evaluated the high-fidelity prototype, and the results showed that all experts and children agreed that the game was suitable for children with autism. Usability issues were identified regarding text presentation and game details. So the results revealed that the tool may be suitable for children with autism.

RQ3.2: Is the game perceived as engaging and enjoyable by the target population? The evaluation studies with children and experts in chapter 6 leaded to a clear conclusion: the game has potential for engaging for children with autism. All children and experts rated the game very highly and stated that they had a good time playing the game. Children found the game appealing. Experts perceived the game as being engaging for children with autism and made some suggestions to increase engagement.

RQ3.3: To what extent might the game be successful in alleviating the challenges faced by children with autism? The feedback from the children and the experts in Chapter 6 leaded to a conclusion that the game has potential to teach children with autism knowledge to face the problems during pandemics. The children reported that they were able to learn from the game and the experts felt that the game was successful in incorporating the desired knowledge into the game which can allow the children with autism to learn and use it to overcome challenges during pandemics.

7.2 Limitations

Limitations of research depth: In fact, experts recognized its potential for children with autism. While it is necessary to conduct studies further with children with autism to better understand to what extend this game can help them.

Limitations imposed by the virtual environment: The process was very limited due to the limitations imposed by the current pandemic, the added complexity of recruiting experts and children, and the need for specific equipment to evaluate the prototypes.

7.3   Future Work

After all the evaluation studies, the researchers analyzed the results based on the design recommendations laid out in the Initial Design Implications, Additional Design Implications, HCI principles, and ASD principles to categorize and rank the directions the project might take in its future development. Firstly, we need to address all the usability issues: adjusting the text display of the game so that a page does not show too much text or add a voiceover; making the main color of the game slightly brighter; indicating the duration of vaccines and the number of pills we owned in the shop, and refining the time system(let the time increase from 0). Then improving some details and personalization of the shop system; explaining the shop and end point and add it to the 'guide section'. Additional features to be developed include more complex levels and more complexity (multiple paths), more variety of shop features, and more complex personalization (characters, virus styles, backgrounds, etc.).

7.4   Conclusions

This project explored how to design and develop a technology-based game to help children with autism face the problems and challenges during COVID-19. It was developed iteratively by using Figma [3], Unity [5] and then evaluated in a participatory way, involving children and experts in ASD, HCI, and Education. Based on the results of the evaluation, the game is fun, engaging, easy to use, and can provide support for children with autism. The contributions of this project are as follows:1. Identification of the problems and challenges that COVID-19 presents for children with autism. 2. A game based on empirical data and the concept of serious game that has the potential to help children with autism face the problems during COVID-19. 3. Empirical evidence from TD children and experts in ASD, HCI, and Education from the evaluation that the game has the potential to help children with autism and offers new directions for serious games for children with autism to support them during pandemics.

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Appendix A

HCI Principles

HCI-1: 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-2: Match between system and the real world:

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

HCI-3: 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-4: Consistency and standards:

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

HCI-5: Error prevention:

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

HCI-6: 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-7: 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-8: 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-9: 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-10: 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 B

Pre-design Workshop Photos
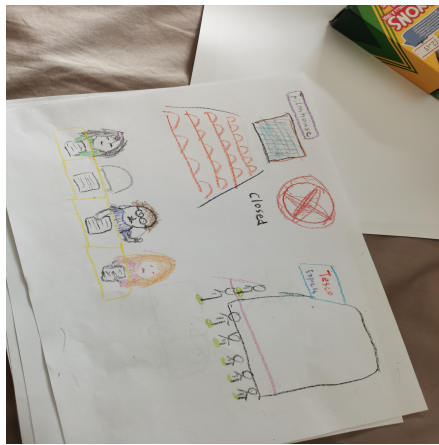
(a) P3's drawing of the problems Robin faced
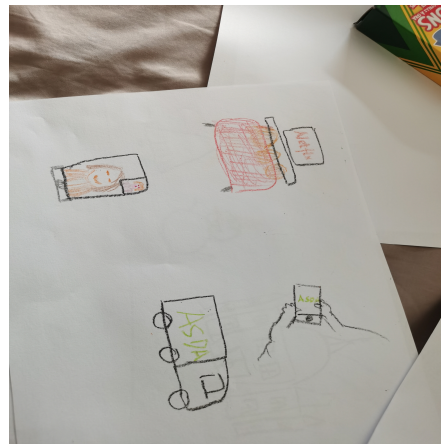
(b) P3's drawing of the solution of these problems

(c) P3's drawing of the storyline

(d) P3's drawing of rewards

Figure B.1: Pre-Design Workshop Photos
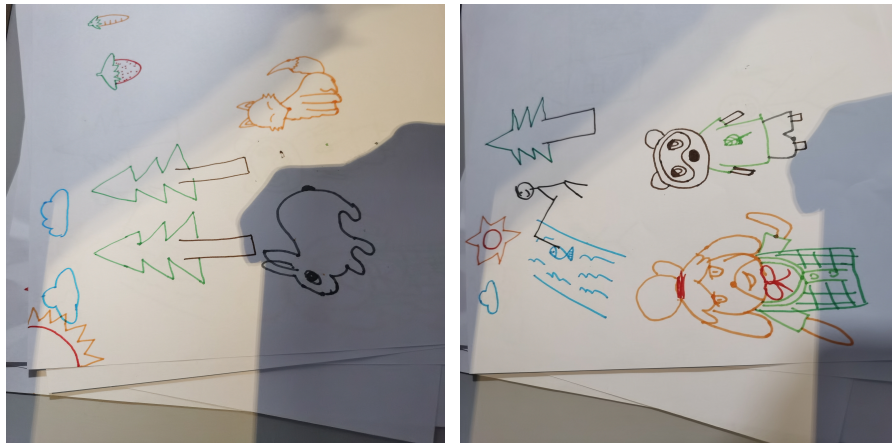
(a) P4's drawing of storyline

(b) P4's drawing of recommended game
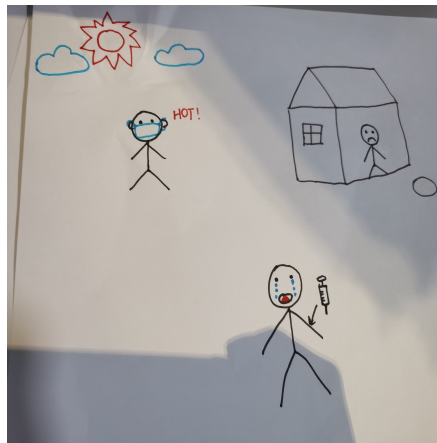
(c) P4's drawing of the problems Robin faced

Figure B.2: Pre-Design Workshop Photos2
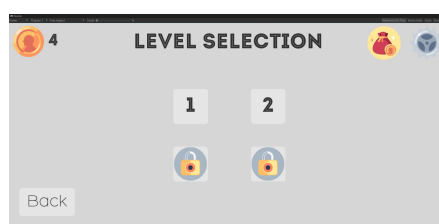
Appendix C

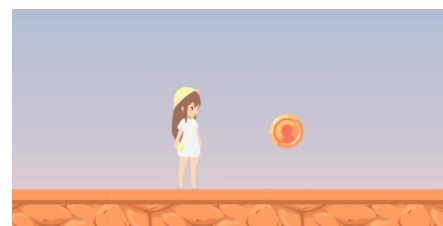# Low-Fidelity Prototype Screenshot
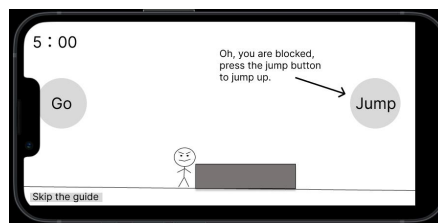
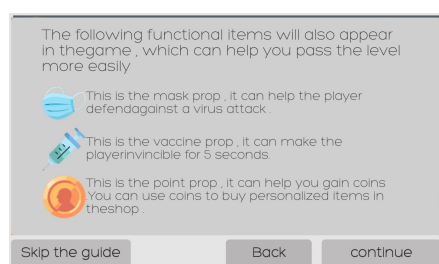

(a) Obstacle
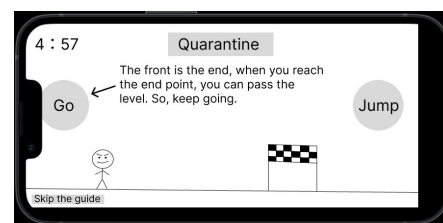
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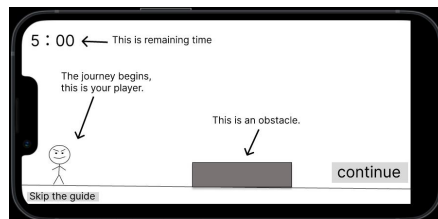
(c) Guide interface

(d) Virus Revolution
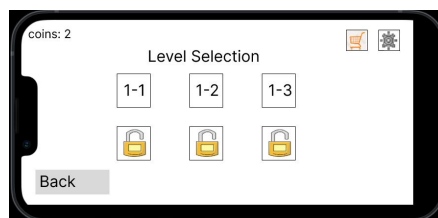
(e) Levels
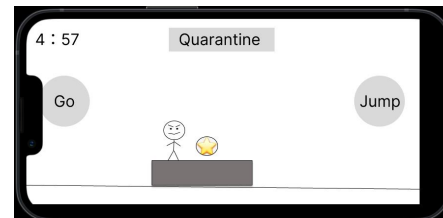
(f) Point prop
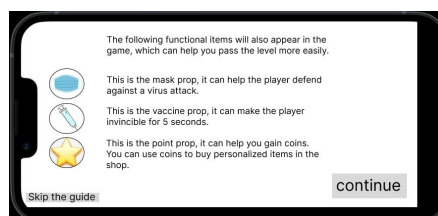
(g) Props
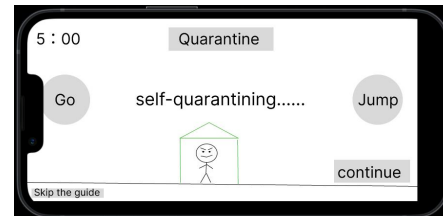
(h) Quarantine

Figure C.1: Low-Fidelity Prototype Screenshot

(a) Rewards
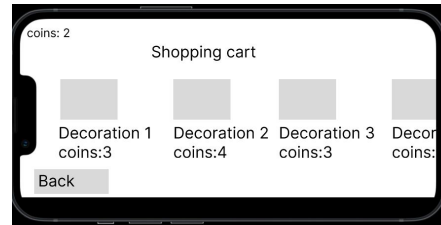
(b) Shop
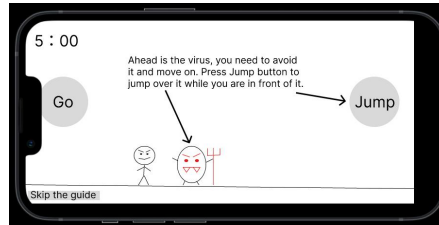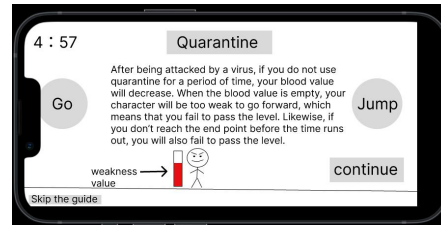
(c) Virus

(d) Weak Value

Figure C.2: Low-Fidelity Prototype Screenshot2

Appendix D

High-fidelity prototype Screenshots
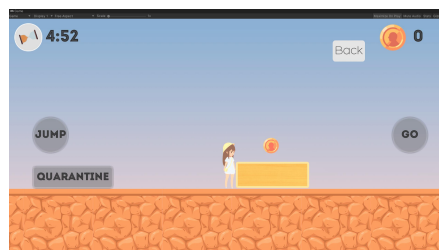
(a) Obstacle
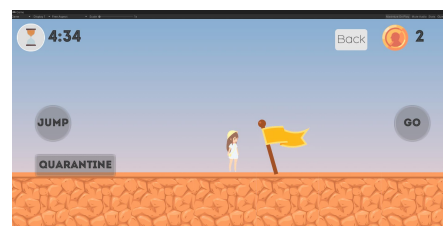
(b) End Point
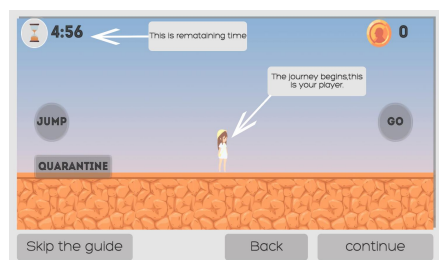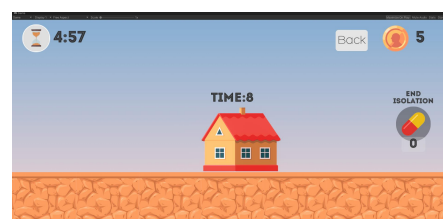

(c) Guide interface

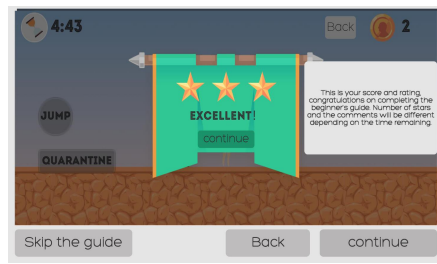(d) Virus Revolution

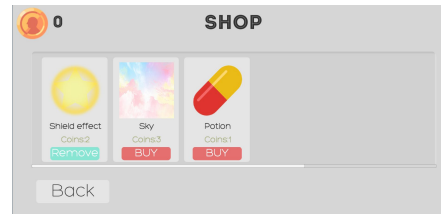(e) Levels

(f) Point prop

(g) Props

(h) Quarantine

Figure D.1: High-Fidelity Prototype Screenshot
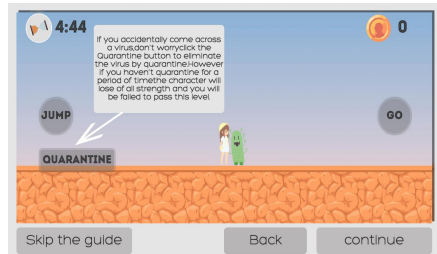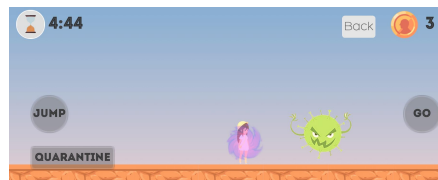
(a) Rewards

(b) Shop

(c) Virus

(d) Weak Value

(e) Villain

Figure D.2: High-Fidelity Prototype Screenshot2

Appendix E

Participants' information sheet

E.1   Participants' information sheet for Children

Participant Information Sheet

Project title:	Supporting the Wellbeing of Children with Autism during COVID-19 Pandemic
Principal investigator:	Dr Aurora Constantin, Viki Galt
Researcher collecting data:	Qi Zhang
Funder (if applicable):	
RT number:	260135

Supporting the Wellbeing of Children with Autism during COVID-19 Pandemic

(may be read aloud to the child)

This page is for children. Some researchers are organising a **study at the University of Edinburgh**. It says who they are, and what they will do **during the study.**

They will ask you to help with designing and testing a tool (probably a game) for children with autism during COVID-19. 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 study?

The research team include Qi Zhang, Dr Aurora Constantin, and Viki Galt. Qi is a student who is developing a tool to help children with autism to face challenges during COVID-19, as part of his programme. Aurora and Viki are Qi's supervisors from University of Edinburgh. Their job is to guide Qi in developing the tool. You will be kindly asked to help them to design and test the tool.

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| Aurora Constantin | Viki Galt | Qi Zhang |

How can I help?

The research team would like you to help design the tool to help children with autism cope with challenges during pandemics. We would need your ideas and suggestions to inspire the design of the tool and to make it more attractive and fun. We also need to test the tool with you to understand what you like, dislike and what else you would like the tool to include

What will happen if I help?

If you agree, you can opt to take part in one or more sessions. In each session you will be ask to do some activities, such as drawing, writing your ideas, playing with an application or answering some questions. Each session will last for 30 minutes and you will participate via Zoom or Teams.

You can tell us if you want to stop doing any of the activities. You do not have to tell us why. Please tell us if you need the toilet, or if you want to take a break. You can also say you do not want to help any more, and that is OK. We will always listen to you.

The researchers will ask if it is OK to make an audio recording of you helping design the tool, doing activities and answering questions. This is because it is too hard for them to write down everything that happens. They will listen to or watch the recording later to help them understand what you said or did.

Note that there is no right or wrong answer or suggestion. Any idea or answer will be very appreciated and will help Qi to succeed in his programme.

What will happen after I have finished helping?

We will look over what you have said and see how we can improve the tool. We will write a report on all the information children and adults have given to us.

Do you want to ask a question?

It is OK to have more questions. You can ask the researchers as many questions as you want about the experiment at any time. Ask your parent or guardian to help you call them on the phone or write an email with your question.

Thank you for taking the time to read this and for your valuable help.

E.2 Participants' information sheet for Guardian

Participant Information Sheet – for parents and guardians

Project title:	Supporting the Wellbeing of Children with Autism during COVID-19 Pandemic
Principal investigator:	Dr Aurora Constantin, Viki Galt
Researcher collecting data:	Qi Zhang
Funder (if applicable):	

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 260135. Please take time to read the following information carefully. A shortened version of this information will be provided to your child should you agree to their participating in the project. You should keep this page for your records.

Who are the researchers?

The researchers include:

Supervisors: Aurora Constantin, Viki Galt

MSc Student: Qi Zhang

What is the purpose of the study?

The purpose of this project is to design a tool/computer-based application to help children with autism cope with challenges during pandemics. We need to identified challenges that children in general faced during Covid-19. We also need to find out children's ideas and suggestions to inspire the design of the tool and to make it more attractive and fun for children in their age.

How can my child help?

We will invite your child in one or more design and evaluation sessions. They will perform various activities, e.g., drawing or writing down their ideas and suggestions, answering questions about various features of the tool being designed, expressing their preferences and dislikes regarding that tool.

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There is not a right or wrong answer/idea/suggestion. Any contribution will be greatly appreciated. The results in the studies will be used to design the computer-based application which is part of Qi's masters programme.

Does my child have to take part?

No – participation in this study is entirely up to you and your child. You can withdraw your child from the study at any time, without giving a reason. Your child may also withdraw at any time by saying that s/he does not want to take part any more. Your rights will not be affected. If you wish to withdraw, contact Dr Aurora Constantin or Viki Galt. We will stop using your child's data in any publications or presentations submitted after you have withdrawn consent and destroy it.

What will happen if my child takes part?

Each study session will last for about 30 minutes and will include various activities in which your child can help design a tool to help children with autism cope with difficulties caused by pandemics. The activities are meant to be friendly and engage your child to contribute their ideas/suggestions.

We will audio record the sessions to be able to analyse them and inform the design of the tool.

Are there any risks associated with taking part?

There are no risks associated with participation.

Are there any benefits associated with taking part?

No. However, we expect that your child will learn about how to design computer-based applications and have opportunities to develop their communication and collaboration skills. And it would help researchers in Autism, HCI and Education understand how to develop such games which may benefit other children in the future.

What will happen to the results of this study?

The results of this study may be summarised in published articles, reports and presentations. Quotes or key findings will be anonymized: We will remove any information that could, in our assessment, allow anyone to identify your child. With

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your consent, information can also be used for future research. Your child's data may be archived for a maximum of 2 years.

How will personal information be protected?

Your child's data will be processed in accordance with Data Protection Law. All information collected about your child will be kept strictly confidential. Your child's data will be referred to by a unique participant number rather than by name. Your child's data will only be viewed by the researcher/research team including Dr Aurora Constantin, Viki Galt and Qi Zhang.

All electronic data will be stored on a password-protected encrypted computer, on the School of Informatics' secure file servers, or on the University's secure encrypted cloud storage services (DataShare, ownCloud, or Sharepoint) and all paper records will be stored in a locked filing cabinet in Aurora Constantin's or Viki Galt's office. Your and your child's consent information will be kept separately from your / your child's responses in order to minimise risk for a maximum of 2 years.

What are my and my child's data protection rights?

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

Who can I contact?

If you have any further questions about the study, please contact the lead researcher, Qi Zhang(Q.Zhang-86@sms.ed.ac.uk).

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

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Updated information.

If the research project changes in any way, an updated Participant Information Sheet will be made available on Informatics research study updates page (http://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 Qi Zhang(Q.Zhang-86@sms.ed.ac.uk).

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 say that s/he does not want to take part anymore.

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

Thank you for taking the time to read this.

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E.3 Participants' information sheet for Experts

Participant Information Sheet – for adult participant

Project title:	Supporting the Wellbeing of Children with Autism during COVID-19 Pandemic
Principal investigator:	Dr Aurora Constantin, Viki Galt
Researcher collecting data:	Qi Zhang
Funder (if applicable):	

This information sheet is for adults (a parent, a practitioner or an expert in Autism, HCI, Education). It explains the research project at the University of Edinburgh. 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 260135. Please take time to read the following information carefully. You should keep this page for your records.

Who are the researchers?

The researchers include:

Supervisors: Dr Aurora Constantin Aurora.constantin@ed.ac.uk, Viki Galt viki.galt@ed.ac.uk

Student: Qi Zhang s2168871@ed.ac.uk

What is the purpose of the study?

The purpose of this project is to design a tool/computer-based application to help children with autism cope with challenges during pandemics. We need to identified challenges that children in general faced during Covid-19. We also need to find out children's ideas and suggestions to inspire the design of the tool and to make it more attractive and fun for children in their age.

Why have I been asked to take part?

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You are invited in this study because you have experience in working or living with children and you have the ability to provide some opinions them.

Do I need to take part?

No – participation in this study is entirely up to you. You can withdraw from the study at any time, without giving a reason. Your rights will not be affected. If you wish to withdraw, contact Aurora Constantin or Viki Galt. We will stop using your data in any publications or presentations submitted after you have withdrawn consent and destroy it.

What will happen if I decide to take part?

You will be asked to participate into design workshops and/or evaluation sessions where you will be asked to perform some tasks and to participate to brief interviews or focus groups. You may also answer brief questionnaires. The tasks may involve using a system prototype and to share your ideas about the challenges and preferences regarding various features of that prototype and suggestions to improve them. The questions in the interviews and questionnaires will be also related to the prototype features and how easy and useful they are for children. The design workshops and/or evaluation sessions you attend may be audio recorded, your audio will only be viewed by the researcher/research team including Aurora Constantin, Viki Galt and Qi Zhang. And the recording will only be used to analyse the project and will not reveal personal information.

Are there any risks associated with taking part?

There are no significant risks associated with participation.

Are there any benefits associated with taking part?

No. However, we expect that children with autism will learn about how to design computer-based applications and have opportunities to develop their communication and collaboration skills. And if you were an expert in Autism, HCI and Education, it may help you understand how to develop such games which may benefit other children in the future.

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What will happen to the results of this study?

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

How will personal information be protected?

Your data will be processed in accordance with Data Protection Law. All information collected about you will be kept strictly confidential. Your data will be referred to by a unique participant number rather than by name. Your data will only be viewed by the researcher/research team including Aurora Constantin, Viki Galt and Qi Zhang.

All electronic data will be stored on a password-protected encrypted computer, on the School of Informatics' secure file servers, or on the University's secure encrypted cloud storage services (DataShare, ownCloud, or Sharepoint) and all paper records will be stored in a locked filing cabinet in Aurora Constantin's or Viki Galt's office. Your consent information will be kept for a maximum of 2 years.

What are my data protection rights?

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

Who can I contact?

If you have any further questions about the study, please contact the lead researcher, Qi Zhang (Q.Zhang-86@sms.ed.ac.uk).
If you wish to make a complaint about the study, please contact inf-ethics@inf.ed.ac.uk. When you contact us, please provide the study title and detail the nature of your complaint.

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Updated information.

If the research project changes in any way, an updated Participant Information Sheet will be made available on Informatics research study updates page (http://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 Qi Zhang (Q.Zhang-86@sms.ed.ac.uk).

General information.

Once again, **this study is completely voluntary, and you are under no obligation to take part.** Even if you say yes now, you may withdraw from the study at any time and for any reason by contacting us.

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

Thank you for taking the time to read this.

Appendix F

Participants' consent form

F.1 Participants' consent form for Children

Project title:	Supporting the Wellbeing of Children with Autism during COVID-19 Pandemic	Participant number:		Date:	

Child Consent Form

Your guardian said it is OK for you to help us. Do you want to be a games designer and tester? You can say "yes" or "no". It is OK to say "no". It will not hurt the researchers' feelings.

- I can choose to answer your questions and fill out the questionnaire.

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

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

- It is OK if I change my mind later and say I don't want to help anymore.

- It is OK if some activities are hard for me!

- There are no wrong answers to questions.

- Anything I can do is helpful.

Do you want to be a games designer and tester?

Yes	**No**

The research will listen to the recordings later. They may show them to other people who make games for children.

Is it OK to take audio recordings and fill out the questionnaire?

Yes	**No**

Write your name: _____ And age _____

Date: _____

THANK YOU!

F.2   Participants' consent form for Guardian

Participant number:_____

Participant Consent Form – for parents and guardians

Project title:	Supporting the Wellbeing of Children with Autism during COVID-19 Pandemic
Principal investigator (PI):	Aurora Constantin, Viki Galt
Researcher:	Qi Zhang
PI contact details:	aurora.constantin@ed.ac.uk , viki.galt@ed.ac.uk

Please tick yes or no for each of these statements.

Yes   No

1. I confirm that I have read and understood the Participant Information Sheet for the above study, that I have had the opportunity to ask questions, and that any questions I had were answered to my satisfaction.

Yes   No

2. I understand that my child's participation is voluntary; that my child can withdraw or I can withdraw my child at any time without giving a reason. Withdrawing will not affect any of my or my child's rights.

Yes   No

3. I agree to my child being audio recorded.

Yes   No

4. I consent to my child's anonymised data being used in academic publications and presentations.

Yes   No

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

Yes   No

6. I allow my child's data (including audio recordings to be used in future ethically approved research. (Note: even if you say 'no' to this, your child can still participate in the study, but the audio data will only be seen by the research team).

Yes   No

7. I agree to my child taking part in this study.

If you **give permission** for this study, please fill out the sections on the next and **return this form to the researchers**.

If you **DO NOT** wish to give permission, **you do not need to do this**. We will not ask your child to participate.

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Participant number:_____

Full name of participating child: _____

Child's date of birth (DD/MM/YYYY): _____

Your relationship to the child: _____

Your name (please print clearly): _____

Contact telephone number: _____

E-mail address: _____

Signature: _____

Date (DD/MM/YYYY) _____

Name of person taking consent   Date   Signature
    dd/mm/yyyy

_____   _____   _____

F.3   Participants' consent form for Experts

Participant Consent Form

Project title:	Supporting the Wellbeing of Children with Autism during COVID-19 Pandemic
Principal investigator (PI):	Dr Aurora Constantin, Viki Galt
Researcher:	Qi Zhang
PI contact details:	aurora.constantin@ed.ac.uk , viki.galt@ed.ac.uk

By participating in the study you agree that:

- I have read and understood the Participant Information Sheet for the above study, that I have had the opportunity to ask questions, and that any questions I had were answered to my satisfaction.

- My participation is voluntary, and that I can withdraw at any time without giving a reason. Withdrawing will not affect any of my rights.

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

- I understand that my anonymised data will be stored for the duration outlined in the Participant Information Sheet.

Please tick yes or no for each of these statements.

1. I agree to being audio recorded.

                                                                          Yes   **No**

2. I allow my data to be used in future ethically approved research.

                                                                          Yes   **No**

3. I agree to take part in this study.

                                                                          Yes   **No**

Name of person giving consent	Date DD/MM/YYYY	Signature
_____	_____	_____
Name of person taking consent	Date DD/MM/YYYY	Signature
_____	_____	_____

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