

Designing and Developing a Technology-based Tool to Help Children with Autism Cope with Changes

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Abstract

Difficulty responding to change is one of the key challenges children with Autism Spectrum Conditions (ASC) face. Restricted and repetitive behaviours and interests and "insistence on sameness" are one of the core impairments of children on the spectrum. This often manifests in very rigid daily routines which are strictly followed down to the smallest of details. Changes to or departures from this routine can cause major distress and anxiety.

This project aims to investigate how technology can be designed and developed to help children with autism cope with changes. Technology has been shown to be successful in supporting children with ASC, helping them to learn new skills and addressing specific impairments, and therefore was considered well-suited to assist children with coping with changes.

A design approach inspired by Informant Design was employed in this project, with typically developing (TD) children, children with ASC, and experts in Human Computer Interaction (HCI), ASC and Education acting as informants (offering input and feedback on the design at key stages) throughout the design process. A high-fidelity prototype was developed according to relevant literature and empirical evaluation with end users. HCI design principles and specific guidelines for designing technology-based interventions for children with ASC were also considered. The summative evaluation of the high-fidelity prototype with children and experts in ASC, HCI and Education showed that the tool has potential to be effective in helping children with ASC cope with changes.

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Chapter 1

Introduction

1.1 Children with Autism and Change

Autism spectrum conditions (ASC) are a group of developmental disorders which are characterised by difficulties with communication and social interaction, and restricted and repetitive behaviours and interests, which can result in resistance to change [1]. Children with ASC can become very anxious when dealing with changes. This could be small changes to their routine, such as taking a different route to school in the morning, or more significant changes, such as moving house. Although change is a fact of life, their attachment to strict routines can mean that changes result in great distress. Children may respond to changes with an increase in other repetitive behaviours, or other more unfavourable responses such as tantrums, refusal to engage, and aggressive behaviours [1]. In addition, their resistance to change may result in refusal to try new activities or engage in new situations, thus limiting the experiences of the child. Just as with any other skill, children with ASC must be taught how to deal with changes, and supported as they cope with change. Technology-based interventions have been effective to help children with ASC learn new skills, such as communication skills and self-management, and to assist them in coping with specific impairments, such as auditory sensitivities [23]. Therefore technology is well positioned to be effective in helping children with ASC to cope with changes.

1.2 Project Goals and Research Questions

The goal of this project is to research how a technology-based tool (TBT) should be designed and developed to help children with ASC cope with changes. Technology has been shown to be effective to support children with autism [23], and many children with autism show a particular interest in technology [25]. There are few tools available which aim to support children with autism in coping with changes, and those which have been researched provide directions for further development [39]. With this project goal in mind, the following research questions have been posed:

1. What are the current interventions used to help children with autism cope with

changes?

2. How should technology be designed to support children with autism coping with changes?
3. How effective is the new tool in helping children with autism to cope with changes?
 - (a) To what extent is the tool suitable for the target population?
 - (b) To what extent is the tool perceived to be engaging for the target population?
 - (c) To what extent is the tool perceived to be enjoyable for the target population?
 - (d) Are the features appropriate to help children with autism cope with changes?

Chapter 2

Literature Review

2.1 Autism Spectrum Conditions: An Overview

Autism spectrum conditions (ASC) are a group of developmental conditions which have an impact on communication and behaviour [28]. They belong to the category of childhood-onset pervasive developmental disorders (PDDs), typically presenting during the first two - three years of life [28]. Autism is recognised as a "spectrum" condition due to the variation in abilities and severity of difficulties experienced by those diagnosed [1, 28]. The primary characteristics of ASC are: difficulties with communication and social interaction, such as minimal or inconsistent eye contact, or difficulty maintaining conversation [1, 28]; restricted and repetitive behaviours and interests, such as repeating words or phrases, or having overly focused interests [1, 28].

The first descriptions of autism can be found in medical literature from the early 1940s. Leo Kanner identified a group of children displaying uncommon behaviours, with most cases showing deficiencies in development of language and cognitive ability [19]. As of the 5th edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-V) [1], Autistic Spectrum Conditions include autistic disorder, Asperger syndrome and Pervasive Developmental Disorder - Not Otherwise Specified (PDD-NOS). Although ASCs were once considered rare, thought to affect 3 - 4 children in 10,000, recent research has challenged this assumption. Recent estimates predict that 1.6% of children in the UK will be diagnosed with autism [22]. Rather than ASC truly becoming more prevalent at such a rate, greater awareness and understanding of ASC amongst professionals are thought to be responsible for the increased rate of diagnosis [16].

Diagnosis can prove very difficult, due to the vast differences in how ASC presents in various individuals. Autism typically presents either in a child's early months, with obvious developmental abnormalities, or it may onset during the second year of life, with the loss of previously attained skills. Due to the improvement of diagnostic tools and increased awareness about ASCs, diagnosis is typically made between the ages of 2 and 4 years old [1, 28]. Early diagnosis is key as appropriate educational interventions can reduce the difficulties faced by those with ASC, assist them in learning key skills, and help to identify and make the most of their unique strengths [28].

2.2 Core Impairments

2.2.1 Difficulties with Communication and Social Interaction

Children with ASC struggle to develop social skills, and show an inability to interact with others in a social setting. Their lack of social skills can include [1, 28]: not looking at or listening to others; failure to respond to verbal attempts to gain attention or other verbal cues; monopolising conversation discussing a favourite topic without allowing others to respond or registering a lack of interest; and facial expressions, gestures and movements which do not correspond to what is being said.

Children with ASC often isolate themselves and display difficulties developing and maintaining relationships with others due to their inability to express their own, or understand and anticipate others', thoughts, emotions and points of view [1, 31, 35]. Children with ASC also often show an absence of imagination, engaging in solitary, repetitive activities rather than "pretend play" [1, 31, 35]. In conjunction with their lack of interest in activities with others, this can limit their social contact [1].

The deficiency of communication skills presents differently across the spectrum. Some children with ASC communicate non-verbally, but the majority - 70% according to recent estimates [40] - gain some level of useful speech, perhaps with some form of language delay or difficulty. The subtleties of conversation, including jokes, sarcasm and verbal cues, are often lost on those on the spectrum [35].

2.2.2 Restricted and Repetitive Behaviours

Repetitive patterns of behaviour and restricted interests are one of the key impairments associated with ASC. This can present in various ways, including [1, 28]: repeating certain words or phrases (echolalia); repetitive gestures and body movements; rigid, obsessive interest in certain topics; intense focus on or use of parts of objects, such as moving objects; strong attachment to routines, and intense reaction to change.

Following rigid routines is very important to children on the spectrum, and changes to this routine can be very distressing [37]. The types of changes which can cause upset include expected changes to their routine, such as a trip to the dentist, unanticipated changes, such as a substitute teacher at school, and transitions between activities. In response to changes, children may increase their other typical behaviours, or respond unfavourably with aggressive behaviours, tantrums and refusal to engage [1, 37].

2.2.3 Additional Impairments

Hypo- and hypersensitivities to sensory input are among the additional impairments quite frequent in individuals with ASC [1]. These include sensitivity to certain sounds or lighting, discomfort of certain textures, and intense responses to certain flavours [20]. It is also common for children with ASC to experience problems sleeping or irritability [28]. Children with ASC are often diagnosed with additional disorders, with 70% receiving a diagnosis of at least one additional psychiatric disorder or intellectual disability [33, 24]. Social anxiety disorder and attention-deficit/hyperactivity

disorder are the most common psychiatric comorbidities [33]. Learning disabilities are also very common among children with ASC, although estimates of the prevalence of comorbid learning disabilities vary between 25% - 75% across studies [27].

2.3 Interventions for Coping with Changes

There exist a number of interventions designed to help children with autism cope with changes. Some strive to develop resilience in children, improving their ability to cope with change regularly, for example, Visual Activity Schedules (VAS) [4]. Others focus on mitigating the anxiety associated with changes as they arise, such as Social Stories (SS) [17]. These interventions, along with others such as cueing, are also successful in improving children's ability to transition between activities [14].

2.3.1 Visual Activity Schedules

One of the most successful methods to assist children with ASC in coping with changes is the use of VAS [4, 10, 30]. These make use of images to represent different activities and can be used to create a schedule for the day. The visual representation appeals to children on the spectrum, who may find it easier to comprehend than a written alternative [4, 26]. Visual schedules are designed to promote independence and offer predictability by outlining what can be expected in the day [10]. They have been shown to assist autistic children with the transition between activities [4, 10, 30, 14] and support children with predicting scheduled events and anticipating changes which occur throughout the day [4, 10, 26].

A number of studies have been carried out to assess the effectiveness of VAS in diverse settings such as classrooms [30] and homes [10]. VAS were shown to be promising for: improving transition behaviours between activities, reducing both the time taken to transition and tantrum behaviours [4, 10, 30, 14]; assisting children in predicting scheduled events throughout the day [4, 10]; supporting children in anticipating changes to the schedule throughout the day [4, 10]; increasing on-task behaviour (successfully completing tasks without becoming distracted by other activities/stimulus) [30].

The effectiveness of VAS in coping with changes is two-fold. The schedule reduces the anxiety associated with a change, allowing children to understand in advance what will be expected of them. If a new activity is introduced on the schedule, they have time to adjust, with the schedule offering a needed feeling of predictability [4]. Secondly, the schedule is a tool which can be used to foster resilience. Once a child adjusts to the routine, small changes should be introduced so they can learn to focus on the overall structure of the day, rather than the specific details [26]. Hence, they can become more flexible, less attached to a rigid routine, and change becomes a less daunting prospect.

However, there are also limitations. In order to be effective, VAS must be customised to describe the specific activities in the child's schedule. This can be time-consuming for practitioners and carers. Additionally, if schedules are kept too rigid, children may become too attached to the routine [26]. The VAS would instead have a negative effect on the child's ability to cope with change, and reinforce rigid behaviours [26].

2.3.2 Social Stories

SS are another widely used intervention designed for children with ASC [13, 17, 36]. SS are short, visual stories which describe specific events and situations, written in a particular format and style following a set of 10 criteria (see Appendix A). These take into account the meaning, desired learning experience and suitability for the target audience. SS are designed to increase the social understanding of children. Their main uses are to develop new skills, both functional and social [13, 36], understand and learn responses to emotions such as anger [13], and reduce anxiety around changes [17, 13].

SS have been applied to the specific use case of introducing changes [17]. By describing the new activity or situation in advance, the novelty of the event decreased, and children engaged more in the activity [17]. Priming children for activities by reading SS immediately before an activity was found to increase on-task behaviour and reduce transition times due to the increased understanding of what was expected [30, 14].

SS make use of visual aids to enhance the understanding of children on the spectrum and have been found to be effective in certain cases, such as introducing changes [17]. SS have also been used to successfully improve communication skills and increase social interaction [36]. Cases where SS were read immediately prior to the situation were found to be more successful than those where SS were not read in close proximity [21]. However, the effect on long-term maintenance of skills once SS were removed remains questionable [36]. Repeated use of SS or more gradual reduction of use were posited to result in better long-term maintenance of skills [36]. In a variety of studies, SS were found to be more effective in teaching *social understanding*, their primary aim, than social skills, a desired application [21].

2.3.3 Priming

Priming is an intervention whereby children are shown a visual representation of an activity in advance of participating in the activity. Doing so reduces the uncertainty associated with the event, and has been shown to reduce transition times and non-compliant behaviours [14].

Priming has been most effective when carried out with visual supports [14]. In addition to the successful use of VAS and SS in priming children for activities as discussed in the preceding sections, video priming has proven very effective in children who enjoy engaging with videos and technology [14, 32]. A study was carried out by Schreiber et al. whereby children were shown videos of successful transitions in specific situations where they had previously displayed disruptive behaviours [32]. This use of video priming was found not only to reduce, if not eliminate, disruptive behaviour during these transitions, but also to improve general transition behaviours in new situations. Video priming has also been shown to reduce transition times [14].

2.3.4 Cueing

Cueing is used to associate a particular signal with transitions, making them more predictable. Cues can be both verbal or visual, and have been beneficial in reducing transition times [14].

Verbal cues such as advance warnings can be used to assist with transitions, however, some autistic children struggle to process such verbal information and therefore this may not be the most suitable method [14]. Due to the heightened interest in and engagement with music often shown by children on the spectrum, the use of a transition song is a growing area of research [18]. When used to both distract the child from the stress of a transition, and to impart information about the transition itself, transition songs have been shown to be more effective than simple verbal cues alone [18].

Visual cues can be more effective than simple verbal cues, as the images make them more accessible to children on the spectrum. A particularly successful visual cue is the use of timers [14]. By showing how much time is left in an activity before moving to the next one, the child has advance warning to prepare. Timers can show actual time elapsing, for older children functioning at a level which would allow them to comprehend such a visual [14]. An alternative is to use an abstract visual of time elapsing, such as a series of countdown cards. The cards are removed as time passes, allowing the child to anticipate the change but not being too rigid, which can help to prevent children from becoming too attached to a strict timeline [14].

2.4 Technology-based Interventions

Technology as a tool to treat ASC has been a growing area of research. Technology-based interventions offer a range of ways to assist individuals on the spectrum: teaching them new skills, such as communication skills and self-management [34], addressing specific impairments, for example, auditory sensitivities [15], promoting independence, and supporting practitioners and carers treating those with ASC [23].

TBT are particularly suited to deliver educational interventions for children with autism due to their interest in technology. Children with ASC are shown to spend twice as much time playing video games as TD children [25]. Additionally, autistic individuals are often visual thinkers, and graphics and the visual nature of technology appeal to the way they process the world around them [23]. Technology is also very adaptable, allowing tools to be adjusted to suit the needs and sensitivities of the user [23].

A TBT which aims to help children with autism cope with changes is the "Change-It" application developed by Varnava [39]. This application made use of visual schedules and SS, and preliminary evaluation showed great promise. In evaluation of this application, most of the suggestions for improvement revolved around implementing a more comprehensive rewards system in order to motivate children to complete activities. Experts offered mixed feedback on the inclusion of coping strategies, with some remarking that children were unlikely to make use of them when they became anxious. Others disagreed and suggested that coping strategies should simply be made more engaging and interactive, in order to encourage children to utilise them.

An interesting example of a tool designed to reduce stress and anxiety in children with ASC is the serious game "New Horizons" developed by Carlier et al [8]. The application used a number of mini-games incorporating relaxation techniques recommended by ASC practitioners. The findings of the evaluation of this tool were inconclusive. No significant reduction of stress nor anxiety was reported after using the tool; however,

the evaluation also revealed that children did not use the tool in the case of stress or anxiety. Therefore, it was not possible to evaluate the effectiveness of the application in the context for which it was designed. This shows that even potentially effective TBTs are limited by the contexts in which children are likely to make use of TBTs, and suggests that children are unlikely to spontaneously resort to technology-based solutions when they become anxious.

2.5 Design Principles

2.5.1 ASC Design Guidelines

The specific target audience of individuals with ASC must also be taken into account.. The set of relevant guidelines for this project was devised based on guidelines recommended by Benton [6] and Bartoli et al. [5] when designing for children with ASC.

ADG_1. Language should be simple and text kept to a minimum with symbols, icons and visual representations used wherever possible.

ADG_2. Graphics should be minimal, with visual elements that are not distracting.

ADG_3. Icons and buttons should be large, and colours should be soft.

ADG_4. Navigation should be kept simple, with the main menu easily accessible at all times, and all options presented on a single level where possible.

ADG_5. Tasks should be intuitive or clear instructions should be provided within the tool to guide children through complex tasks.

ADG_6. Tasks should have a clear structure with an obvious start and end, an explicit goal, and minimal choices.

ADG_7. Actions should provide direct feedback, which should be non-critical in the case of failures.

ADG_8. The tool should have a rewards system to motivate children, but rewards should not be over-stimulating nor distract too much from the task.

ADG_9. Personalisation and customisation are vitally important to account for varying abilities, needs and preferences of children with ASC.

ADG_10. The tool should be predictable and consistent, with the ability to repeat tasks and actions.

2.6 Motivation

Restricted and repetitive patterns of behaviour leave children with ASC resistant to change, inflexible and make their everyday life more challenging. In order to become more adaptable and broaden their range of interests and engage in new activities, it is important to foster resilience in children with ASC and give them the skills to cope with changes. Research shows that early intervention is key in order to develop these skills, and therefore tools and interventions designed with children in mind are essential.

Some of the interventions described in Section 2.3, particularly SS and VAS, can prove very time consuming for practitioners and carers to implement. Additionally, the different presentation of autism across the spectrum can make it difficult for practitioners

to address the specific needs of all the children in their care. Technology offers a unique opportunity to make it easier to create, maintain and adapt the tools that practitioners use to help children cope with changes in their daily lives. The interest in technology shown by many children on the spectrum is another benefit of using TBT.

Although there are a number of tools used to support children in coping with changes, there are several shortfalls. The most important of these at the moment is the focus on educational, school-based tools. This arises because school is a key location where children must adapt to changes in their routine and transition between activities. Therefore in many cases the SS and VAS that children with ASC have been using are prepared by teachers or practitioners, focused on activities in a classroom setting, or kept in their school. However, during the COVID-19 pandemic there has been a switch to home schooling and online classes. This has meant that parents have suddenly become responsible for providing these interventions, and they may have neither the resources nor the skills to do so. Tools which can be used in the home, that practitioners can interact with remotely and carers can easily use, have become a necessity. Children on the spectrum have faced unique difficulties in adapting to the challenges of the pandemic. The move to home-schooling and online learning, and the constantly changing circumstances of the pandemic have been very disruptive and anxiety-inducing for children with ASC. Therefore, there is a particular need to provide tools to support them.

The purpose of this research is to design and evaluate a TBT which makes use of current interventions for coping with changes. The tool will be designed to be used by practitioners and carers to support children coping with changes, particularly in a remote environment. The interventions which will be applied in this tool aim to address expected changes, unanticipated changes, and transitions between activities. The design of the tool will build on the findings of existing applications in this area, particularly the “ChangeIt” app [39], by increasing the functionality of the visual schedules and providing support for transitioning between activities. It will also include a comprehensive rewards system, with a design informed by children’s preferences.

2.7 Methodology

2.7.1 Design Approach

Informant Design (ID) is a framework where children and teachers/experts act as informants at various stages in the design process. In their role as informants, children are involved at certain key stages to offer input and feedback on the design. First introduced by Scaife et al. in 1997 [29], ID takes input from different people at different stages, maximising the value of their contributions. Scaife et al. suggest four phases of design [29]: 1. Define domain and problems; 2. Translation of specification; 3. Design low-tech materials and test; 4. Design and test high-tech materials. The approach taken in this project was inspired by ID.

TD children and experts in Human-Computer Interaction (HCI), ASC and Education are involved in most stages of development: informing the design, evaluating the low-fidelity prototype (LFP), and evaluating the high-fidelity prototype (HFP). It is essential to involve children in the design process, as children are the end users of the tool.

Although children with ASC are the target audience of this tool, TD children were also involved as proxies for children with ASC. The limited time frame of the project made it difficult to recruit children with ASC, and therefore only one child with ASC was involved in the design workshop. Involving children with ASC in evaluation studies may cause unnecessary stress [12] and is therefore approached with caution. However, working with TD children and gaining the insights and suggestions of ASC experts could better approximate the needs and interests of the target population [12].

2.7.2 Development Stages

1. Define domain and problems

The literature review presented in Chapter 2 aims to gather information about ASC and the interventions which are currently being used to help children with ASC cope with changes. In the design workshop described in Chapter 3, the children are asked to identify activities which might make children anxious, suggest coping strategies, and inform the design of the tool by contributing their ideas for features such as calming activities and the rewards system in the tool. Based on the literature review and this workshop, an initial set of requirements for the tool is identified. This stage aims to answer the first research question '*What are the current interventions used to help children with autism cope with changes?*'. It also begins to answer the second research question '*How should technology be designed to support children with autism coping with changes?*'

2. Low fidelity prototype design and formative evaluation

In this stage, the requirements gathered in the literature review and the design workshop were used to design a LFP which was then evaluated by HCI, ASC and Education experts in order to refine the design. 3 experts were recruited at this stage and 'Cooperative Evaluation' [11] was used to gain their feedback on the design. Thematic analysis [7] of the results from these evaluations was used to improve the design. The evaluation studies are described in Chapter 4. This stage partially answers the second research question '*How should technology be designed to support children with autism coping with changes?*'

3. High fidelity prototype

This stage involves the implementation of a HFP (Chapter 5) based on the refined design. It also aims to answer the second research question '*How should technology be designed to support children with autism coping with changes?*'

4. High fidelity prototype evaluation

In this stage, the HFP is evaluated with typically-developing children and HCI, ASC and Education experts. 4 children were recruited to take part in a workshop where they completed a list of tasks and took part in a semi-structured interview. 4 HCI/ASC experts evaluated the prototype through 'Cooperative Evaluation' [11] and a semi-structured interview. Thematic analysis of the data from the evaluation studies was carried out [7]. Chapter 6 reports on the evaluation studies. This stage aims to answer the third research question '*How effective is the new tool in helping children with autism to cope with changes?*'. Chapter 7 discusses 'Future Work' based on the results of the evaluation.

Chapter 3

Design Studies

This chapter reports on the workshops which were carried out with children to inform the design of the tool. This chapter aims to help answer the second research question: *'How should technology be designed to support children with autism coping with changes?'*

3.1 Workshop with Children

In order to design the tool with the target audience of children in mind, a workshop with children was conducted over two sessions. The main aims of the workshop were to determine: what kind of activities or changes might make children anxious; ideas to help cope with this anxiety; what sort of rewards could be used to motivate children; how these rewards could be integrated into the tool.

3.1.1 Participants

The participant for the first session was a child with ASC, and the participants for the second session were two sets of siblings, acting as proxies for children with ASC [12]. The details can be found in Table 3.1.

Participant	Age	Gender	ASC/TD?
1	6	Male	ASC
2	13	Male	TD
3	13	Male	TD
4	12	Male	TD
5	9	Female	TD

Table 3.1: Details of the Workshop Participants

3.1.2 Materials

The materials used for the workshops were: 1. Consent form and information sheet for children (See Appendix B); 2. Consent form and information sheet for parent/guardian

(See Appendix C); 3. Paper and coloured pencils; 4. Laptop with microphone and camera; 5. Instruction sheet for researchers; 6. Backup voice recording device.

3.1.3 Procedure

The workshops took place over Microsoft Teams due to Covid-19 restrictions. The meetings were recorded on Teams in order to allow the researchers to focus on running the workshops rather than taking notes. An audio recording device was also used to record the meeting in order to provide a back-up. Immediately after the meeting, the recording was downloaded to a password-protected encrypted laptop. A back-up copy of the recording was uploaded to the School of Informatics' secure file servers.

The parents/guardians were contacted through email. The information sheets and consent forms for both parents and children were provided to allow the parent/guardian to read them in advance of the workshop. The parents were asked to fill in the consent form in advance of the workshop to allow their child to take part. The consent from the children was verbally confirmed at the beginning of the workshop.

The workshops lasted 30 - 45 minutes. Each workshop began with a brief icebreaker, where each child and researcher was asked to introduce themselves and describe their favourite food. The purpose of the icebreaker was to make the children comfortable and ease them into the activities. The children were then given a brief overview of the project and the goals of the workshop, before moving on to the activities.

The first activity asked the children to draw a picture of one thing that makes them happy, and one thing that makes them sad. The children were then asked for ideas of situations or activities which could make other children worried. This was followed up by asking the children for suggestions of ways to make children feel better in these situations. The next activity involved asking the children to think of ideas for rewards they could get for completing an activity in the game. The children were then asked for suggestions on how these rewards could progress throughout the game.

Most of the activities for the workshop involved the children drawing and then showing the drawings to the group over the camera. The parents were asked to preserve the drawings and take pictures after the workshop to share with the researchers (see Appendix D). The children also received a certificate of participation.

3.1.4 Data Collection and Analysis

After the workshops, the recordings were transcribed by hand. In light of the data gathered from the session transcripts, the researcher's notes and the drawings collected from the children, thematic analysis was selected as an appropriate method to analyse the data [7]. This approach resulted in the following themes: Anxiety-inducing activities; Positive activities; Rewards: Cumulative rewards and Collected rewards.

3.1.5 Results

The data analysis described in the previous section lead to the following results.

Anxiety-inducing Activities

A common sentiment expressed by the children when asked which activities might cause children anxiety was that changes and new experiences were likely to make children worried. 4 out of the 5 participants suggested that starting at a new school would make children anxious. P1 said *"when you start at a new school and maybe you don't know where to sit... that would make you nervous"*. Another common topic in the activities was social situations where the child doesn't know other children. 4 of the participants responded with activities where not knowing other children would make the child stressed. P2 answered *"going to a new club, if you don't know anyone, that would be a bit stressful"*.

Positive Activities

The workshop provided suggestions of activities which made children happy or which could be used to cheer children up when faced with an anxiety-inducing situation. There was a common theme of video or audio based activities making the children happy. In response to the first question, where children were asked to draw something that makes them happy, P1 drew a picture of the 'Youtube' logo. P3 responded that *"Cartoons are definitely something that makes me happy, I love watching them!"*. When asked for ideas of things children could do when they are worried about a situation, similar responses arose. Three of the children, P2, P3 and P5, suggested doing something they like such as watching something they enjoy. P3 suggested that children could *"maybe listen to their favourite song or watch a video they like"*.

Rewards

Throughout the workshop, the children came up with a number of suggestions for rewards they could earn in the tool, and for how these rewards could progress.

Cumulative Rewards

Two of the children suggested rewards which build up to earn something better, with P3 suggesting *"if you pass a level, you get one, two or three stars depending on how well you do and then you get a trophy at the end"*. P2 similarly came up with the idea of earning coins when you perform well, remarking *"after completing a task or level, you get coins which you use for upgrades"* and suggesting various rewards you could buy, such as a pet to accompany you, or a UFO for your pet.

Collected Rewards

Two of the other participants suggested an approach where different rewards are collected with the goal of collecting them all, rather than working towards one overall reward. P5 suggested that each achievement earns a different reward such as different pets. In a similar vein, P4 responded *"usually the reward in games is a list of achievements, you can race your friends to get them so you get a medal for each"*.

3.2 Impact on Design

The analysis of the results from the workshop proved useful in informing the design. Learning about the sort of changes which the tool should support children coping with helped to identify the features which should be integrated into the tool. The suggestions from the children regarding the activities which might make children anxious

highlighted that many changes can cause anxiety but also showed that the social aspect can be the most challenging part of a change. The emphasis on struggling with social interactions in new situations reinforced the importance of including SS in the tool, as they are designed to help improve the social understanding of children.

The children had similar ideas of activities which made them happy or could be used to cheer them up, namely videos and songs. These answers suggest that technology can be used to offer access to things that make children happy. When designing the tool, a feature it should include is the ability to save videos, from Youtube and other sources, in a space that children can use to cheer themselves up or reduce their anxiety.

The children had two overall approaches to how the rewards system in the game should work. These two different approaches can both be used to inform the design of the rewards system in the game. The tool should allow for incremental rewards which accumulate to earn an overall reward, and for a number of overall rewards which can be collected throughout the game. This confirmed the results obtained by Constantin et al. when researching computer-based rewards for children with ASC [9].

Using the research carried out in the literature review, ASC design guidelines identified in Section 2.5, and the outcomes of the design workshop with children discussed in the previous section, a preliminary list of design requirements was outlined. Nielsen's Usability Heuristics were also considered, as these are the most general principles for designing interactive systems (See Appendix E). These requirements were used to inform the design of a LFP. ASC design guidelines are referred to as ADG_x and the usability principles as HCI_x, numbered according to their respective lists.

User Requirements

The target users are children with ASC between the ages of 7-11 years old. At this stage, children are capable of more logical and methodical thought, and more aware of the world around them, according to Piaget's theory of cognitive development. The users are assumed to be familiar with a laptop or desktop computer.

The tool should be easy to use for the target group, with simple language and straightforward tasks (ADG₁, ADG₅). Icons, symbols and visual representations should be used where possible, and text kept to a minimum (ADG₁). Sounds, animations and graphics should not be distracting, and the system should allow users to turn off sound effects and animations, if the child becomes over-stimulated or has sensory sensitivities (ADG₉). It should be easy to recover from mistakes (HCI_{P3}, HCI_{P9}), and the structure of the tool should be straightforward (ADG₄).

Educational Requirements

The tool should allow children to view VAS, and to read through SS. These interventions were selected due to their effectiveness helping children with ASC to cope with changes. The tool should allow children to use transition aids (TA) such as watching videos or countdowns between activities. These are included based on the research which suggests priming and cueing are effective ways to improve transition behaviours. Rewards should be offered for successfully completing certain activities (ADG₈) to motivate children. It was decided not to include coping strategies in the initial design, due to the research which suggests children do not use TBTs when they become

anxious [8].

Task Requirements

The user will be able to select to view a VAS, read a SS from a list, watch a video or view a countdown in TA, and review the rewards they have collected.

When viewing a schedule, users can see a list of activities to complete that day. Users can view further details about an activity, access a linked SS from an activity and mark activities as complete (ADG_6). Users can access TA such as videos between certain activities. Users can earn rewards by completing certain activities.

When reading a SS, users can click through the different steps of the story, and mark it as read when they reach the end (ADG_6).

In the rewards section, users can see the activity they completed to earn a star. Collecting a number of stars earns a particular trophy. This was inspired by the cumulative rewards suggested by the children. By having numerous trophies to collect, the second approach to rewards suggested by the children in the workshop was also implemented.

In the practitioner interface, practitioners can add, delete and edit VAS and SS. All text and images can be set by the practitioner so as to customise the schedules and stories to the child's preferences. Practitioners can link SS to activities in the schedule, add TA between activities, and set a reward for completing certain activities. Practitioners can upload and remove videos and songs from the TA. Practitioners can set trophies for the child to earn. All of these features are to allow customisation of the tool (ADG_9).

User Interface Requirements

The application will offer both a child and practitioner interface. The tool will open on the main menu which allows users to see the main features available (ADG_4). Users can access the practitioner interface from the menu, which will require a password to prevent children accessing it.

In the VAS section, the user can view a list of activities and see whether they have completed each activity. Users can see which activities will earn a reward (ADG_5).

When reading a SS, the interface should be very simple in order to focus their attention on the story (ADG_2).

In the TA section, users can see a list of videos or songs to aid transitioning between activities (ADG_4). They can also see a visual countdown used as a visual support for transitioning between activities. When a user is watching a video, the interface should have no other elements in order not to distract their attention (ADG_2).

In the Rewards section, users can view the stars they have been awarded, and see the trophies they are working towards (ADG_1, ADG_8). A star was chosen as the reward based on the children's suggestions in the workshop.

In the Practitioner interface, practitioners should be able to see which features they have the ability to edit (HCI_P6). When they are adding a new resource, e.g. a visual schedule, there should be a simple template to fill in to remind users which fields are necessary and of the additional functionality they can add to a resource, e.g. linking a SS to an activity (HCI_P6).

Chapter 4

Low Fidelity Prototype Design

At this stage of the design process, the aim was to design a LFP based on the requirements defined in Chapter 3, and evaluate it with experts on HCI and ASC. The LFP was developed using Balsamiq [3], as described in Section 4.1. Then evaluation studies were carried out with 3 HCI, ASC and Education experts, presented in Section 4.2. This chapter aims to address the second research question: *'How should technology be designed to support children with autism coping with changes?'*

4.1 Description of the Design

Based on the requirements presented in Section 3.2, a LFP was developed using Balsamiq [3]. Balsamiq allows users to design interfaces and provide connections between them, simulating how users would navigate through a real application. The realistic interface and inclusion of links between pages helped to uncover usability issues such as inconsistent navigation, or buttons which were difficult to use.

Additional images of the screens described below can be found in Appendix F.

4.1.1 Menu Screen

The application opens on the main menu of the child interface (Figure 4.1a). This menu provides access to the main features and to the practitioner interface.

4.1.2 Schedules

'Schedules' opens a page displaying the first section of the VAS for the day (Figure 4.1b). A user can navigate through the sections using arrows at the top of the screen. Every section shows a list of activities which users can mark as complete. If completion of the activity will earn a reward, it is marked with a star icon (see Figure 4.1b).

Clicking on an activity opens a pop-up with a textual description of the activity and a button which will lead to the attached SS, if there is one. If this is a reward activity, the pop-up will include a reminder of the reward and a link to 'My Track Record', where users can view the rewards they have earned.

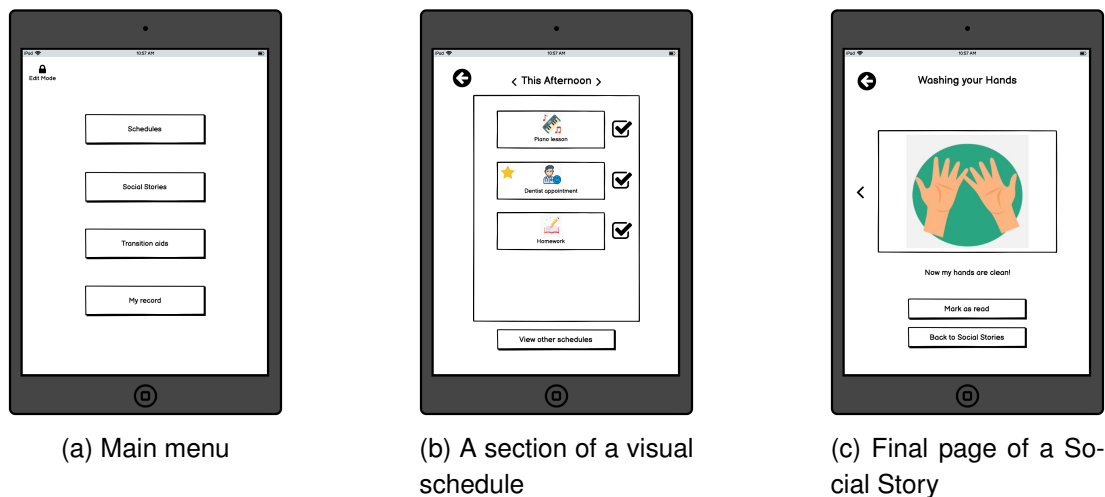


Figure 4.1: Examples of screens from the low fidelity prototype

When an activity is marked complete, if the practitioner has added support for the transition to the next activity, a pop-up will explain the transition aid which has been provided, e.g. there is a descriptive video to watch, and provide a link to that aid. If a reward is offered for completion of the activity, the pop-up will congratulate the child on earning the reward, and provide a link to 'My Track Record' to view the reward.

The back button can be used to return to the main menu. Users can click 'View all schedules' to see the icons and titles of all available schedules. Selecting one will open that schedule, informing children of the activities they will have to complete on other days, as advance notice can help children prepare for changes.

4.1.3 Social Stories

When the user clicks 'Social Stories', they can view the icons and titles of all available SS. Selecting one opens the first page of that SS, showing the picture and caption for that step of the story. Users can navigate through different pages using the arrows (see Figure 4.1c). On the final page, there are two buttons, one allowing users to mark the story as read, the other to return to the SS menu. The arrow in the top left corner returns to the main menu.

4.1.4 Transition Aids

'Transition Aids' leads to the menu showing all the TA which can be used for priming or cueing (Figure 4.2a). 'Transition Songs' or 'Transition Videos' opens a new page where the video/song is played. Selecting 'Transition Sounds' allows users to view the different sounds available as transition cues. Users can play the sound by clicking the icon. 'Countdown' leads to a new screen (see Figure 4.2b) showing a visual countdown which is used to show time elapsing in an activity in preparation for the transition to the next activity. Only the card shown in green can be clicked, when it will become grey and the next card will become green. Once the last card has been 'removed' (turned grey), a pop-up will explain that it is time to move on to the next activity.

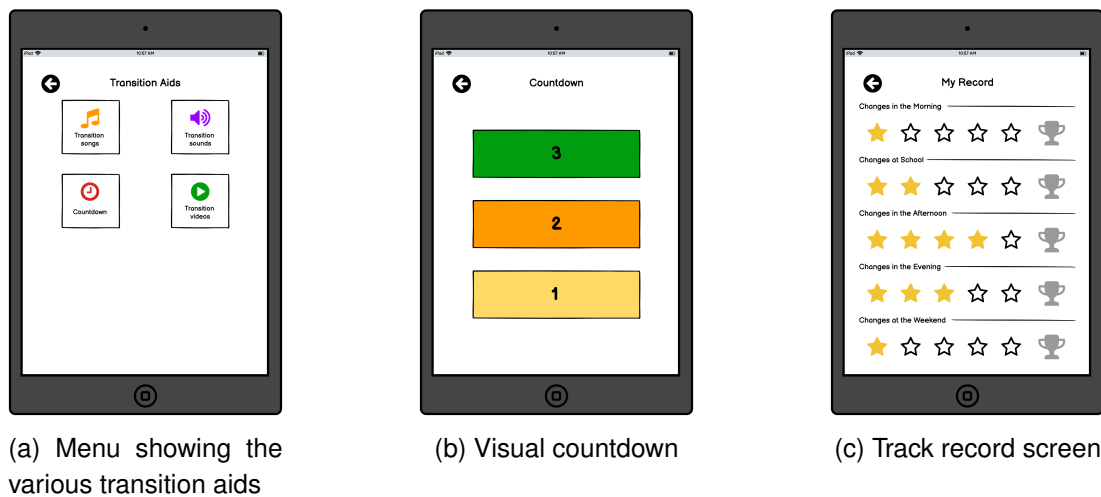


Figure 4.2: Examples of screens from the low fidelity prototype

4.1.5 Record

'My Track Record' shows the stars a user has earned, the remaining stars necessary to earn a trophy, and the trophies available (Figure 4.2c). The stars the child has earned are shown in yellow. Trophies they have not yet earned are shown in grey. Clicking on a star opens a pop-up which names the activity for which they were awarded the star.

4.1.6 Practitioner Interface

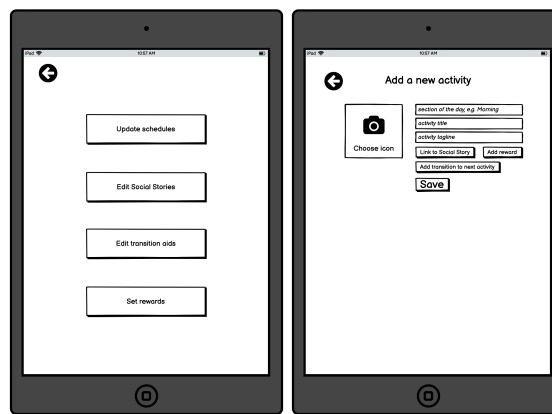
Clicking on 'Edit Mode' prompts users to enter a password. This authentication is included in the design as it is a desired feature but will be considered 'Future work' due to the constraints of the project, and will not be implemented in the high fidelity prototype. From the main menu of the practitioner interface (Figure 4.3a), practitioners can customise the resources available to the child.

'Update schedules' provides the options to add a new schedule or edit an existing one. 'Add new' prompts practitioners to upload an icon and set a title for the schedule. They then have the ability to add activities using the template shown in Figure 4.3b.

Similarly, practitioners can add or update SS, with a simple template that allows them to set an icon and title for the story, and then provide an image and caption for each step of the story. Practitioners can edit TA by saving additional songs or videos; the visual countdown and transition sounds are not customisable. Finally, practitioners can add or update rewards, providing a title for the reward and the number of stars the child must achieve in that section in order to earn the trophy.

4.2 Evaluation with Experts

A formative evaluation of the LFP was carried out with 3 experts in the areas of HCI, ASC and Education. It was crucial to involve experts in these areas in the design process due to the limited access to children with autism in this project in light of the time constraints. The aims of the study were to: Determine whether the tool is



(a) Practitioner interface menu (b) Example of a template to add a new activity to a visual schedule

Figure 4.3: Examples of screens from the low fidelity prototype

appropriate for the target population; Determine whether the interventions featured in the tool are suitable to help children with autism cope with changes; Identify usability issues in the design; Elicit suggestions for improving the tool.

4.2.1 Participants

The details of each participant can be found in Table 4.1. Each study was conducted with one expert in order to collect as much data as possible.

Participant	Areas of expertise
1	Psychology, Education and learning technology
2	HCI, designing technology for children with ASC
3	HCI, designing technology for children with ASC

Table 4.1: Details of the Evaluation Experts

4.2.2 Materials

The materials used were: 1. Consent form and information sheet for experts (See Appendix G); 2. Balsamiq prototype; 3. Laptop with microphone and camera; 4. Instruction sheet for the researcher; 5. Backup voice recording device

4.2.3 Procedure

The evaluation studies took place over Microsoft Teams due to Covid-19 restrictions. The meetings were recorded on Teams and an audio recording device was also used to record the meeting to provide a back-up. Immediately after the meeting, the recording was downloaded to a password-protected encrypted laptop. A back-up copy of the recording was uploaded to the School of Informatics' secure file servers.

The experts were contacted by email and provided the information sheet and consent form to allow them to learn what will be expected of them in the evaluation. Each session was conducted with one participant, but the procedure was the same.

The method adopted in this study was 'Cooperative Evaluation', a variation of the 'Think-aloud' protocol [11]. It varies from 'Think-aloud' in that users are encouraged to participate as a collaborator rather than simply as a participant. Users are allowed to ask questions to clarify aspects of the design and researchers can ask the users to explain their behaviour and present alternatives, e.g. "what if...?". Users are encouraged to actively criticise and suggest improvements to the design. This approach led to a more open atmosphere and increased engagement from the participants [11].

At the start of the session, the researcher gave a brief overview of the project and its goals, and an explanation of the aims and procedure for the evaluation. Once the participants had completed the consent form, they were given the link to the Balsamiq prototype and asked to share their screen. The researcher gave a short introduction to the tool, explaining the main features. The participant was then asked to freely explore the prototype, sharing their thoughts, asking questions, and making suggestions as they did so. This relaxed approach resulted in participants sharing many ideas with the researcher. The sessions lasted 40 - 60 minutes.

4.2.4 Data Collection and Analysis

After the sessions, the recordings were transcribed by hand. Thematic analysis was selected as an appropriate method to analyse the data gathered from the transcripts and the researcher's notes [7]. A top down approach was taken, with the aims for the evaluation study being used as the pre-established themes. This approach resulted in the following themes: Appropriateness of the tool for children with ASC; Suitability of the interventions selected; Suggestions for improvements; Usability issues.

4.2.5 Results

This section presents the results obtained under each theme.

Appropriateness of the tool for children with ASC

The feedback from the experts was very positive, with all three experts expressing their appreciation of the tool. Each of the experts responded positively when asked whether the tool was appropriate for the target population. E1 responded that the tool was *'certainly very appropriate, the design is simple and suitably configurable to appeal to children across the spectrum.'* Similarly, E2 answered *'definitely yes - I love the project'*. E3 also discussed how easy the tool was to use, and praised the use of visuals.

Suitability of the interventions selected

All three experts were in agreement that the interventions were very suitable to help children with ASC cope with changes. E1 and E2 mentioned their experience seeing visual schedules and SS in particular in use to support children with ASC coping with changes and commented that they are very effective. E3 responded that the interventions were *'absolutely suitable, very nice... I can see this being a great day to day*

tool for children with autism'. Each of the experts also commented that the integration of all the interventions into the VAS was particularly useful. The experts mentioned that the level of customisation helped to make the interventions even more appropriate. E2 remarked *'Being able to personalise everything, that's really crucial... setting the visuals in the schedule, having the ability to provide as much text as is appropriate for the child, these things will make the schedule really work'*.

Suggestions for improvements

The experts had a number of suggestions to improve the tool.

Transition Aids

All 3 experts suggested improvements for the TA section. Each of the experts was of the opinion that although there are some cases where it may be useful for children to be able to access the TA outside of the schedule, it is unlikely that it will be used for this purpose. E1 commented *'Children are most likely to become distracted and view items here at random times'*. E3 expressed a similar feeling, saying *'I'm unclear on how a child would make use of these...definitely the countdown and the transition sounds are unnecessary outside of the schedule'*. Both E2 and E3 suggested that this section could be repurposed as a general space for coping strategies, with E2 saying *'I can see how some elements would be useful, if framed as general coping strategies'*. Some of the more useful TA, e.g. the songs and videos, can still be made available for the general purpose of calming children down or cheering them up. E2 and E3 suggested that practitioners be able to add other coping strategies as appropriate for the child, and they should be able to limit the access to videos/songs if they would act as distractions.

E2 and E3 also suggested options to make the visual countdown more effective. Both expressed that they could see the value, with E2 stating *'I definitely really like that there are visual TA along with the video and audio options'*. However, they found the countdown difficult to use, E3 commented *'I don't think it's clear that the cards are clickable and I don't think this is particularly usable if the child has to manage the countdown themselves'*. The recommended improvement from both experts was to allow practitioners to set a timer associated with each card when they add the countdown as a transition aid between activities so that they are automatically removed.

Rewards System

The experts liked the integration of the rewards system, and commented that it would be motivate children. However, they had some suggestions to improve it.

All three experts recommended that there should be a space where children can view the trophies they have earned so far. E1 commented *'I think this will be helpful to remind children of what they have achieved and to motivate them to collect more'*.

Both E2 and E3 suggested that practitioners be able to associate a real world reward with a trophy, so that when the child earns the trophy, they have a real reward as well. This was mentioned particularly to help motivate children to earn trophies more than once. E3 commented *'there might be more changes for some trophies, making them easier to earn, so there needs to be more motivation so they want to earn it again'*. Both experts also recommended that practitioners be able to replace the trophy with the picture of the reward the child will earn, in order to keep them motivated.

Another suggestion from both E2 and E3 was to add animation to the rewards. When a child completes an activity that earns a reward, *'they should see stars or fireworks, something fun and exciting!'* (E2). Animations were also suggested to deal with the issue that stars in the rewards section aren't obviously clickable. E3 recommended *'a new star should have sparkles around it to draw attention and make them click it'*.

E2 also suggested that children should be able to build up 'streaks' by completing all the activities in a schedule for a number of days in a row. She recommended that *'when a child completes the last task they get a little pop-up telling them their streak'*. She also commented that children should be able to view their current streaks on the schedule page, and *'they should be able to see the stars they have earned today too'*.

Other Schedules

E1 had some concerns about allowing children to view schedules other than the one for the current day. E1 said *'for some children, the idea of the future is too daunting'*. He suggested that practitioners should be able to configure whether children can view other schedules. In doing so, not only can they be hidden from children who wouldn't cope well with the concept of the future, but he also suggested that *'this provides an opportunity to introduce some level of lengthening time horizons as its own developmental activity'*, as practitioners could slowly introduce access to future schedules.

Other suggestions

E2 and E3 made the suggestion that, if the TA section is repurposed to provide general coping strategies, a help button should be added to the schedule. E3 commented *'while I don't think children who become anxious would go automatically to the coping strategies, if they become stressed while working through the schedule, having a button right there would help them to make use of these'*.

All three experts commented that for VAS and SS, practitioners should be able to upload their own images or videos. E2 remarked *'this would make it more familiar to the children, and some families or practitioners have gone to a lot of trouble to make their own videos and things to use and it would be nice if they can integrate that here'*.

E2 suggested that it would be nice to add sounds to certain steps in SS. She recommended that *'this would make them more engaging, and could also be used to prepare them for strange sounds, like the noise of tools in the dentist's office'*.

Usability issues

The usability issues encountered during the studies included: 1. It is unclear that stars in the rewards section are clickable (3/3 experts); 2. It is unclear that cards in the visual countdown are clickable (2/3 experts); 3. Title 'My track record' for the rewards section is unclear (2/3 experts); 4. It is unclear that the activities in the Visual Schedule are clickable (2/3 experts); 5. The use of a drop-down menu to select the transition song/video playing is unclear (2/3 experts); 6. 'Back to Social Stories' button on last page of a SS is redundant; the arrow at the top left corner should return to the SS menu (1/3 experts); 7. Lock icon for access to practitioner interface is unclear (1/3 experts)

4.3 Impact on Design

The suggestions made by the experts are listed in Table 4.2. Each is labelled as 'Implemented' or 'Future work', according to the priority and feasibility to implement in the HFP. Priority was set based on discussions with a research group (RG) which included 3 other UG4 students, an MSc student and 4 experts in HCI, ASC and Education. Features which are high priority and can be easily added or adjusted in the current design will be implemented, and those which are more demanding will be set as 'Future work', due to the limited time to implement the tool or lack of priority.

No	Suggestion	Priority	Decision	Justification
1	Rename 'My Track Record' to 'My Prizes'	High	Implemented	E2, E3, HCI.P2, ADG.1
2	Add button to schedule activities for extra details	High	Implemented	E2, E3, HCI.P4, HCI.P6, ADG.5
3	Replace dropdown menu for videos with list of options	Medium	Implemented	E2, E3, HCI.P6, ADG.4
4	Remove redundant 'Back to Social Stories' button	Low	Implemented	E3, HCI.P8
5	Replace lock with edit icon in button to access practitioner interface	Medium	Implemented	E3, HCI.P2
6	Replace 'Transition Aids' section with space for coping strategies	High	Implemented	E1, E2, E3
7	Add help button to schedule to access coping strategies	High	Implemented	E2, E3, HCI.P6, ADG.4, ADG.5
8	Allow children to view streaks and stars earned today while on the schedules page	Medium	Implemented	E2, HCI.P1, ADG.8
9	Associate a real world reward with trophy	High	Partially implemented	E2, E3, ADG.8
10	Add animation when receiving a reward	High	Future work	E2, E3, ADG.8
11	Add animation to most recently earned star in 'My Prizes'	Medium	Future work	E3
12	Allow practitioners to upload personal videos and icons	High	Future work	E1, E2, E3, ADG.9
13	Allow users to add sounds to SS	Medium	Future work	E2
14	Add timer to visual countdown	Medium	Future work	E2, E3, HCI.P2, HCI.P7
15	Require password to access practitioner interface	High	Future work	HCI.P5
16	Add space for viewing trophies earned so far	Medium	Future work	E1, E2, E3, ADG.8

Table 4.2: Suggestions and justification from experts, HCI Principles and ASC Design Guidelines

Chapter 5

High Fidelity Prototype Implementation

At this stage, the goal is to implement a HFP of the tool, based on the results of the evaluation studies in Chapter 4. This chapter begins with a brief overview of the technologies being used for this prototype, and then presents a description of the prototype. This chapter aims to address the second research question: *'How should technology be designed to support children with autism coping with changes?'*

5.1 Platform

Originally, this tool had been designed as an Android application, to run on mobile touch screen devices. However, due to restrictions of the COVID-19 pandemic, all evaluation studies had to be accommodated online. Therefore, an Android application became unsuitable due to the difficulties of sharing it with participants and it was decided that the tool would be developed as a web application instead. This had the advantage of being suitable for any device with a web browser, and it could simply be hosted externally and a link to the website shared with study participants.

5.2 Resources

Angular Typescript and Angular Material

Angular is a TypeScript-based framework for building mobile and desktop web applications [2]. The researcher had experience developing web applications using Angular and therefore it was selected for this project. This application also made use of the Angular Material UI components library [38]. Angular Material components were used as templates for some UI elements of the application.

Firestore Hosting and Firestore

In order to allow external users to evaluate the web application, it was necessary to host the website at an external link. Firestore Hosting was selected for this project as

it provides free production-grade web content hosting. Firebase Hosting is suitable for serverless, dynamic web sites, and therefore it was appropriate for this project.

Cloud Firestore is a cloud-hosted, No-SQL database. It was chosen as the database for this project because web applications can interact with it directly using HTTPS requests, with no backend code required. By integrating a Cloud Firestore database with this application, it was possible to store and retrieve data dynamically. It provided the functionality for practitioners to add, modify and delete data, and for children to view dynamically updated data.

Version Control System

Github was selected as the version control system. A private git repository was created, preventing unauthorised access to the code. Changes were pushed to the repository frequently, to provide a back up of the most up to date version of the application.

5.3 Description of the Prototype

Taking into account the updated set of requirements after the evaluation studies in Chapter 4, the HFP was developed as a web application using Angular TypeScript. Most of the functionality from the LFP was maintained, with some small adjustments. The following can be performed on the application: Practitioners can add, modify or delete VAS, SS, coping strategies and rewards ; Children can view their daily schedule, organised into sections as defined by the practitioner; Children can earn and view their rewards, and build up streaks for completing all the activities in a schedule; TA are accessible, as are coping strategies in their 'Happy Space'.

Additional images of all the screens described in the following sections can be found in Appendix N.

5.3.1 Menu Screen

The application opens on the child interface main menu (Figure 5.1a). This menu provides access to the main features and a button which leads to the practitioner interface.

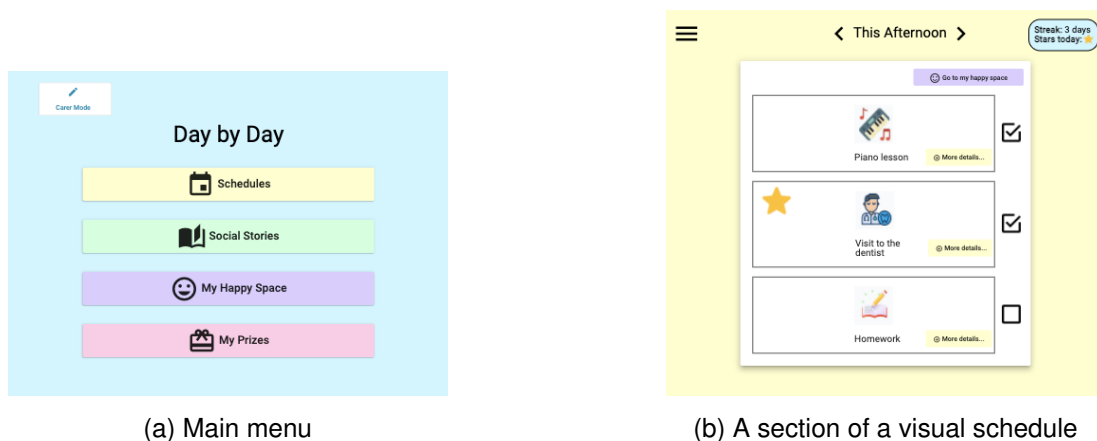


Figure 5.1: Examples of screens from the high fidelity prototype

5.3.2 Schedules

'Schedules' opens a new page displaying the first section of the visual schedule for the day (Figure 5.1b). A user can navigate through the sections using the arrows. Every section shows a list of activities, each with a checkbox beside it and a button labelled 'More details...'. Activities which will earn a reward are marked with a star icon.

'More details...' opens a pop-up with a textual description of the activity and a button which will lead to a SS, if a SS has been linked. For reward activities, the pop-up will include a reminder of the reward and a link to 'My Prizes'.

When an activity is marked complete, if the practitioner has added support for the transition to the next activity, a pop-up will explain the transition aid which has been provided and include a link to that aid. If a reward is offered for completion of the activity, the pop-up will congratulate the child on earning the reward, and provide a link to 'My Prizes', if they wish to view the reward they have earned. When the child marks the final activity in the schedule as complete, the pop-up will congratulate them on completing all the activities, and update them on their current 'streak': the number of days in a row the child has successfully completed all the activities in the schedule.

The menu button will return to the main menu. In the top right corner users can view their 'streak' and the number of stars they have earned that day. Above the list of activities is a button which will lead directly to the 'Happy Space', suggested during the LFP evaluation to help soothe children who become anxious.

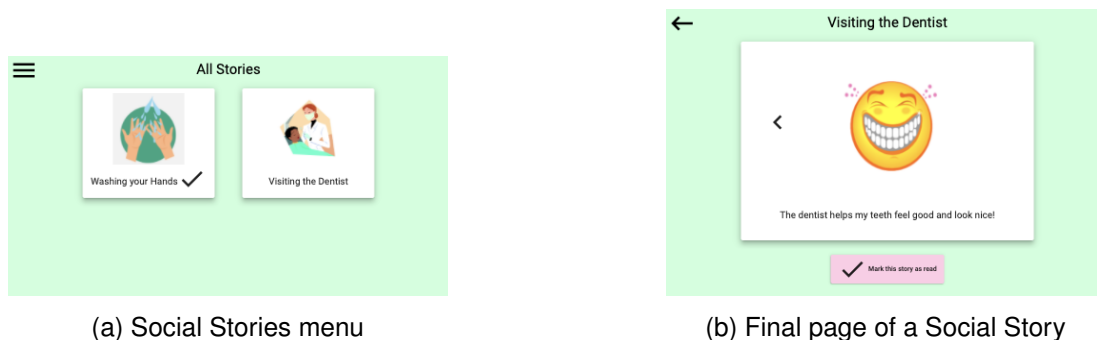


Figure 5.2: Examples of screens from the high fidelity prototype

5.3.3 Social Stories

When the user clicks 'Social Stories', they can view the icons and titles of all available SS. Any which have been marked as read will have a tick beside the title (Figure 5.2a). Selecting one opens the first page of that SS and users can navigate through different pages using the arrows (see Figure 5.2b). On the final page, users can mark the story as read. The arrow in the top left corner returns users to the stories menu.

5.3.4 Happy Space

'Happy Space' leads to the menu screen showing all the coping strategies available to the child (5.3a). In this prototype, practitioners can only add videos to this section. Choosing a video opens a new page where the video is played.



Figure 5.3: Examples of screens from the high fidelity prototype

5.3.5 My Prizes

'My Prizes' shows the stars a user has earned and the stars necessary to earn a trophy (Figure 5.3b). Clicking on a star opens a pop-up which names the activity which earned the star. Clicking on a trophy names the real reward they will earn with the trophy.

5.3.6 Practitioner Interface

'Edit Mode' leads to the practitioner interface menu (Figure 5.4a). This prototype does not require password authentication as this was marked as 'Future work'.

'Edit schedules' provides the options to add a new schedule or edit an existing one. 'Add new' prompts practitioners to upload an icon and set a title for the schedule. They then have the ability to add activities using the template shown in Figure 5.4b.

Users can also: add or update SS, with a template that allows them to set an icon and title for the story, and provide an image and caption for each step; add coping strategies by saving videos which can be used in the 'Happy Space' or as TA, i.e. for priming; add or update rewards, providing a title, the number of stars required to earn the trophy and the description of the real reward the child will earn.

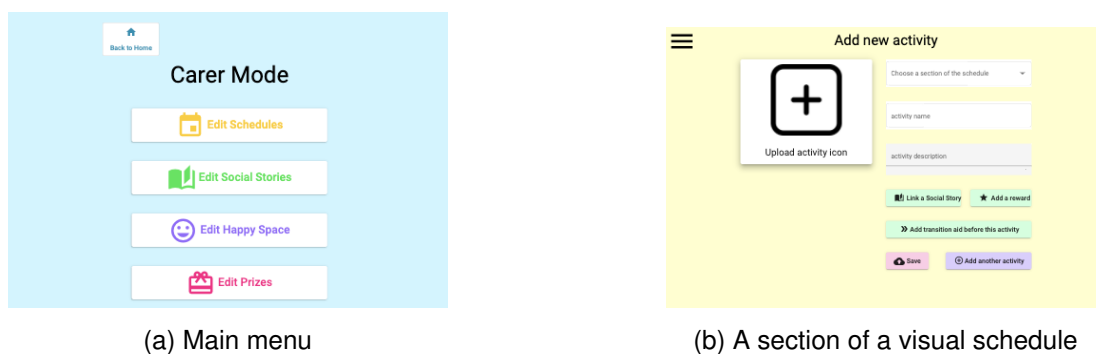


Figure 5.4: Examples of screens from the high fidelity prototype

Chapter 6

High Fidelity Prototype Evaluation

This chapter presents two evaluation studies using the HFP: a study with TD children and a study with HCI, ASC and Education experts. The goal is to answer the final research question: *'How effective is the new tool in helping children with autism to cope with changes?'* Section 6.1 describes the evaluation with TD children, Section 6.2 presents the evaluation with experts and Section 6.3 discusses the results.

6.1 Evaluation Workshop with Children

An evaluation with 3 TD children acting as proxies for children with ASC was conducted to evaluate the HFP from the perspective of children. Three sessions were carried out. The aims were as follows: Determine whether the tool is easy for children to use; Determine whether the tool is engaging for children: What did the children like about the tool?; What did the children dislike about the tool?; Gather suggestions to improve the tool; Determine the general experience of children with the tool.

6.1.1 Participants

The details of each participant can be found in Table 6.1.

Participant	Age	Gender
1	11	Male
2	9	Female
3	12	Male

Table 6.1: Details of the Study Participants

6.1.2 Materials

The materials used for the evaluation studies were: 1. Consent form and information sheet for children (See Appendix H); 2. Consent form and information sheet for parents (See Appendix I); 3. Link to HFP; 4. Laptop with microphone and camera; 5. Instruction sheet for the researcher; 6. Backup voice recording device

6.1.3 Procedure

The workshops took place over Microsoft Teams. The meetings were recorded on Teams and a back-up recording was taken on a separate device. After the meeting, the recording was downloaded to a password-protected encrypted laptop. A back-up copy was uploaded to the School of Informatics' secure file servers.

The parents/guardians were contacted through email. The information sheets and consent forms for both parents and children were attached to the emails to allow the parent/guardian to read them in advance of the workshop. The parents were asked to fill in the consent form in advance of the workshop to allow their child to take part. The consent from the children was verbally confirmed at the beginning of the session.

The sessions lasted 25 - 45 minutes. Each session began with a brief icebreaker activity. The children were then given a brief overview of the project and the goals of the workshop, before moving on to the workshop activities.

The evaluation consisted of both a task-based evaluation and free exploration of the tool. The researcher requested that the children complete a set of tasks (details in Appendix J) including: describing the activities in today's schedule; identifying the special activity in the schedule; finding and reading a SS. The researcher did not prevent the children from trying out different features or exploring the tool themselves. After completing the tasks, or discovering all the features of the application, the researcher asked the child a number of questions (details in Appendix J) regarding the overall use of the app, what the children liked/disliked about the tool, their favourite features, their suggestions to improve the tool, and their overall rating of the app.

After the workshops, the children received a certificate of participation.

6.1.4 Data Collection and Analysis

After the sessions, the data from the recordings were transcribed by hand. Thematic analysis [7] was carried out on the transcription and the researcher's notes from the session. A top-down approach was taken, with the pre-established themes based on the aims identified at the beginning of this section: Ease of use; Favourite features; Areas for improvement; Overall opinion of the tool; Usability issues.

6.1.5 Results

The children responded positively to the application, each of them engaging with it immediately and showing an interest in discovering the features of the application. The children successfully completed all the tasks.

Ease of use

All three children perceived the application as being very easy to use. P1 pointed out *'it's really easy to move through this schedule, and you can access everything else from here too'*. The children could not think of any elements which were confusing or difficult to use. The researcher observed that each of the children discovered most of the functionality of the app without any guidance, and they did not appear to have

difficulties with any elements. However, P2 was confused about the 'My Prizes' page, asking *'What does this mean?'*. Once the researcher explained that the stars you earn are stored there, she returned to the schedule and pointed out the activity she received a reward for and commented *'Oh, so that's where this star gets to go'*.

All three children successfully identified 'Visit to the dentist' as the special activity, and P1 and P3 correctly guessed that it was special because this activity earned a reward.

Favourite/most enjoyable features

Both P1 and P3 mentioned that their favourite feature was the ability to earn rewards for completing activities, with both commenting that they wanted to earn trophies. When P3 realised that he could earn prizes he remarked *'Ooh my prizes, let's go get that star - I want my trophy!'*. P1 noticed that the trophies in 'My Prizes' were clickable, and when he saw that he could earn a real reward, he said *'I really like these real prizes!'*.

All three children also mentioned that they enjoyed using the schedule. P2 said *'I like all the options, and keeping track of my day here'*, and P1 and P3 agreed.

All three children expressed excitement when they encountered videos in the application. P1 remarked *'yay, I want to watch the video'* when the option appeared in the schedule, and later *'nice, more videos'* when he found others in the 'Happy Space'. Similarly, P3 mentioned *'Oh I like having these videos but not 'Baby Shark', choosing my own would be better'* ('Baby Shark' is a video the researcher added to the 'Happy Space' for this evaluation). When the researcher confirmed that the children could choose which videos would appear in this section, P3 responded *'that's great then'*.

The three children were in agreement that the integration of TA in the schedule was useful. When asked whether they thought watching the dentist video would be helpful before visiting the dentist, they all agreed that it would be, with P3 remarking *'if I was nervous about going to the dentist, I think watching that would make me less nervous'*.

Areas for improvement

When asked what they disliked about the application, all three children agreed that there was nothing they did not like about the application. When asked what feature they liked the least, P3 responded *'Actually, I hate 'Baby Shark' but nothing else'*, and admitted that since he could choose his own videos, *'that isn't really something you have to change'*.

P1 was the only child to discover that the trophies in 'My Prizes' were clickable. He commented *'I don't think it's very obvious that you can click this, and I really like the real reward so you should make sure people find that.'* This had already been raised during the LFP evaluation with the experts and the idea of replacing the trophy with an image of the real reward was marked as 'Future work', but P1 confirmed that it would be a valuable improvement. The fact that P2 and P3 did not discover this at all reinforced this.

After P3 had completed all the activities in the day schedule, he was disappointed that he did not earn a star, saying *'Aww why don't I get a star at the end? I think I should'*. Although he liked the idea of building up a streak, he also wanted to earn a star for completing all the activities partly because, as he said *'I really want to get my trophy'*.

P1 and P3 suggested that children should be able to check activities off the schedule out of order. The tool was set up so that checkboxes only became clickable when the preceding activity was complete. This was due to a comment made during a test-run of this study, where it was suggested that the order of activities should be enforced to make full use of the TA between them. P1 and P3 disagreed, with P3 commenting *'But if I have to skip an activity that day, I still want to tick everything else'*.

Overall opinion of the tool

The children enjoyed working with the tool and responded with positive feedback during the session. P2 and P3 rated the tool 5/5. P1 gave the tool 4/5, and commented that in order to achieve 5 stars, *'just fix the link problem and it gets 5'*. All three children also agreed that children would use the application very frequently, with P3 commenting that it would be used *'probably daily to check your schedule'* and P2 agreed. P1 felt that *'a younger, less independent age group would probably use it every day'*.

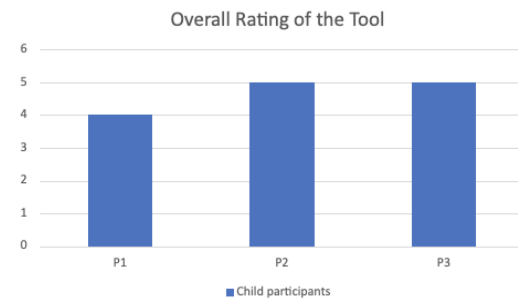


Figure 6.1: Children's overall rating

Usability issues

Two usability issues which were identified in this evaluation: 1. Confusion regarding the purpose of 'My Prizes' (1/3 children); 2. It was unclear that trophies in 'My Prizes' are clickable (1/3 children commented, 2/3 children did not attempt to click this).

6.2 Evaluation with Experts

An study was carried out with experts in HCI, ASC and Education to evaluate whether the tool was considered to be effective in helping children with ASC cope with changes. The aims of the study were to: Determine the suitability of the application for the target audience; Determine the appropriateness of the tool for supporting children with autism coping with changes; Determine the general experience of the experts with the tool; Discover usability issues; Gather suggestions for improving the application.

6.2.1 Participants

The participants were 4 experts in HCI, ASC and Education. Their details can be seen in Table 6.3. Only one of the experts, E2, had taken part in the LFP evaluation, although E1 was familiar with the project as they were part of a RG with the researcher.

6.2.2 Materials

The materials used for the evaluation studies were: 1. Consent form and information sheet for experts (See Appendix K); 2. Link to HFP; 3. Laptop with microphone and camera; 4. Instruction sheet for the researcher; 5. Backup voice recording device

Participant	Areas of expertise
1	Clinical psychology
2	HCI, designing technology for children with ASC
3	HCI, participatory design, and Education
4	HCI, designing technology for children with ASC

Table 6.2: Details of the Evaluation Experts

6.2.3 Procedure

These evaluation studies repeated the same procedure as the LFP evaluation discussed in Chapter 4. The experts were contacted by email, with the consent form and information sheet for this study attached. Each session was conducted on Microsoft Teams with a single expert but the procedure remained the same.

The study employed a 'Cooperative Evaluation' method [11]. The researcher and the participant had the opportunity to ask questions and make suggestions as the participant explored the tool, which elicited a lot of opinions and suggestions from the participant.

Initially, the participant was informed about the project and its aims, and given a brief overview of the goals and structure of the study. After completing the consent form, the researcher introduced them to the HFP, giving a short description of the tool, its main features and how it attempts to support children with autism coping with changes.

The evaluation mostly consisted of a free exploration of the tool, with some suggestions of tasks to complete from the researcher depending on how the participant explored the tool, such as completing all activities in the schedule or adding an activity to a schedule. After discovering all the functionality of the application, there was a short, semi-structured interview, where the researcher asked a number of set questions (details in Appendix L) and follow-up questions as necessary. 4 of the questions were five-point Likert scale questions regarding the ease of use, appropriateness of the methods to help children with ASC cope with changes, suitability of the tool for the target population, and overall rating of the tool. There were open-ended questions about the most useful feature and suggestions to improve the tool.

Each session lasted between 25 - 40 minutes.

6.2.4 Data Collection and Analysis

After the session, the data from the recordings were transcribed by hand, and the transcriptions and researcher's notes were analysed using top-down Thematic Analysis [7]. The pre-established themes were based on the aims identified at the beginning of this section: Ease of use; Suitability of the application: Appropriateness of the methods for supporting children with autism coping with changes; Appropriateness of the application for the target population, children with ASC aged 7 - 11 years old; Overall rating of the application; Suggestions to improve the application; Usability issues.

6.2.5 Results

The feedback from all 4 experts was very positive. They were all very enthusiastic as they explored the application and appreciated many elements of it.



Figure 6.2: Expert ratings of different aspects of the tool

Ease of use

All 4 experts found the application easy to use, with E1, E3 and E4 rating this aspect as 5/5. These three experts discussed the use of visuals and symbols, and E1 mentioned *'I like how it's so straightforward, it's very clear what everything does and it's very direct to access all of the features'*. E2 gave the application 4/5 for ease of use, stating that *'it was mostly very easy to use but there were a few occasions where I wasn't sure if something was clickable but they were small things'*.

Suitability of the application

Appropriateness of the application for the target population

The experts viewed the application as very appropriate for the target population of children aged 7 - 11 years old with ASC, with all 4 experts rating this aspect as 5/5. All 4 experts mentioned the effective use of soft, friendly colours, plenty of visuals and simple language when responding to this question. E4 commented *'the ability to customise the amount of text means you can really make it suitable for the specific child you are working with'*. E3 also mentioned *'the obvious, clear tasks, how focused they are, that's really key for this target group'*.

Appropriateness of the methods

The appropriateness of the methods selected to help children with ASC cope with changes was also rated very highly by the experts, with an overall score of 4.75/5. One aspect which was praised by all 4 experts was the integration of all the features into the schedule; they all remarked that this was very effective. E1, E2 and E4 awarded the application 5/5 for the appropriateness of the methods, agreeing that the methods were highly suitable for the goal, and that a good selection of methods had been integrated into the application to support children in different ways. E3 rated this aspect 4/5, commenting *'I think this app deals really well with the approach of gently and subtly introducing changes in the schedule but it would be good to allow an alternative approach, I'm not sure what exactly but just for some children this wouldn't be the best'*

way'. All 4 experts also commented that the rewards system was a great way to keep children motivated and returning to the app.

Overall rating of the application

The average score for the overall rating of the application was 4.75. P1, P3 and P4 gave the application 5/5, with P3 commenting *'it's appealing, intuitive, easy to use and great features. I really love the customisability, and the fact that as well as considering the child, you have put thought into the experience of the practitioner too'*. P2 gave a score of 4/5 but remarked *'it's a really nice application, just a few improvements needed - even just the addition of the animations and I would give it a 5'*.

Suggestions to improve the application

The experts provided a number of ideas for improvement. Some suggestions had been mentioned in the LFP evaluation and already marked as 'Future work'.

Rewards

A number of suggestions centred around the rewards system in the application. The most common was that there should be an animation when children earn a reward, with E2, E3 and E4 making this suggestion. This had already been mentioned in the LFP evaluation and designated as 'Future work' and the repetition in this study shows that this is a key area for improvement. Similarly, as mentioned in the LFP evaluation, E2 suggested that the most recently earned star should have some kind of animation around it on the 'My Prizes' page, *'maybe little sparkles so it stands out'*.

E4 suggested that children should earn a reward for completing all activities in either a section of the schedule or the entire day, and E3 recommended that children should earn a reward for reading a SS and marking it as read.

As suggested in the LFP evaluation, E3 thought that replacing the trophy on 'My Prizes' with a picture of the real reward would be effective, saying *'the real reward is very motivating so they should easily be able to see that'*.

E3 had a suggestion to extend the rewards system beyond earning stars and trophies. Having expressed concern that children would be distracted by having access to videos in the 'Happy Space' and spend less time using the schedule, she recommended *'it would be nice if the children can earn access to these videos. So they get into the habit of using the schedule while they earn enough stars to unlock the videos, and then even if the videos are distracting, they have already gotten used to using the schedule'*. This aligned with a comment made by E2, who felt that children would initially need to be directed to use the schedule until they formed the habit.

Icons on activities in the schedule

All 4 experts praised the integration of SS into the schedule, but they felt that this feature was not obvious without clicking on 'More details...' on each activity in the schedule. E2, E3 and E4 recommended that a suitable icon be added to the activity to make it clear that a SS was available. E4 commented *'this icon here for the reward, have something like that, maybe a book'*. E2 also recommended that an icon be added to the activity to show if there was a video attached. She said *'the video before the dentist, that was really useful but maybe they want to watch it again, not just when they finish the previous activity, so let's have an icon for that too'*.

Track progress of child

There were a few suggestions about ways to allow practitioners and carers to keep track of the progress of the child. E4 suggested that practitioners be able to upload videos of the child carrying out certain activities, saying *'maybe they record the child doing well so they can see that next time if they are anxious about the activity'*. She also recommended that these videos could be used to share information about the progress of the child. The examples she gave were *'maybe the teacher records the child during the day, and then the parent can view it later. Or perhaps the parent records the child not responding well to an activity and they can share that with the practitioner'*.

E1 and E3 also wanted to provide a way for practitioners to track the progress of the child, suggesting that practitioners be able to view a calendar of the child's behaviour. The calendar could have icons for days where the child completed all the activities in a schedule, days where the child successfully dealt with a change to the routine, and days where the child responded poorly, perhaps with tantrum behaviours.

Other suggestions

When observing the steps required to create schedules and SS, E3 and E4 made the suggestion that practitioners should be able to share completed schedules and stories to a public database that other practitioners can search, so they can make use of them. E4 said *'I know how time-consuming these are to make and it would be really nice that if someone else has made a story for something you need, you can just use that'*.

E4 suggested that allowing children to have accounts on the application would make it more flexible. She raised the possibility that *'in a lot of schools, there are maybe one or two devices so to let many children make use of this app on those, they should be able to log in to access their personal schedules and other features'*. She also considered that this would allow children to use the app on different devices in different settings.

E2 and E3 made the suggestion that practitioners should be able to add sounds to SS, which had already been designated as 'Future work' after being raised in the LFP evaluation. However, E3 took this one step further and recommended that practitioners should be able to add a voiceover to the story as well, saying *'for a child who isn't as literate or just doesn't concentrate well on text, having the SS read to them as they look at the pictures could be really effective'*.

E2 repeated a suggestion that was raised in the child evaluation study, recommending that the current setting of only being allowed to mark activities as complete when the previous activity had been completed be removed. She commented *'there are some activities that aren't essential and you can skip them, you shouldn't be prevented from completing everything else'*. Interestingly, in contrast E4 supported this feature, saying *'I like how structured it is, that you can only complete each activity after finishing the previous one; this helps to encourage the child to stick to the schedule'*.

Usability issues

Some usability issues were encountered during the expert evaluation. These include: 1. It is not clear when a SS is linked to an activity (3/4 experts); 2. The box showing the streak and number of stars earned today is not very obvious (2/4 experts); 3. Checkbox to mark activity as complete is not very obvious on a quick viewing, a more obvious

visual change should be used to show completed activities (1/4 experts); 4. The mouse arrow should change to a pointer to show which items are clickable (1/4 experts); 5. Once 'Mark story as read' has been clicked (on final page of a SS), the button should be disabled and read 'Marked as read' (1/4 experts); 6. Menu icon leads back to home page and should therefore use the 'Home' icon instead (1/4 experts)

6.3 Discussion

The aim of the evaluation studies was to investigate the overall effectiveness of the tool to help children with ASC cope with changes in terms of suitability for the target population, level of engagement and enjoyment for the target population, and appropriateness of the methods to help children with ASC cope with changes. Both the children and experts were very satisfied with the tool, with all participants rating their overall experience with the tool between 4/5 and 5/5, resulting in an average score of 4.7/5.

The children and the experts found the application easy to use. When asked, the children could think of no features which they found difficult, and the experts rated this aspect as 4.75/5. These findings were reflected in the session, with all participants discovering most of the features and completing all the tasks without any input from the researcher. The experts also thought that the tool was highly suitable for the target group, giving this aspect an average rating of 5/5.

Children were interested in the tool and eager to complete the tasks in the session, and none of the children became distracted during the study. The experts were of the opinion that the tasks were suitably focused to maintain children's interest, and they praised the rewards system which would motivate children. The children in the evaluation study did enjoy the rewards system and the videos in the tool the most, responding with enthusiasm when they encountered either of these features. The response of the children to the tool during the study showed that it was engaging and enjoyable.

A key area which the experts praised was the appropriateness of the methods implemented in the tool, giving this aspect an average rating of 4.75/5. Their experience of the tool itself during the study, and their experience of the interventions in use in other settings convinced them that the interventions would be effective in supporting children with ASC coping with changes.

The children and the experts offered a number of suggestions to help improve the tool, with the rewards system being a key area of focus for both participants. The experts also felt that there is an opportunity to extend the tool to allow long-term progress to be tracked, which would be useful for practitioners, carers, and the children themselves. At this stage of the design process, these suggestions can be considered a starting point for future development of the tool.

The results of the evaluation studies show that the tool was perceived to have the potential to be effective in helping children with ASC cope with changes. How these findings answer the specific sub-questions of the third research question are discussed in detail in the next chapter.

Chapter 7

Discussion, Conclusion and Future Work

The aim of this project was to investigate how a TBT can be designed and implemented to support children with autism coping with changes. Three main research questions were established for this project and these were used to guide the design process. These questions are answered in this chapter, which also discusses the limitations of the research and presents suggestions for future development in this area.

7.1 Research Questions

1. What are the current interventions used to help children with autism cope with changes?

This question was addressed through the review of the relevant literature.

The researcher analysed the current research in the area of supporting children with autism coping with changes, and evaluated existing TBTs designed with this goal in mind. Thus, a number of interventions designed to help children with ASC cope with changes were identified. VAS were shown to be successful in reducing the time taken for children with ASC to transition between activities [4], and to support children in anticipating changes made to the routine [26]. SS have been effective in introducing children with ASC to novel events [17]. Priming and cueing are both employed to shorten transition times, and reduce non-compliant behaviours during transitions [14]. In addition to these interventions, it has been shown that the integration of rewards in TBTs is an important factor in keeping children with ASC engaged and motivated [9].

A particularly successful application designed to help children with autism cope with changes, the ChangeIt app designed by Varnava [39], was also evaluated. This application showed the potential of a TBT which integrated VAS, SS, and a basic rewards system to be effective in supporting children with ASC coping with changes.

Therefore, four primary interventions were identified: VAS, SS, priming and cuing, and a rewards system.

2. How should technology be designed to support children with autism coping with changes?

This question was answered based on the findings of the literature review (Chapter 2), design studies (Chapter 3), low fidelity prototype evaluation (Chapter 4), and high fidelity prototype implementation (Chapter 5) and evaluation (Chapter 6).

The literature review and the design workshop conducted with 5 children (1 with ASC, 4 TD), as discussed in Chapter 3, resulted in a set of requirements for a tool to help children with ASC cope with changes. Based on these requirements, a LFP was developed (Chapter 4). This prototype was evaluated with 3 experts in the areas of HCI, ASC and Education. The data collected in the evaluation suggested that the design of the tool was suitable for the target population, children with ASC between the ages of 7 - 11 years old, and appropriate to meet the aim of the project, to help children with ASC cope with changes. A number of suggestions to improve the tool also arose from these evaluations. Thus, the initial design of the tool was updated to incorporate these.

A HFP was developed according to the updated design (Chapter 5) and then evaluated with 3 TD children, and 4 experts in ASC, HCI and Education (Chapter 6).

3. How effective is the new tool in helping children with autism to cope with changes?

In order to answer this question, the high fidelity evaluation studies with 3 TD children and 4 experts in HCI, ASC and Education were conducted (Chapter 6). These studies focused on answering the following sub-questions to address this research question.

i. To what extent is the tool suitable for the target population?

In the evaluation with children, all 3 participants reported that the tool was very easy to use. They successfully completed the tasks set out in the evaluation, and discovered most of the functionality of the tool without any input from the researcher. The experts agreed that the tool was highly appropriate for the target population of children with ASC aged 7 - 11 years old, rating this aspect 5/5. They mentioned the use of visuals, minimal text, straightforward tasks and customisability when addressing the suitability of the tool for the target group. The experts also found the tool very easy to use, with this aspect achieving a rating of 4.75/5. Therefore this shows that the tool is regarded as highly suitable for the target population.

ii. To what extent is the tool perceived to be engaging for the target population?

In the evaluation conducted with children, the children showed immediate interest when presented with the tool. All 3 children were eager to explore the tool until they had discovered all of the features available. They were not distracted by other stimuli around them and remained on task throughout the entire session. They also expressed the opinion that they would use the tool frequently, showing that it caught their interest. The experts agreed that the tool would be engaging for the target audience, referring to the clear, straightforward tasks and motivating factors such as the rewards system. This demonstrates that the tool is perceived to be engaging for the target population.

iii. To what extent is the tool perceived to be enjoyable for the target population?

During the evaluation, the children appeared to enjoy interacting with the tool, showing enthusiasm as they explored. They expressed particular excitement when they discov-

ered the reward system, with 2 participants especially eager to earn rewards. All 3 participants were also excited by the presence of videos throughout the application, praising their inclusion whenever they encountered a video. The experts were also of the opinion that the tool would be enjoyable for the target population. They mentioned similar features to those which caught the attention of the children, commenting that the rewards system and the inclusion of videos in particular would be enjoyable. Hence, the tool is considered to be enjoyable for the target population.

iv. Are the features appropriate to help children with autism cope with changes?

This question was answered based on the evaluation studies conducted with experts. The experts rated the features as very appropriate to help children with autism cope with changes, with this aspect earning 4.75/5. All 4 experts agreed that the selected interventions would be effective to support children with autism coping with changes, and that the selected features accommodated various ways to support children. They highlighted the ability to customise the interventions to suit the needs of each individual child when praising the effectiveness of the methods.

It is essential to highlight that this project only involved one child with ASC in the design phase, and that this was at an early stage. Thus any conclusions drawn from the evaluation with TD children should be applied with caution, as the target population of the tool is children with ASC. Although the opinions of experts in ASC were helpful to evaluate the potential of the tool to support this audience, evaluation with children with ASC would be needed to fully answer this research question. However, the results of the evaluation show that this tool is easy to use, and it is perceived to be engaging, enjoyable, and to have potential in helping children with ASC cope with changes.

7.2 Limitations

It was not possible in the time available to fully implement the tool; therefore a HFP of the tool was developed as a proof of concept. All of the suggestions raised throughout the design process could not be incorporated in this prototype so a number of suggestions made by experts in the LFP evaluation were designated as 'Future work'. Although the project involved TD children and experts in ASC, HCI and Education throughout all stages of the design process, only small numbers of both TD children and experts were involved in the evaluation studies due to the difficulty of recruiting many participants in such a limited time. Due to the lack of both time and access to children with ASC, no children with ASC took part in the evaluations studies; hence it was not possible to evaluate whether the tool is effective in helping children with autism cope with changes. Such an evaluation would require a much longer time frame than this project allowed and the participation of many children with ASC. However, in light of these limitations, it was shown that the design of the tool had potential to help children with autism cope with changes.

7.3 Future Work

As discussed in the previous section, due to the limited time available, a number of suggestions raised in the evaluation studies were designated as 'Future work'. These

suggestions are considered to be a starting point for future development. The evaluation studies show that the prototype provides a base for a fully functioning tool that can be easy to use, engaging for children, and suitable to help children with autism cope with changes. In order to implement such a tool, a number of additional improvements are recommended. Some of the suggestions which arose from the evaluation studies include: progress calendar on practitioner interface; public, searchable database of resources created by practitioners, e.g. schedules, SS; animations for rewards; practitioner and child user accounts. A list of suggestions can be found in Appendix M.

Although the application was designed to support children with ASC coping with changes, further research into features which could be added or how existing features could be extended to assist children with ASC in other ways should be conducted.

An essential aspect of any future development is evaluation of the tool with children with ASC, as this was not feasible during this project. In addition to including children with ASC in evaluation studies, further evaluation with a greater number of participants should be carried out in order to confirm the findings of the studies in this project. Although TD children and experts in HCI, ASC and Education were involved in the evaluation of this tool, it would be useful to include parents and practitioners also.

A long term comparative study to evaluate the effectiveness of the tool in helping children with autism to cope with changes would be a vital component in any further development. By studying the impact of long term use of the tool, it would be possible to observe the extent to which the tool addresses children with ASC's ability to cope with change, and whether any newly attained skills are maintained and/or transferable.

Additional long term studies should be conducted to evaluate the use of the tool in various settings, such as within the home and at school. The tool may be more or less effective in certain settings and identification of successful features and shortfalls in the application in specific settings could inform further development of the tool.

7.4 Conclusion

This project researched how a technology-based tool can be designed and developed to help children with autism cope with changes. Taking an approach based on ID, a prototype web application was designed, developed and evaluated iteratively with TD children, one child with ASC and experts in HCI, ASC and Education at different stages of this process. These evaluations suggested that the tool has potential to be effective in helping children with autism to cope with changes. The contributions of this research are: 1. identification of interventions for helping children with ASC cope with changes; 2. a design solution for a tool to support children with ASC coping with changes; 3. the implementation and evaluation of this tool to be used by children with ASC to anticipate and cope with changes; 4. empirical evidence from the evaluation of this tool with TD children and experts in HCI, ASC and Education that suggests that it has potential to be effective in helping children with ASC cope with changes.

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Appendix A

Criteria for Social Stories (Gray, 2010)

1. The Social Story Goal

Authors follow a defined process to share accurate information using a content, format, and voice that is descriptive, meaningful, and physically, socially, and emotionally safe for the Audience.

2. Two-Step Discovery

Keeping the Goal in mind, authors gather relevant information to 1. improve their understanding of the Audience in relation to a situation, skill, or concept and/or 2. identify the specific topic(s) and the most critical information (focus) of each Story.

3. Three-Parts and a Title

A Social Story/Article has a title and introduction that clearly defines the topic, a body that adds detail, and a conclusion that reinforces and summarizes the information.

4. Fourmat Makes it Mine!

The Social Story format is tailored to the individual abilities, attention span, learning style and talents and/or interests of its Audience.

5. Five Factors Define Voice and Vocabulary

A Social Story has a patient and supportive 'voice' and vocabulary that is defined by five factors:

1. First or Third person perspective statements
2. Past, present, or future tense
3. Positive and patient tone
4. Literally accurate
5. Accurate meaning

6. Six Questions Guide Story Development

A Social Story answers relevant WH questions that describe context, including place (WHERE), time-related information (WHEN), relevant people (WHO), important cues (WHAT), basic activities, behaviors, or statements (HOW), and the reasons or rationale behind them (WHY).

7. Seven is About Sentences

A Social Story is comprised of Descriptive Sentences and may also have one or more Coaching Sentence(s). Descriptive Sentences accurately describe relevant aspects of context, including external and/or internal factors while adhering to all applicable Social Story Criteria. They are free of assumption or bias, judgment, devaluation, or unidentified opinion. Coaching Sentences gently guide behavior via descriptions of effective Team or Audience responses, or structured Audience Self-Coaching, adhering to all other applicable Social Story Criteria.

8. Gr-Eight! Formula

The Social Story Formula ensures that every Social Story describes more than directs.

9. Nine to Refine

The first draft of a story is rarely the final draft. A story draft is always reviewed by relevant caregivers and revised if necessary to ensure that it meets all defining Social Story criteria.

10. Ten Guides to Editing and Implementation

The Ten Guides to Implementation ensure that the philosophy and Criteria that guide Story/Article development are consistent with how it is introduced and reviewed with the Audience. They are:

1. Plan for Comprehension
2. Plan Story Support
3. Plan Story Review
4. Plan a Positive Introduction
5. Monitor
6. Organize the Stories
7. Mix Match to Build Concepts
8. Story Re-runs and Sequels to Tie Past, Present, and Future
9. Recycle Instruction into Applause
10. Stay Current on Social Story Research and Updates

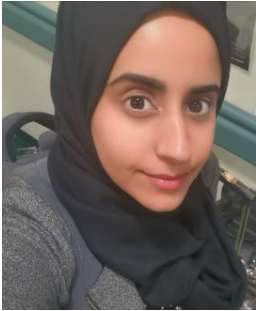







Appendix B

Child Information and Consent Form - Design Workshop

Designing and Testing Games to Help Children (to be read aloud to the child)

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

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

			
Aljawharah	Helen	Aurora	Aimee
			
Sophia	Ethan	Andreas	Kaiwen

How can I help?

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

What will happen if I help?

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

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

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

What will happen after I am finished helping?

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

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

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

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

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

Child Consent Form

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

I can choose to be a game developer.

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

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

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

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

There are no wrong answers to questions.

Anything I can do is very helpful.

Do you want to be a game developer? YES NO

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

Is it okay to take video recordings?

YES

NO

Write your name:

THANK YOU 😊!!

Appendix C

Parent Information and Consent Form - Design Workshop

Designing Educational Games and Tools for Children with Autism

Information sheet for parents and guardians

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

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

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

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

University of Edinburgh, School of Informatics

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

Overview of the project



THE UNIVERSITY of EDINBURGH
informatics

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

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

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

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

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

Andreas: The aim of the project is to develop a technology that would help children interact in an online environment, facilitating the reduction of their anxiety levels in social situations. The purpose of this workshop is to gather information from children regarding social anxiety. The main aims are:

- Determine social situations where children might feel anxious
- Determine practices that help them cope with those situations



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

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

How can my child help?

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

Workshop Information

What happens during the workshop?

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



activities, we will ask them a few questions. They will each participate in X (will edit depending on each workshop structure) workshops, if they are happy to do so.

Video and audio recordings

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

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

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

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

Will this project teach my child new skills?



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

What happens when the project is over?

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

How will personal information be protected?

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

Who paid for this research?

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

Who can I contact?

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



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

Updated information.

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

Alternative formats.

To request this document in an alternative format, such as large print or on coloured paper, please contact any of the lead researchers or the research supervisor.

General information

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

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

Thank you for taking the time to read this.



Parent Consent Form

* Required

1. Have you read the information sheets? *

Yes

No

2. Have you received enough information about the study? *

Yes

No

3. Do you understand that participation is completely voluntary and your child can leave the study at any time, without having to give a reason? *

Yes

No

4. Do you consent for your child to take part in this study? *

Yes

No

Details

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

5. Full name of participating child: *

6. Child's date of birth: *

Format: M/d/yyyy

7. Your relationship to the child: *

8. Your full name: *

9. Email address: *

10. Date: *

Format: M/d/yyyy

4/7/2021

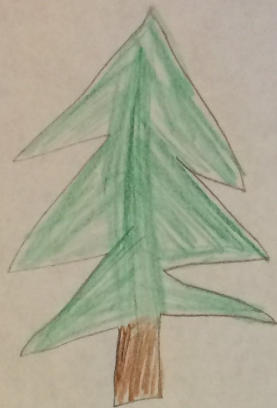
This content is neither created nor endorsed by Microsoft. The data you submit will be sent to the form owner.



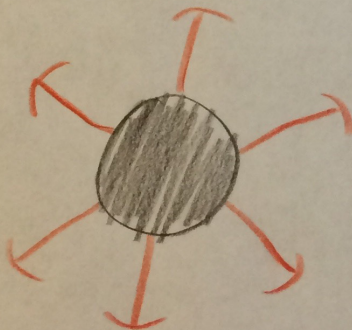
Appendix D

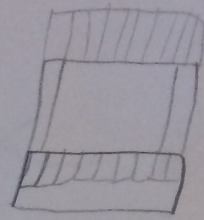
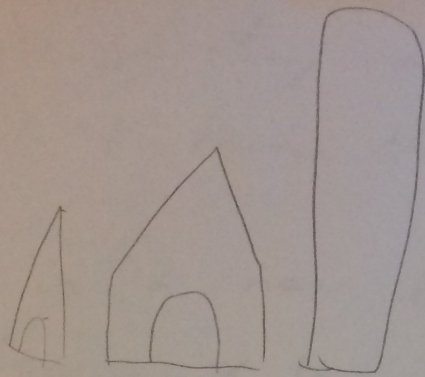
Children's Drawings from Design Workshop

Happy:

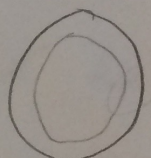
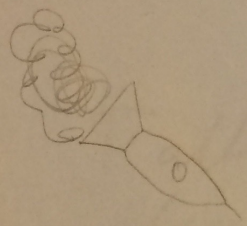
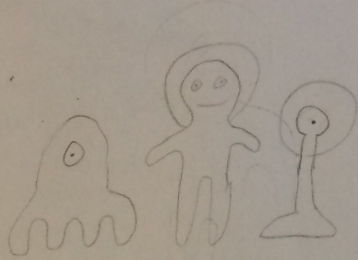


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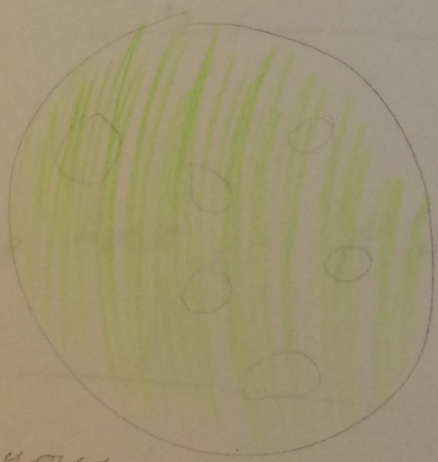
Stall



Coins

Upgrades

- UFO gets around the planet faster
- Pets - follow you around
- Hats
- Accommodation

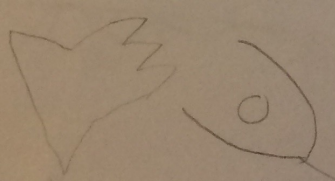


Find the parts

~ - Wire

⊗ = Turbo-charger

⚙ = Cog



- 18 Alex is starting a new club and doesn't know the people there.
- 18 there is a new teacher that has a different teaching style to the last one.

Talking to people that he already knows

Spending time in places that he likes

Listening to music

to

If you get them to go to a place
successfully then it says well done
you will come to the place repeatedly

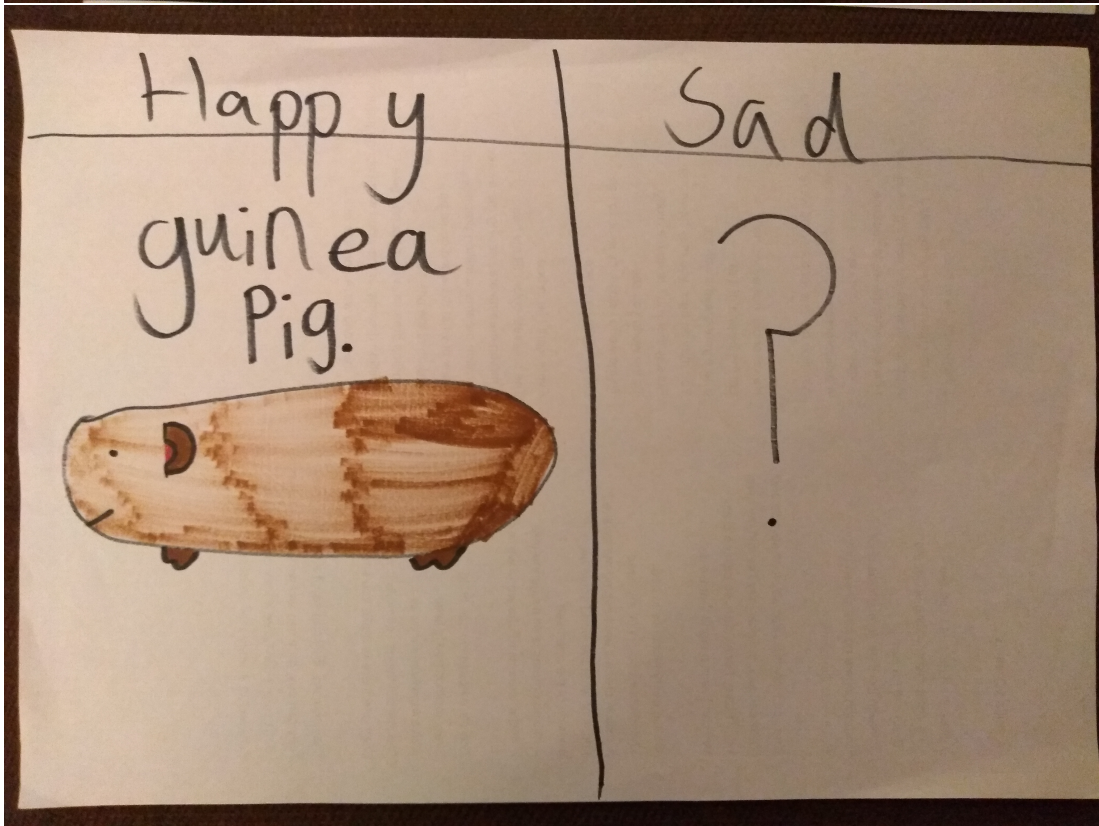
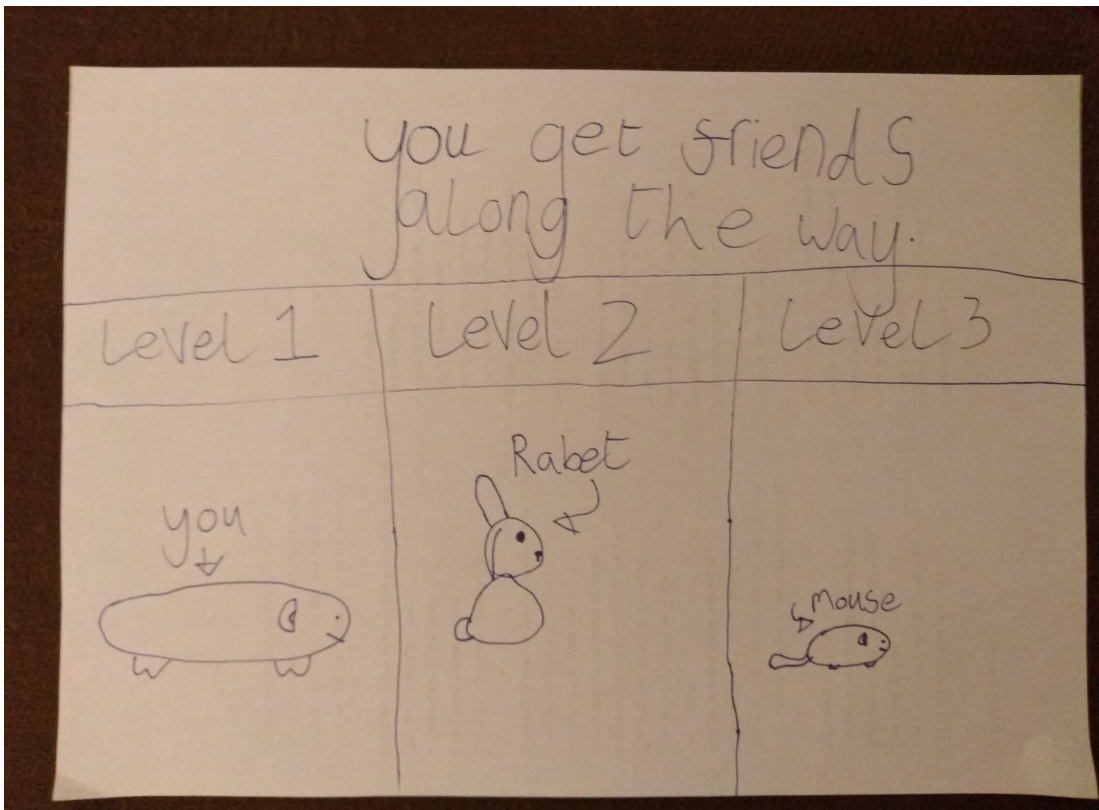
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Well done
now you
3 stars

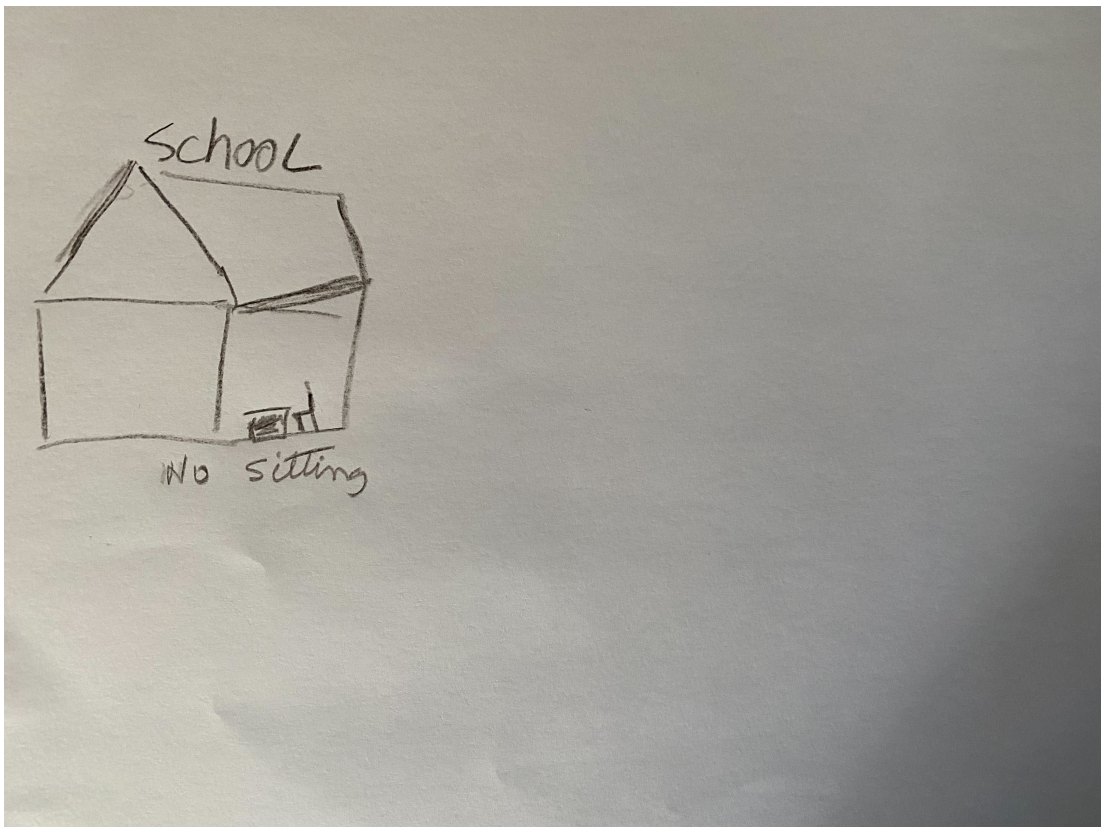


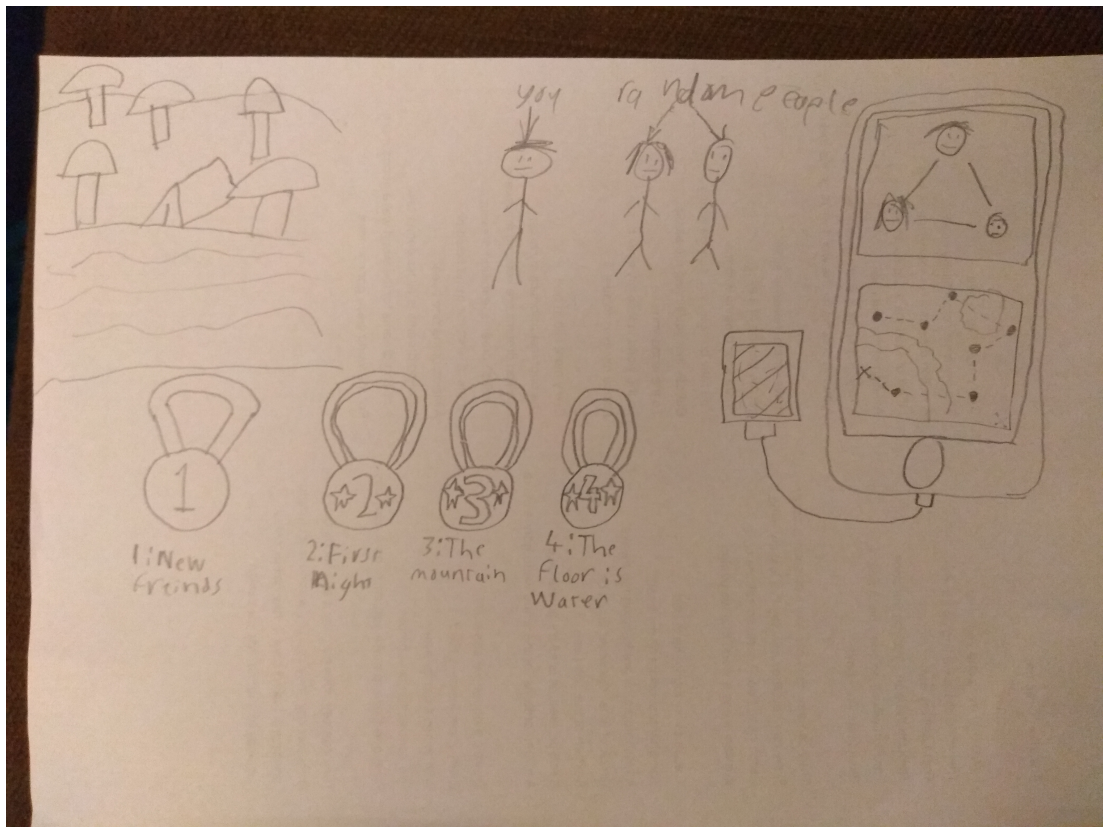
end the
robot's cycle
perhaps











Appendix E

Nielsen's Usability Heuristics (1994)

HCI P1: Visibility of system status

Appropriate feedback should be given to the users within appropriate time so the users are always informed about their status. The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.

HCI P2: Match between system and the real world

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

HCI P3: User control and freedom

Allow the user to have control of the interaction. Users should be able to undo actions, exit from any sequence of actions, and not be forced into a series of actions.

HCI P4: Consistency and standards

Information that is the same should appear to be the same. Information that is different should be expressed differently. Developers need to know the conventions being used in the software

HCI P5: Error prevention

If possible, prevent errors from happening in the first place

HCI P6: Recognition rather than recall

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

HCI P7: Flexibility and efficiency of use

Experts should have a way to use the interface faster or more efficiently Design should have accelerators like keyboard shortcuts to allow skilled users to move faster

HCI P8: Aesthetic and minimalist design

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

HCI P9: Help users recognize, diagnose, and recover from errors

Error messages should be clear, written in plain English, explain the problem, give

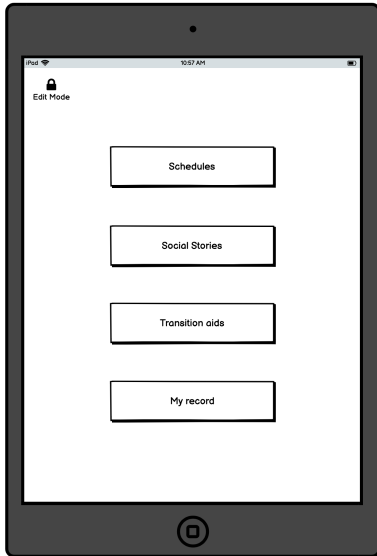
constructive advice on how to solve the problem

HCI P10: Help and documentation

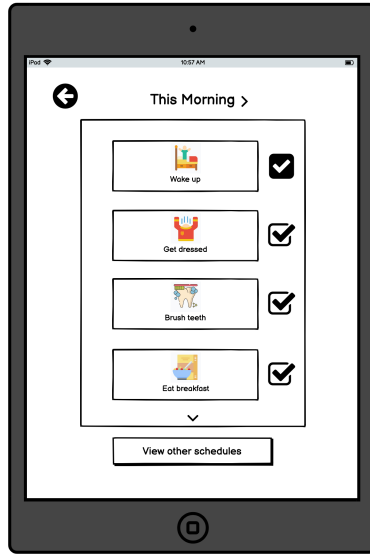
Unless the system is extremely simple, some people will need help documentation

Appendix F

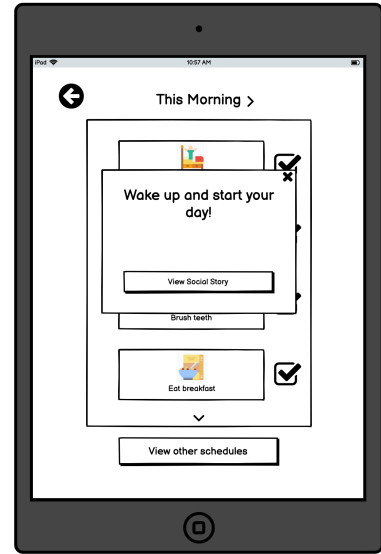
Low Fidelity Prototype Design



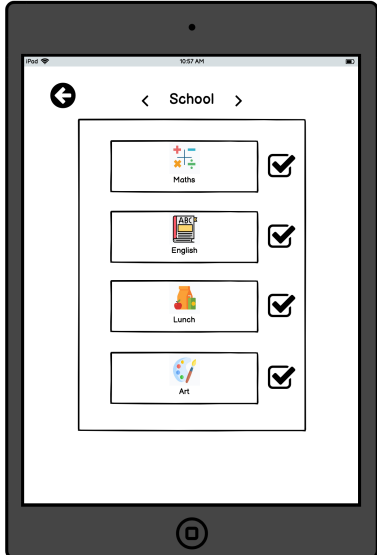
Main menu (child interface)



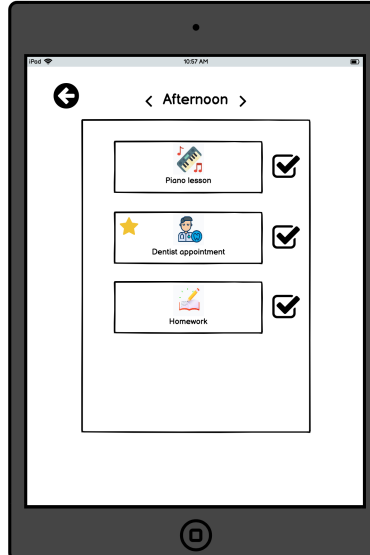
First page of Visual Activity Schedule, with icons and titles for each activity, and a checkbox to mark activities as complete



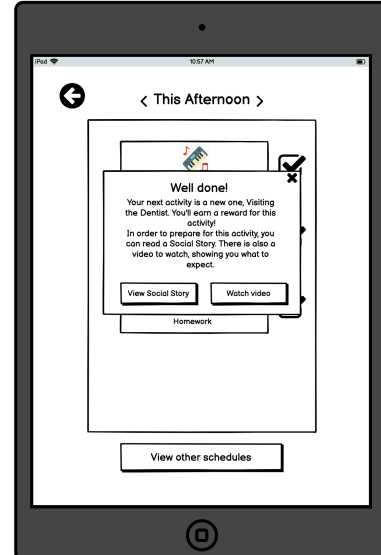
Details such as a longer caption/text description pop-up, and a link to a Social Story is shown if applicable, when you click on an activity



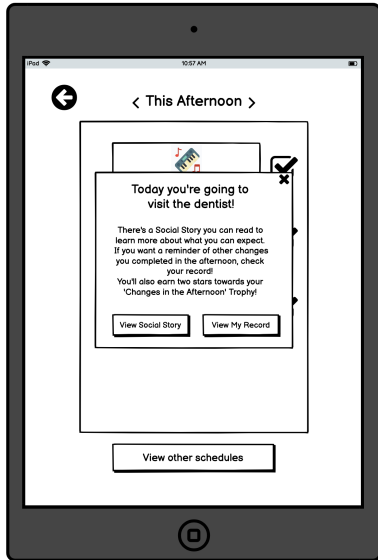
Second page of Visual Activity Schedule



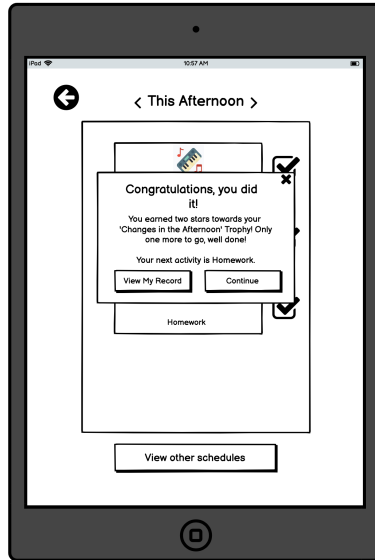
Third page of Visual Activity Schedule, with one 'reward' activity, marked with a star icon



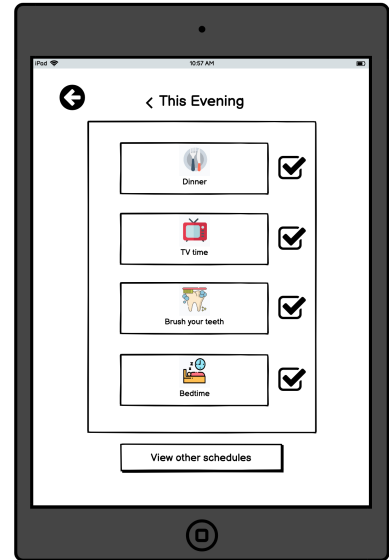
Pop-up when marking an activity with a transition aid attached as complete, provides links to relevant transition aids



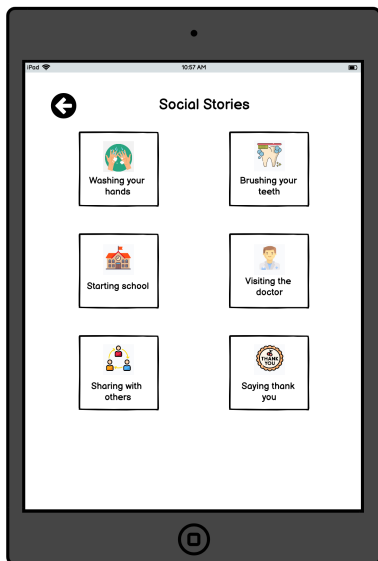
Details pop-up and link to Social Story and Rewards page when you click on a 'reward' activity



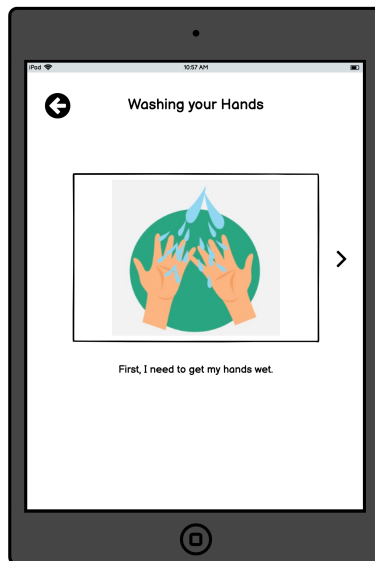
Pop-up when marking a 'reward' activity as complete, with congratulatory message and link to Rewards page



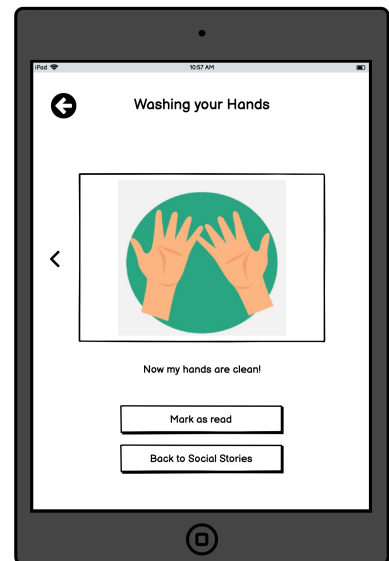
Final page of Visual Activity Schedule



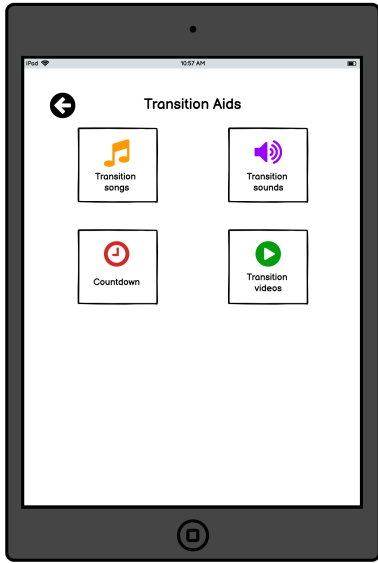
List of Social Stories to choose from



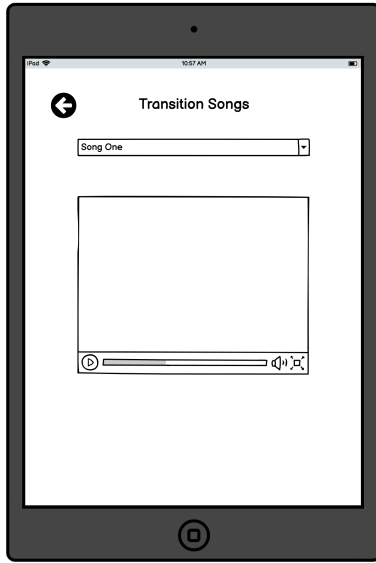
First page of a Social Story, with an image and caption



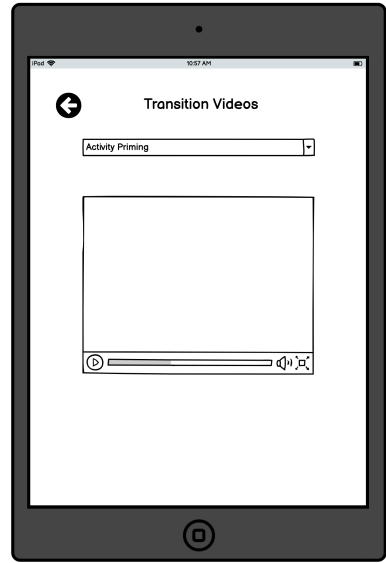
Last page of a Social Story, where users can mark the story as read



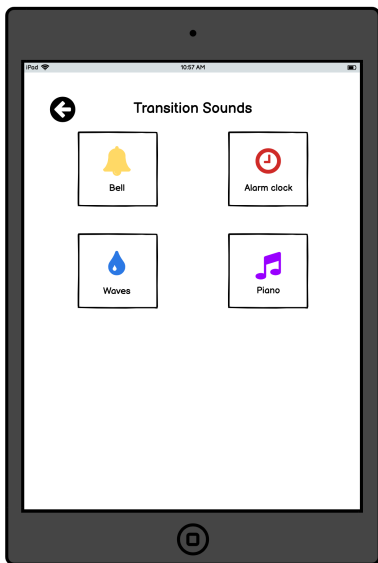
List of Transition Aids to choose from



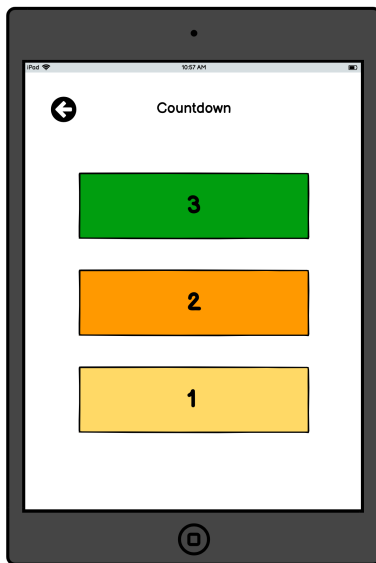
Embedded video to listen to a transition song when selected



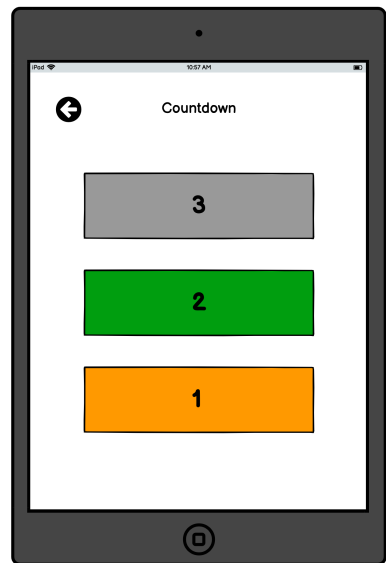
Embedded video to watch a transition video when selected



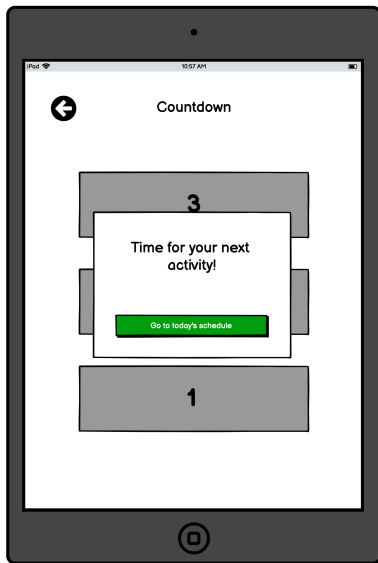
List of transition sounds which can be played directly by clicking



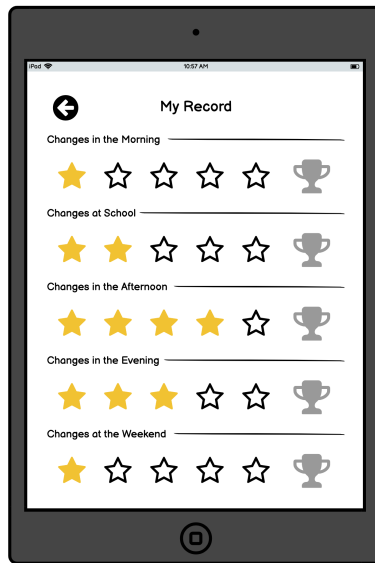
Visual countdown with cards which can be removed sequentially to show time passing



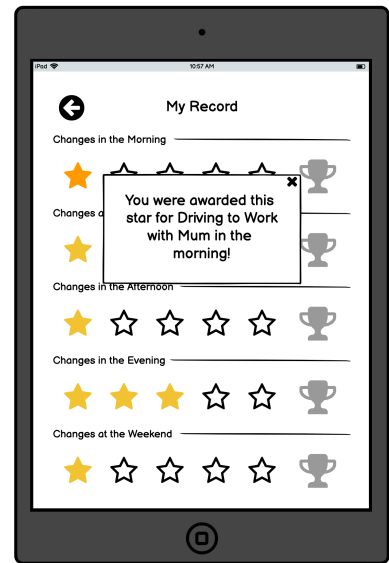
Time elapsing as cards are removed by clicking on the green card



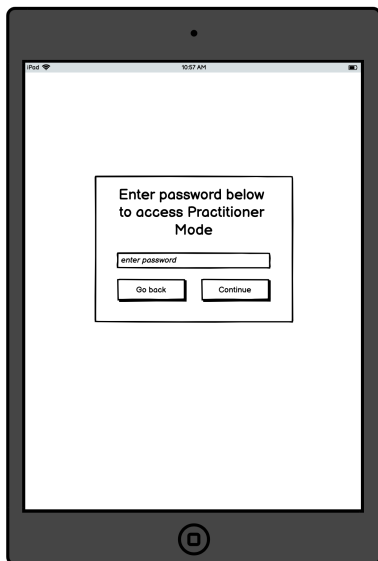
Pop-up when the final countdown card is removed



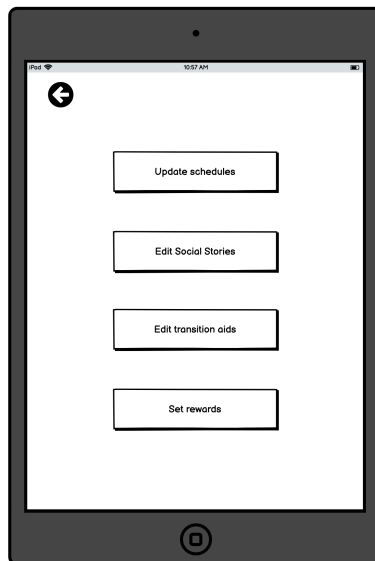
Track Record page showing the stars you have been awarded and the trophies you are working towards



Clicking on a star shows a pop-up explaining what the star was awarded for



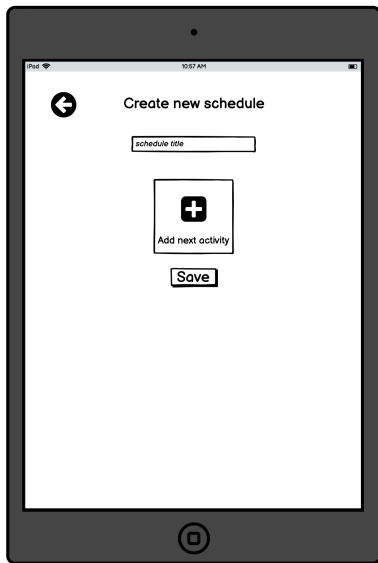
Password protected entry to the practitioner interface



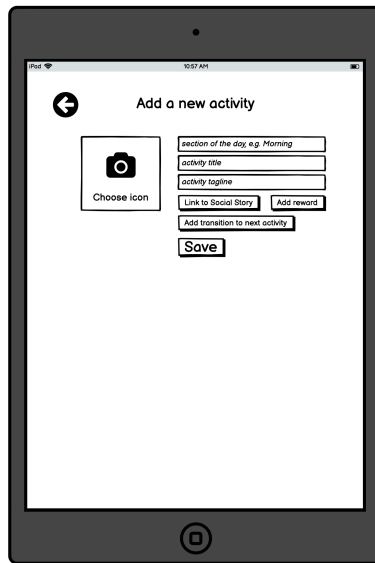
Main menu (practitioner interface) allowing users to edit all aspects of the child interface



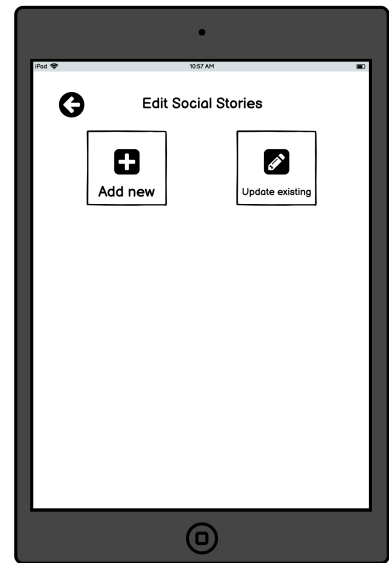
Options to add new schedules and edit existing schedules



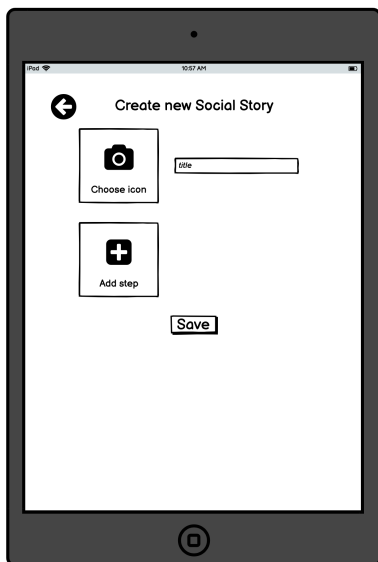
First page of 'Add new schedule' template allows users to set a title and icon for the schedule, and add activities



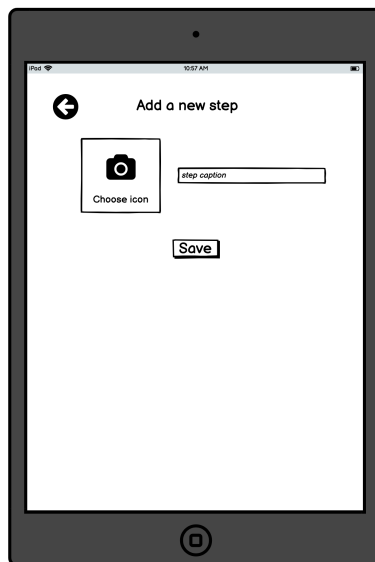
Template for adding a new activity to a schedule allows users to set a section of the schedule for it to belong to, an icon and title, a caption which will appear in the pop-up, link a Social Story, add a reward for completing the activity, and add a transition to the next activity



Options to add a new Social Story or edit an existing one



First page of 'Add new story' template allows users to add a title and icon for the story, and add steps



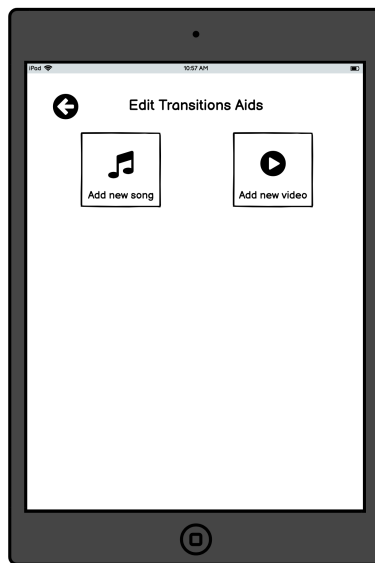
Template for adding a new step to a story allows users to set the image and caption for the step



Options to add new rewards and edit existing schedules



When adding a new reward, users can set the trophy title and the number of stars required to earn it



When editing Transition Aids, users can upload new songs or videos; the visual countdown and transition sounds are not customisable

Appendix G

Expert Information and Consent Form - Low Fidelity Evaluation

Designing Educational Games and Tools for Children with Autism

Information sheet for researchers

This information sheet contains information about the research project at the University of Edinburgh in which you are invited to participate. After reading the information you are asked to fill in the consent form accepting your participation in the evaluation workshop. If you have further questions, do not hesitate to contact us and discuss them.

This study was certified according to the Informatics Research Ethics Process, RT number 5381. Please take time to read the following information carefully. You should keep this page for your records.

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

- Aimee Redbond: s1713640@sms.ed.ac.uk (Lead Researcher)
- Dr. Aurora Constantin: aurora.constantin@sms.ed.ac.uk (Research supervisor)
- Aljawharah Alabdullatif: s1500319@sms.ed.ac.uk (Research advisor)
- Prof. Helen Pain: helen@staffmail.ed.ac.uk (Research supervisor)

University of Edinburgh, School of Informatics

Please return the consent form to one of the researchers if you consent to participate in the project.



Overview of the project

I am one of five UG4 students from the University of Edinburgh working on educational tools for children with autism as a part of our Honours projects. Each student pursues research in their chosen area and will develop their own tool.

What is the goal of the project?

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

I aim to develop an interactive app which will help children with ASC to cope with changes. The purpose of the app is to reduce the anxiety caused by changes, and to help children with autism to become more flexible and resilient when faced with changes in the future.

Workshop Information

What happens during the workshop?

Workshops will take place online using Microsoft Teams. At this workshop, you will be asked to evaluate a low fidelity prototype of a technology based tool, designed using the Balsamiq online software, which aims to help children on the autism spectrum cope with changes. Once you interact with it, I will ask for your opinion on the design and any suggestions you have to improve it.

Video and audio recordings

I would like to video record the session, to provide a record for later analysis and allow us to freely interact during the session without worrying about taking notes. The video would be accessed only by the researchers named above during the analysis. If you are not comfortable with being video recorded at all, then you should not participate in this particular study.



What happens after the workshop?

After the workshop has finished and the data has been analysed, it will be used to inform the design of, and later implement, the technology based tool. The results will be summarised in an anonymised format in an undergraduate dissertation. The data and findings may be presented or shared in scientific journals or conferences.

How will personal information be protected?

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

Who paid for this research?

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

Who can I contact?

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

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



Updated information.

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

Alternative formats.

To request this document in an alternative format, such as large print or on coloured paper, please contact any of the lead researchers or the research supervisor.

General information

Once again, this study is completely voluntary and you 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.



Low Fidelity Design Expert Consent Form

* Required

1. Have you read the information sheet? *

Yes

No

2. Have you received enough information about the study? *

Yes

No

3. Do you understand that participation is completely voluntary, and you can stop the study at any time, without having to give a reason? *

Yes

No

4. Do you consent to take part in the study? *

Yes

No

Details

By filling in the details below, you indicate that you understand and accept the conditions of the study, including recording of the session.

5. Please enter your full name: *

6. Please enter your email address: *

7. Please briefly describe your area of expertise: *

8. Date: *



Format: M/d/yyyy

4/12/2021

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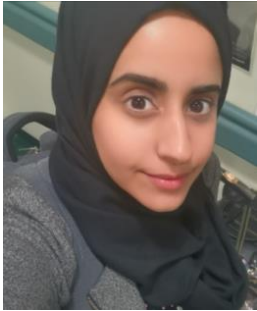







Appendix H

Child Information and Consent Form - Evaluation Workshop

Designing and Testing Games to Help Children (to be read aloud to the child)

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

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

			
Aljawharah	Helen	Aurora	Aimee
			
Sophia	Ethan	Andreas	Kaiwen

How can I help?

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

What will happen if I help?

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

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

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

What will happen after I am finished helping?

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

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

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

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

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

Child Consent Form

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

I can choose to be a game tester.

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

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

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

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

There are no wrong answers to questions.

Anything I can do is very helpful.

Do you want to be a game developer? YES NO

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

Is it okay to take video recordings?

YES

NO

Write your name:

THANK YOU 😊!!

Appendix I

Parent Information and Consent Form - Evaluation Workshop

Designing Educational Games and Tools for Children with Autism

Information sheet for parents and guardians

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

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

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

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

University of Edinburgh, School of Informatics

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



Overview of the project

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

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

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

Kaiwen: I have designed and developed a web game, the purpose of this game is to help children with autism overcome their anxiety and understand dentist meaning when they go to the dentist. Children will be asked to explore the game, complete some game tasks and provide some feedback on what can be changed, added or improved. **To play this game, children will need a computer with window operation system and download a document by email in advance and put it on the desktop. A short text " --enable-webgl --ignore-gpu-blacklist --allow-file-access-from-files" need to be copied and then paste. The steps are right-click on the Google browser to select properties, the copy then at the end of target (T), notice the first two space.**

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

Andreas: I have developed a Minecraft map that simulates social situations (going to school, going to the hairdresser, playing soccer) that children might find stressful in



real life and I have designed calming rooms that tries to teach the player self-calming techniques (i.e. counting in your head from 1 to 10, breathing exercise, relaxing in a quiet place). Children will be asked to explore the game by following the instructions given on the screen and provide feedback on their experience. **To play the game, children will need Minecraft Java Edition (the Official version) installed on their computer.**

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

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

How can my child help?

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

Workshop Information

What happens during the workshop?

Workshops will take place individually online using Microsoft Teams. At least one researcher and one supervisor will be present for all workshops. Your child will get to



engage in the numerous different games that have been made and provide feedback and ideas for c. 30 minutes. In order to facilitate these activities, we would request that you provide sheets of blank paper and colouring pencils for your child to use during the session. We may request that any materials created by your child during the session be uploaded for our review after the session. If your child is willing to talk to us about the activities, we will ask them a few questions. They will each participate in X (will edit depending on each workshop structure) workshops, if they are happy to do so.

Video and audio recordings

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

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

If you say “yes” when returning the permission form, we will explain the game designer role to your child and ask them if they want to help. We will remind your child that they can stop being a developer at any time, without having to give any reason, and that we will always listen to them. We will check that the child agrees to be video recorded. This explanation will be based on the child information sheet included in this packet. We feel strongly that children should be given a real choice about whether to participate. Even if you say “yes” on the permission form, your child



may still say “no” if s/he does not want to be a game developer. We will respect your child’s decision.

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

Will this project teach my child new skills?

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

What happens when the project is over?

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

How will personal information be protected?

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

Who paid for this research?



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

Who can I contact?

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

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

Updated information.

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

Alternative formats.

To request this document in an alternative format, such as large print or on coloured paper, please contact any of the lead researchers or the research supervisor.

General information

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

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



Thank you for taking the time to read this.



Parent Consent Form

* Required

1. Have you read the information sheets? *

Yes

No

2. Have you received enough information about the study? *

Yes

No

3. Do you understand that participation is completely voluntary and your child can leave the study at any time, without having to give a reason? *

Yes

No

4. Do you consent for your child to take part in this study? *

Yes

No

Details

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

5. Full name of participating child: *

6. Child's date of birth: *

Format: M/d/yyyy

7. Your relationship to the child: *

8. Your full name: *

9. Email address: *

10. Date: *

Format: M/d/yyyy

4/7/2021

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Appendix J

High Fidelity Evaluation - Children

No	Task
1	Find today's schedule and describe the activities you have in each section.
2	Identify which activity in the schedule is special. What do you think makes it special?
3	Mark the special activity as complete.
4	Find your prizes and tell me what the first star was awarded for. Tell me what the real prize is for the first trophy.
5	Read the Social Story about going to the dentist.
6	If you were sad or worried, where would you go in the app?

Table J.1: Details of the Study Tasks

Questions

1. Was the app easy or hard to use overall?

Possible follow-up: What was hard to use?

2. What did you like about the app?

3. What did you dislike or like the least?

4. What was your favourite part of the application?

Possible question depending on exploration: When you were going through the schedule, was it helpful to view the video before the dental appointment?

5. Do you have any suggestions to help improve the app?

6. Do you think children would use the app frequently?

7. How would you rate the app from 1 - 5 stars?

Possible follow-up: What would need to change to make that 5 stars?

Appendix K

Expert Information and Consent Form - High Fidelity Evaluation

Designing Educational Games and Tools for Children with Autism

Information sheet for researchers

This information sheet contains information about the research project at the University of Edinburgh in which you are invited to participate. After reading the information you are asked to fill in the consent form accepting your participation in the evaluation workshop. If you have further questions, do not hesitate to contact us and discuss them.

This study was certified according to the Informatics Research Ethics Process, RT number 5381. Please take time to read the following information carefully. You should keep this page for your records.

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

- Aimee Redbond: s1713640@sms.ed.ac.uk (Lead Researcher)
- Dr. Aurora Constantin: aurora.constantin@sms.ed.ac.uk (Research supervisor)
- Aljawharah Alabdullatif: s1500319@sms.ed.ac.uk (Research advisor)
- Prof. Helen Pain: helen@staffmail.ed.ac.uk (Research supervisor)

University of Edinburgh, School of Informatics

Please return the consent form to one of the researchers if you consent to participate in the project.



Overview of the project

I am one of five UG4 students from the University of Edinburgh working on educational tools for children with autism as a part of our Honours projects. Each student pursues research in their chosen area and will develop their own tool.

What is the goal of the project?

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

I aim to develop an interactive app which will help children with ASC to cope with changes. The purpose of the app is to reduce the anxiety caused by changes, and to help children with autism to become more flexible and resilient when faced with changes in the future.

Workshop Information

What happens during the workshop?

Workshops will take place online using Microsoft Teams. At this workshop, you will be asked to evaluate a high fidelity prototype of a technology based tool, which aims to help children on the autism spectrum cope with changes. Once you interact with it, I will ask for your opinion on the design and any suggestions you have to improve it.

Video and audio recordings

I would like to video record the session, to provide a record for later analysis and allow us to freely interact during the session without worrying about taking notes. The video would be accessed only by the researchers named above during the analysis. If you are not comfortable with being video recorded at all, then you should not participate in this particular study.

What happens after the workshop?



After the workshop has finished and the data has been analysed, it will be used to inform the design of, and later implement, the technology based tool. The results will be summarised in an anonymised format in an undergraduate dissertation. The data and findings may be presented or shared in scientific journals or conferences.

How will personal information be protected?

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

Who paid for this research?

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

Who can I contact?

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

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

Updated information.



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

Alternative formats.

To request this document in an alternative format, such as large print or on coloured paper, please contact any of the lead researchers or the research supervisor.

General information

Once again, this study is completely voluntary and you 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.



Final Evaluation Consent Form

* Required

* This form will record your name, please fill your name.

1. Have you received enough information about the study? *

Yes

No

2. Do you understand that participation is completely voluntary, and you can stop the study at any time, without having to give a reason? *

Yes

No

3. Do you consent to take part in the study? *

Yes

No

4. Please enter your full name: *

5. Please enter your email address: *

6. Please briefly describe your area of expertise: *

7. Date *



Format: M/d/yyyy

4/12/2021

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Appendix L

High Fidelity Evaluation - Experts

Questions

1. On a scale of 1 - 5, how easy was the tool to use?
2. On a scale of 1 - 5, how appropriate is the tool for the target population, children with ASC aged 7 - 11 years old?
3. On a scale of 1 - 5, how suitable are the methods selected to help children with autism cope with changes?
4. On a scale of 1 - 5, what rating would you give the tool overall? 5. In your opinion, which feature is the most useful?
6. What suggestions would you make to improve the tool?

Appendix M

Suggestions to Improve the Design

- Implement progress calendar on practitioner interface
This suggestion requires further research (see 6.2.5 Suggestions for further details).
Practitioners can view icons relating to the child's progress on this calendar and also upload videos of child's performance at certain activities
- Create public, searchable database of resources, e.g. schedules, Social Stories
Allow practitioners to save resources created by other practitioners, and to share resources they create
- Add celebratory animation when receiving a reward, e.g. fireworks, sparkles
- Add animation to most recently earned star in 'My Prizes'
- Add space for viewing trophies earned so far
- Replace trophy icons in 'My Prizes' with an image of the real world reward the child will earn
- Add reward for reading Social Story
- Add reward for completing section/day schedule
- Add additional functionality to rewards system: children earn access to videos in 'Happy Space'
- Add additional icons to activities in schedule to show link to Social Stories and videos
- Allow practitioners to set one of three options for completing activities:
 1. Strict: Activities in the schedule must be completed and checked in order
 2. Loose: Activities in the schedule can be completed and checked in any order
 3. Hybrid: Certain activities are optional and therefore can be skipped; all others must be completed and checked in order
- Allow practitioners to configure whether 'Other Schedules' can be viewed, e.g. tomorrow's schedule, schedule for the week

- Allow practitioners to upload personal videos and images for use in schedules, Social Stories, or as transition and 'Happy Space' resources
- Allow practitioners to add sounds to Social Stories
- Allow practitioners to add a voice over to Social Stories
- Allow users to customise the tool appearance i.e. background and colour scheme
- Integrate timer with visual countdown for use in schedule as a transition aid
- Require user authentication
 1. Child account
Require child log-in to access child interface. Allows children to access their resources on multiple devices, and allows multiple children to make use of the app on a shared device
 2. Practitioner account
Require practitioner log-in to access practitioner interface. Allows practitioners to make changes from multiple devices. Practitioners could have links to children accounts, so they can create schedules, stories, etc for multiple children and link them to the correct child.

Appendix N

Images of High Fidelity Prototype

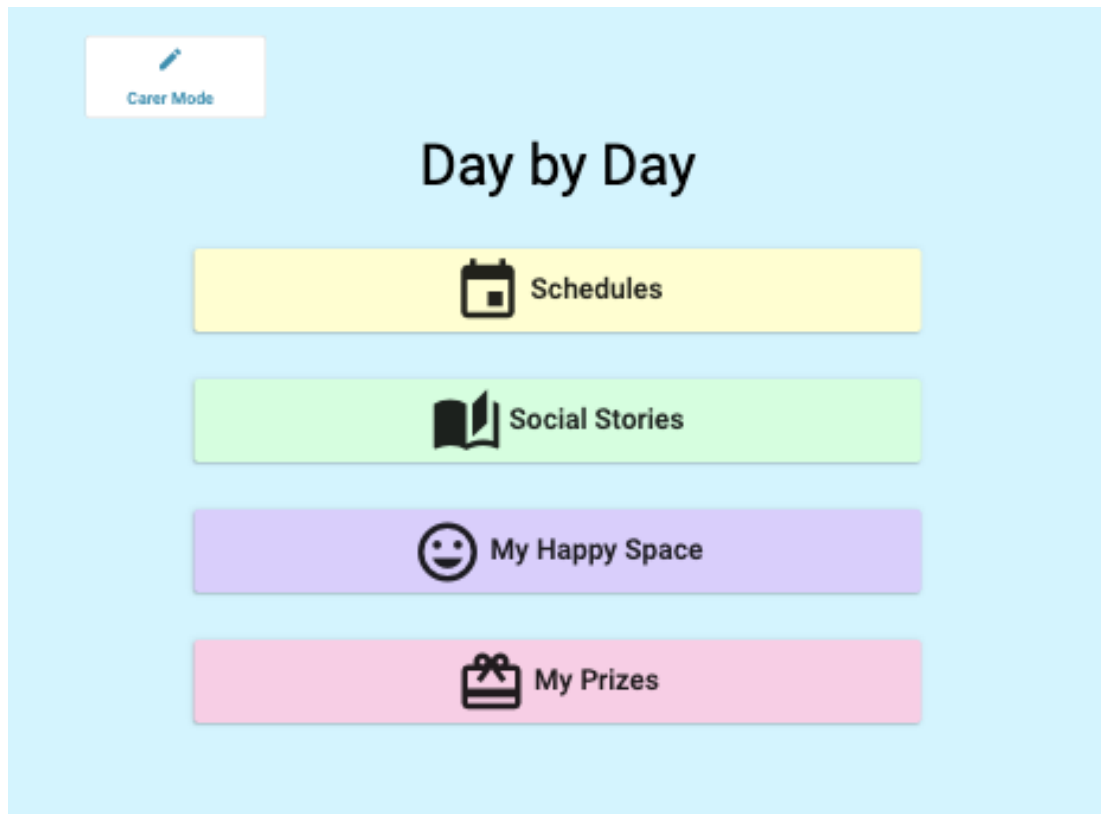


Figure N.1: Child interface menu

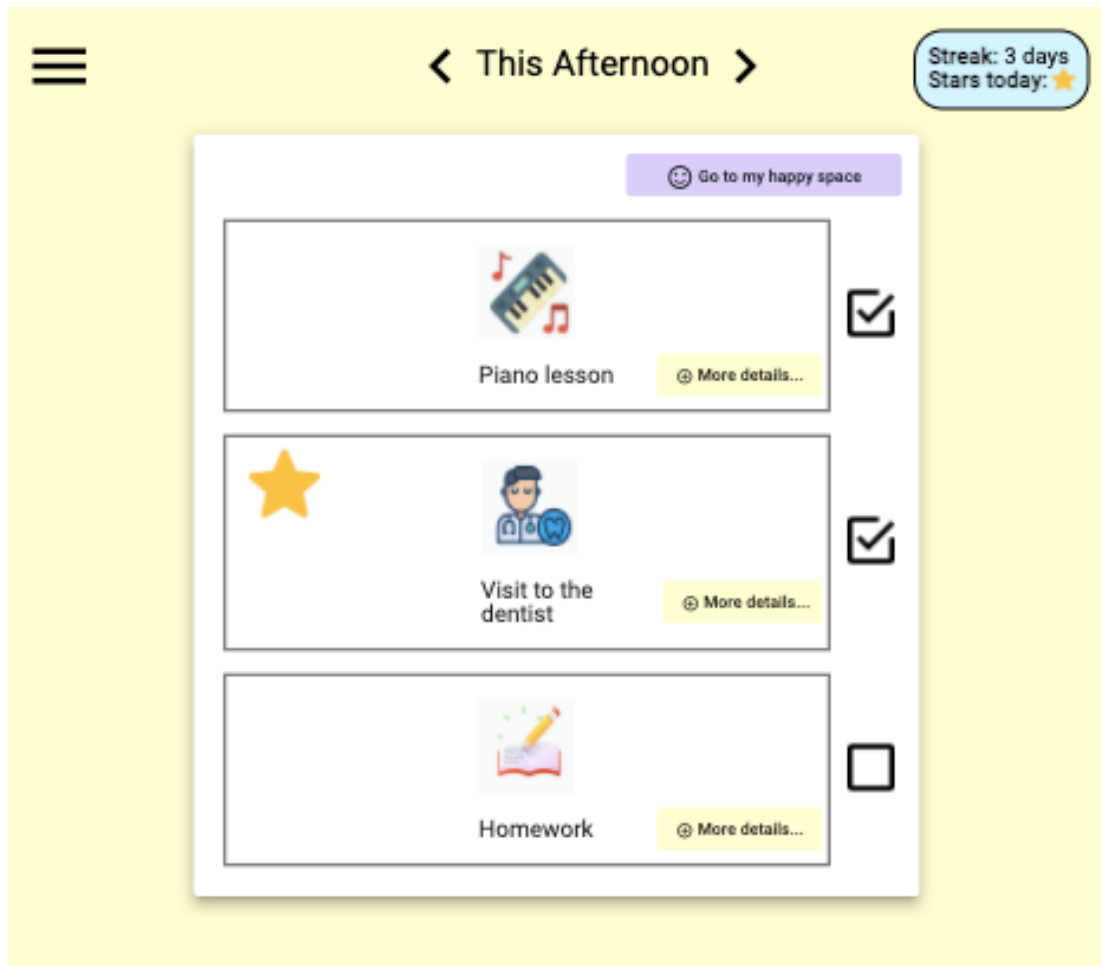


Figure N.2: A section of a visual schedule

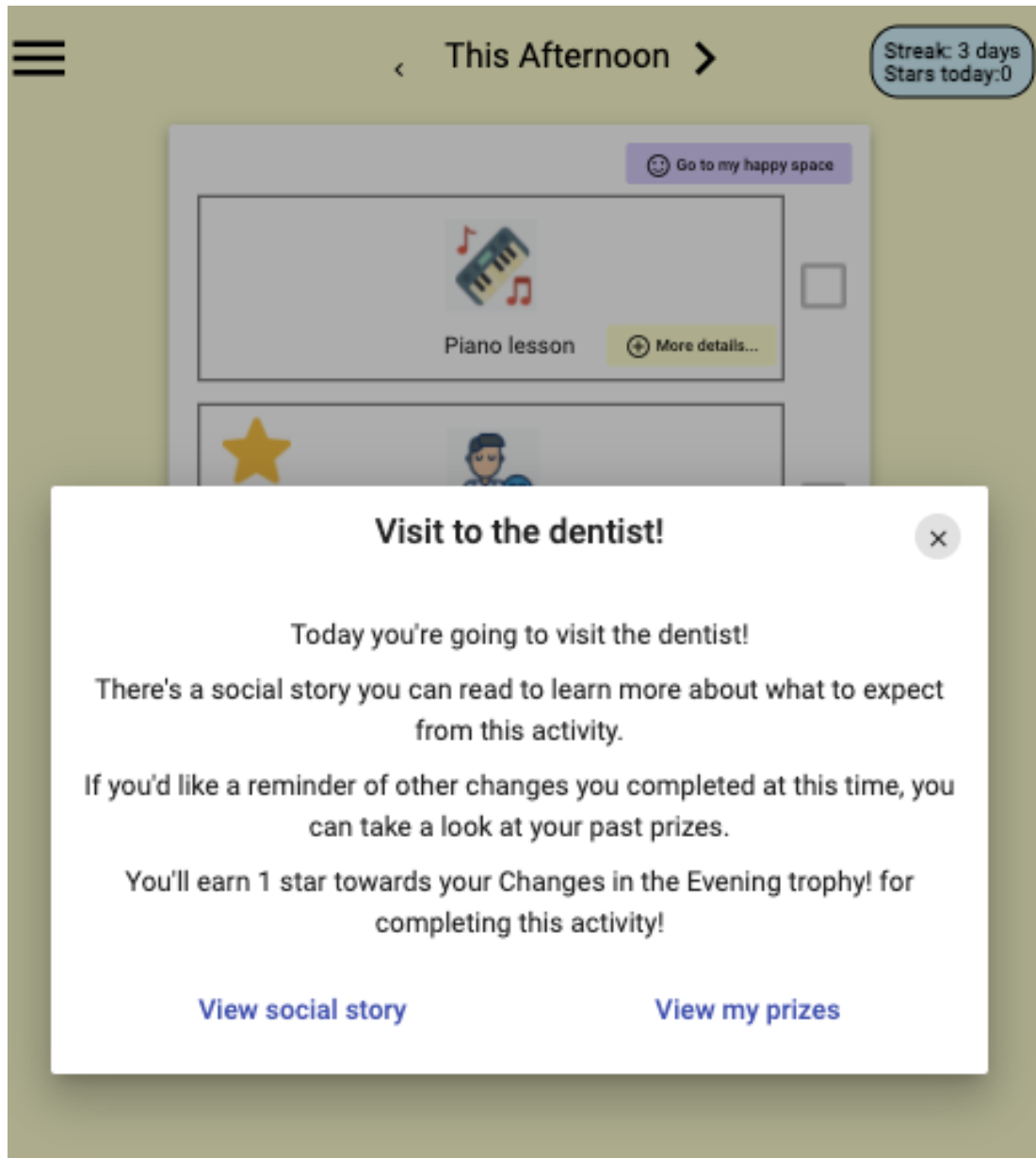


Figure N.3: Pop-up that appears when you click 'More details...' on a reward activity

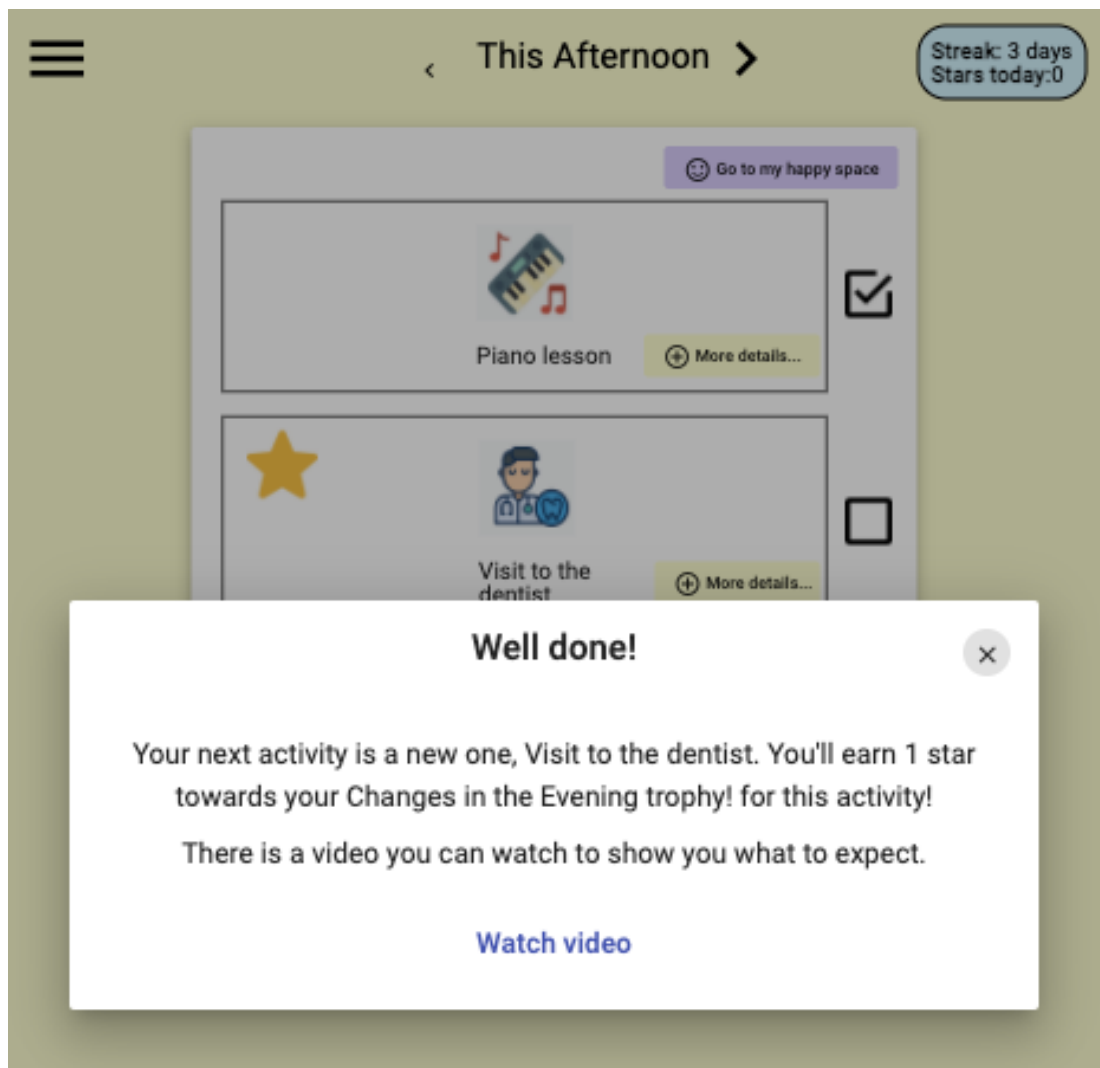


Figure N.4: Pop-up that appears when you complete an activity and a transition aid has been provided before the next activity

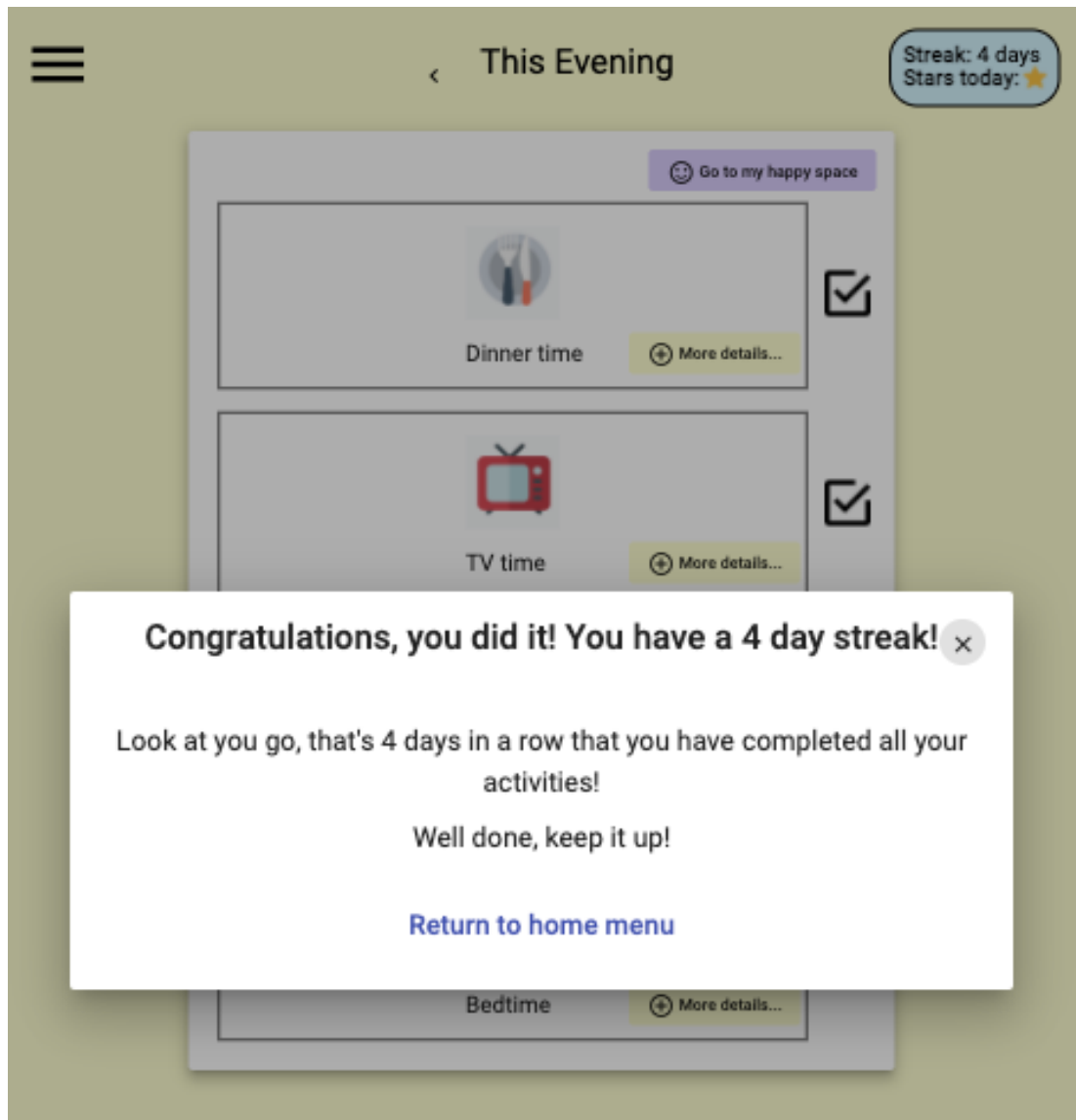


Figure N.5: Pop-up that appears when you complete the last activity in the schedule, showing your streak

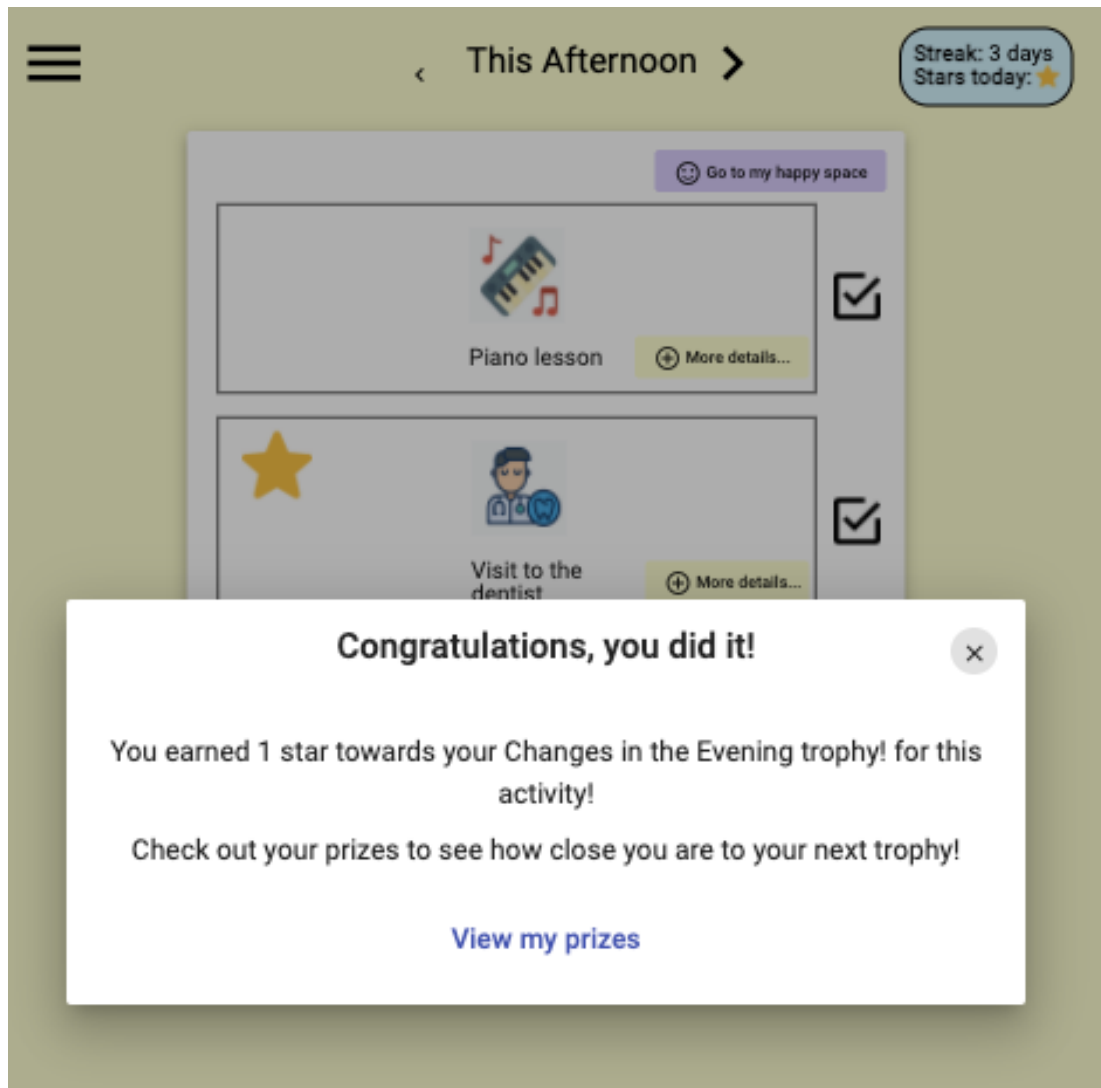


Figure N.6: Pop-up that appears when you complete an activity for which you earned a reward

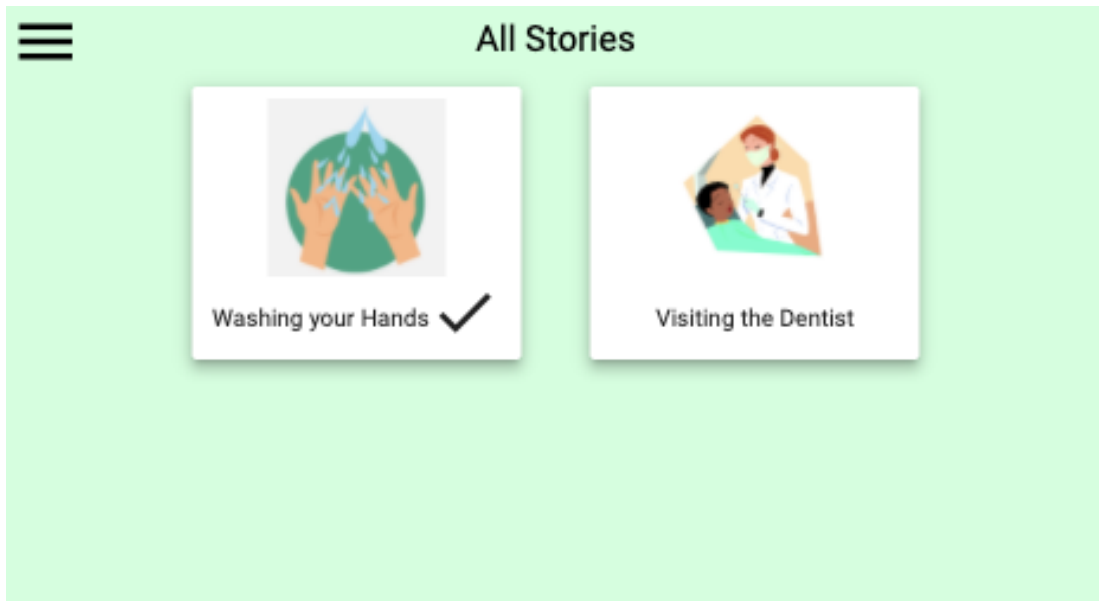


Figure N.7: Social Stories menu

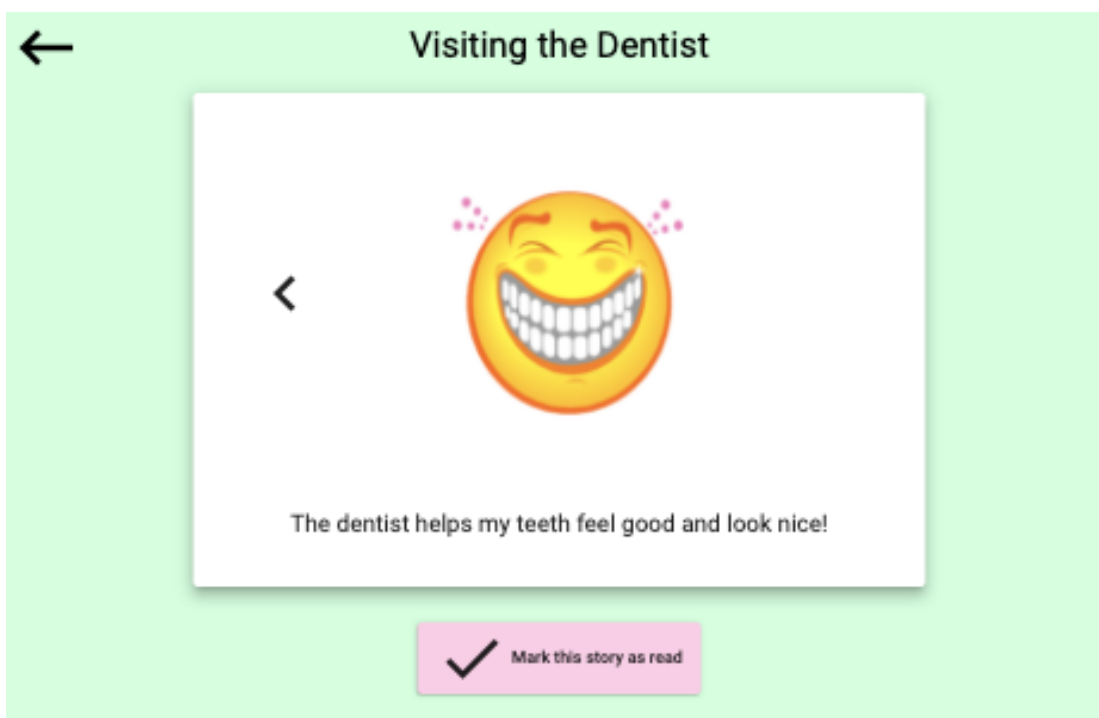


Figure N.8: Step of a Social Story

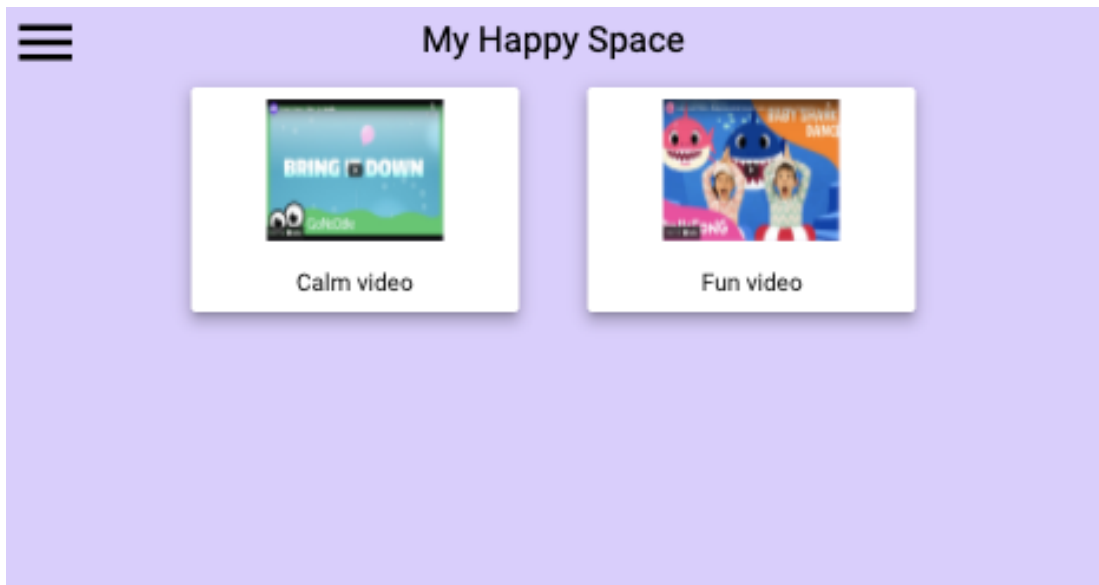


Figure N.9: Happy Space menu

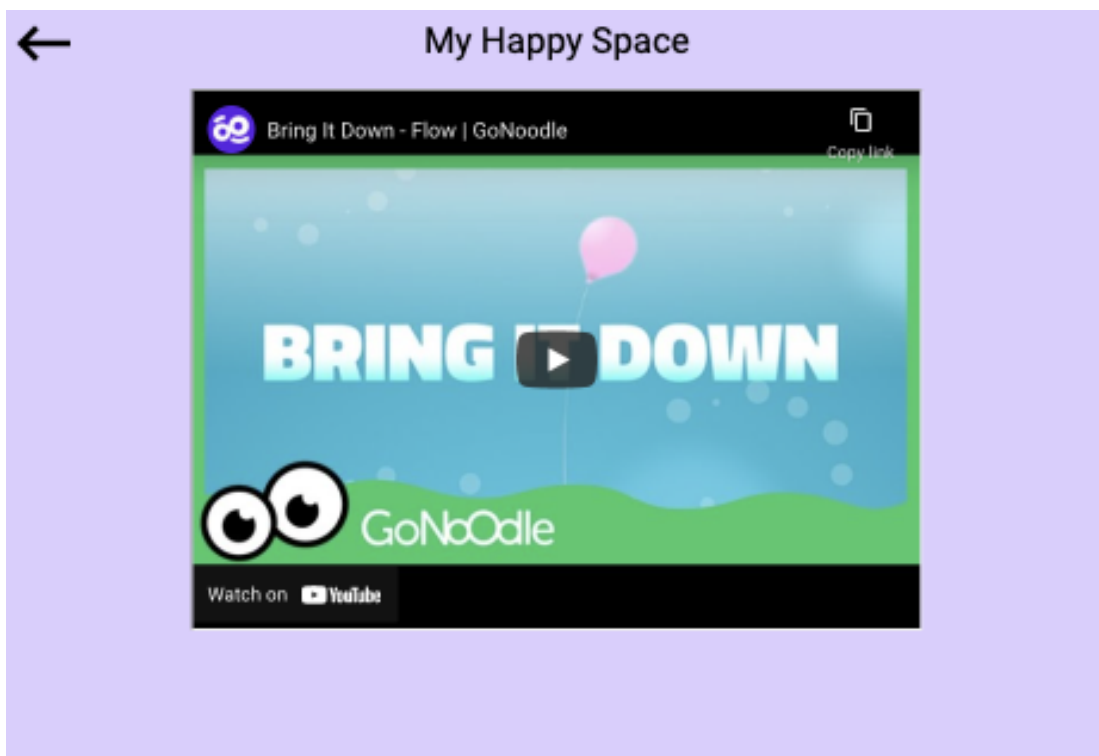


Figure N.10: Screen which opens when you click a video in Happy Space

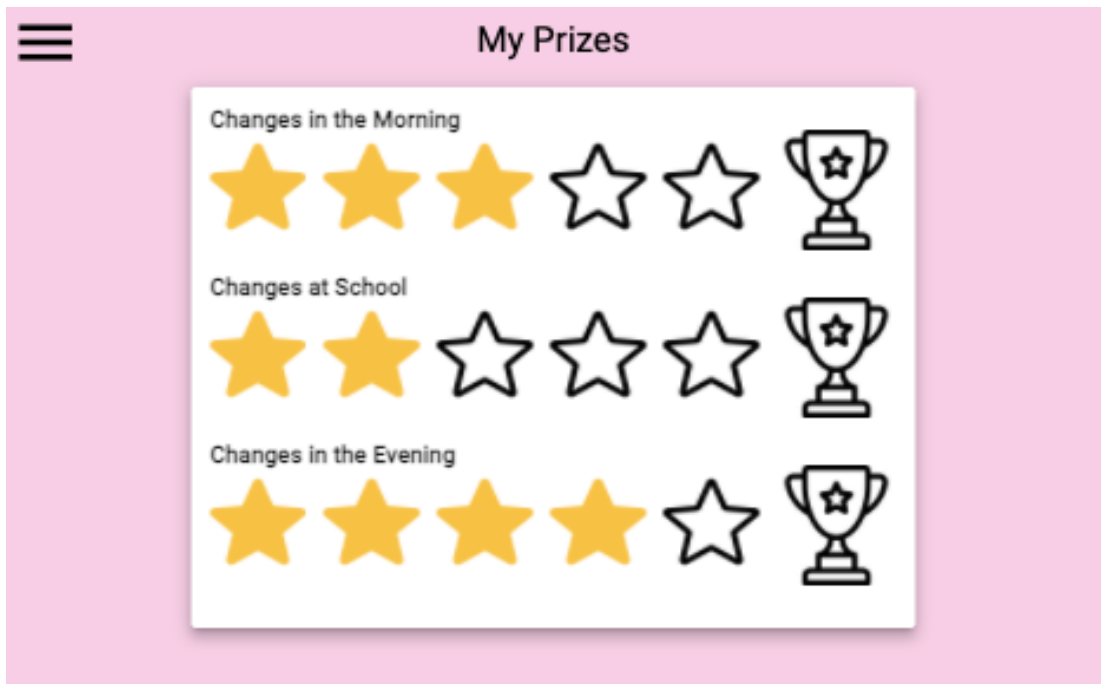


Figure N.11: My Prizes screen

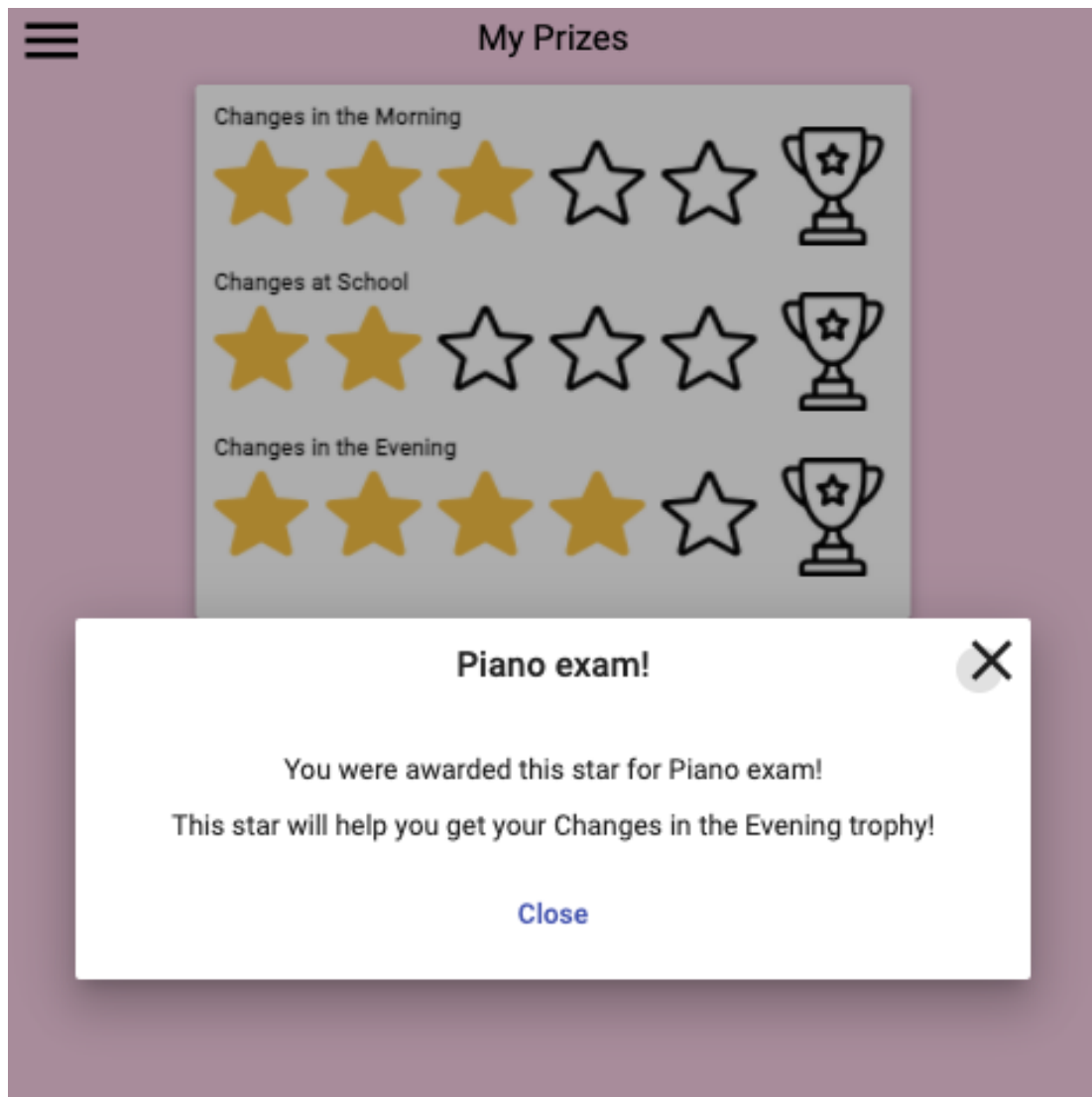


Figure N.12: Pop-up which opens when you click on a star in My Prizes

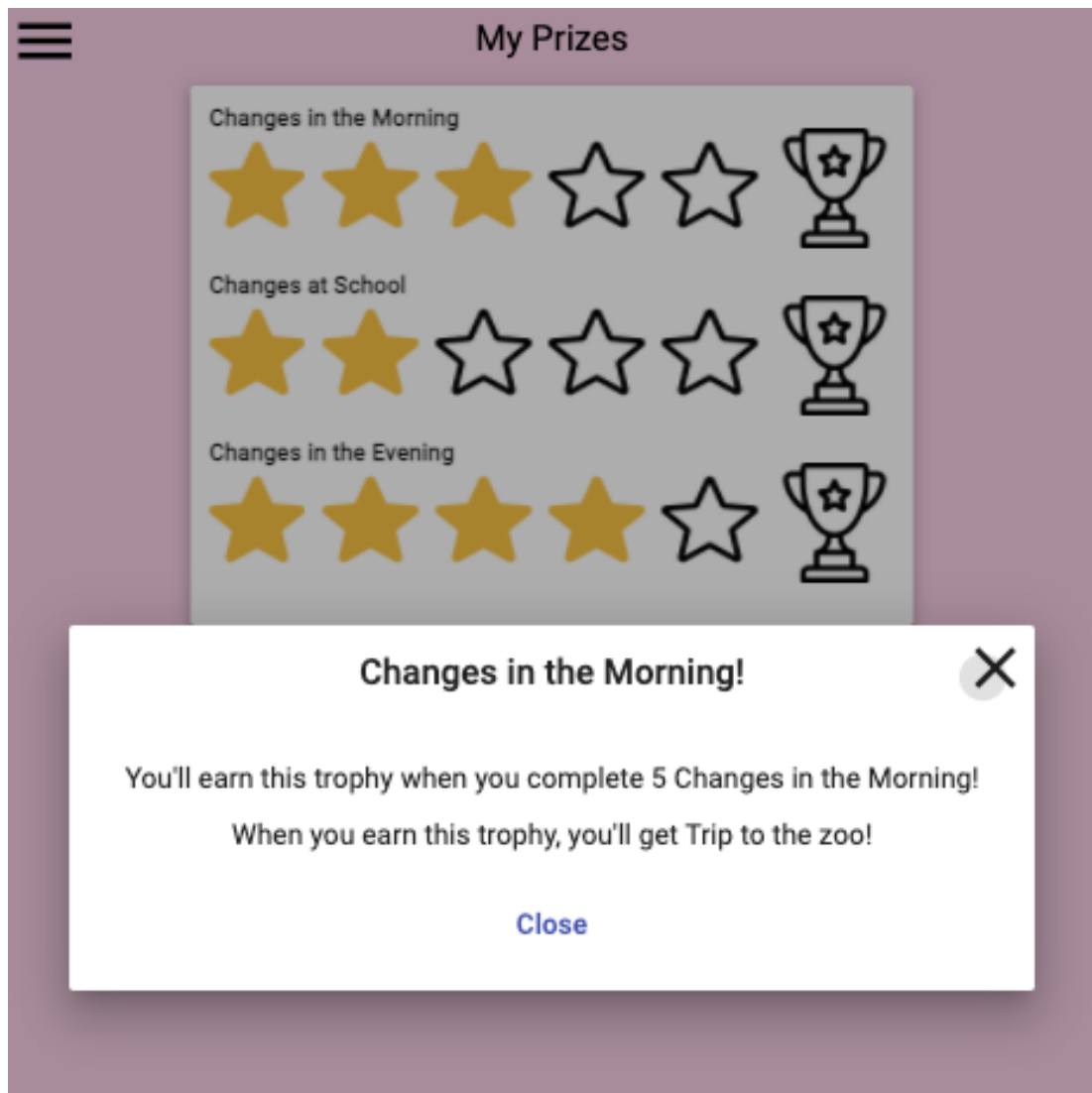


Figure N.13: Pop-up which opens when you click on a trophy in My Prizes

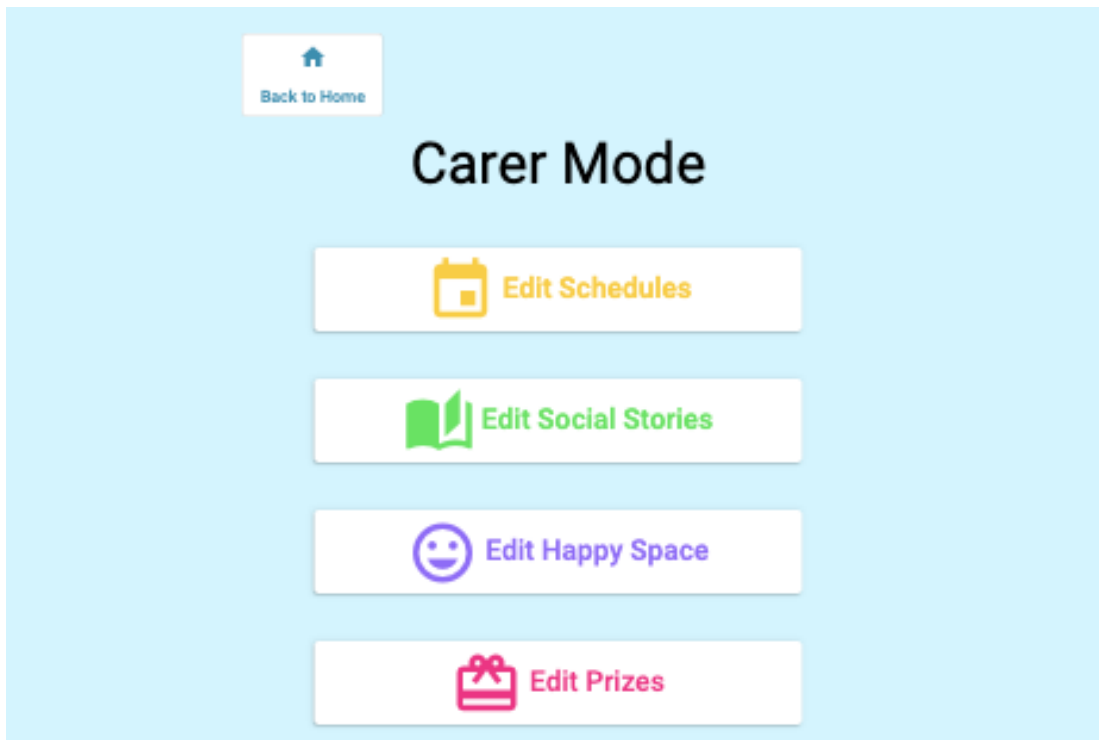


Figure N.14: Practitioner interface menu

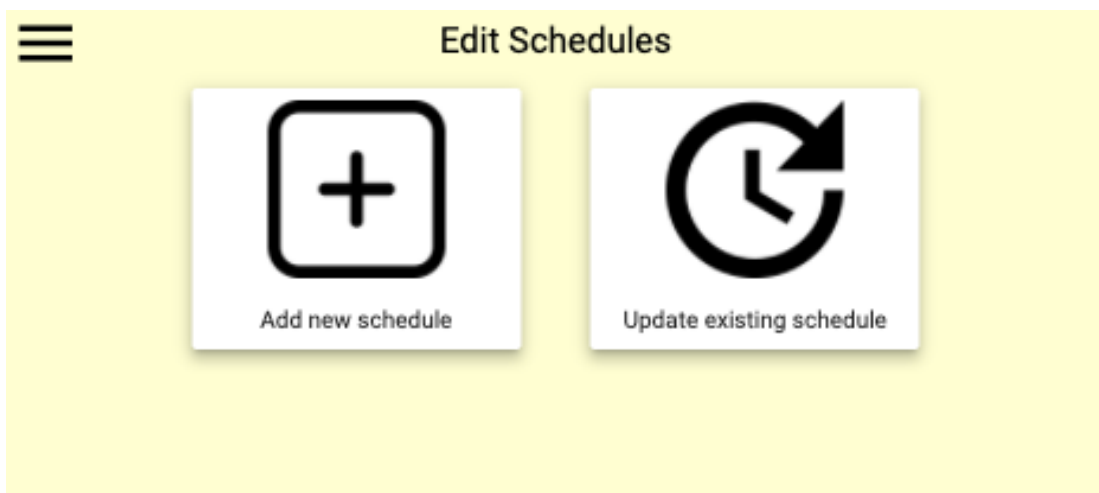


Figure N.15: Options to edit visual schedules

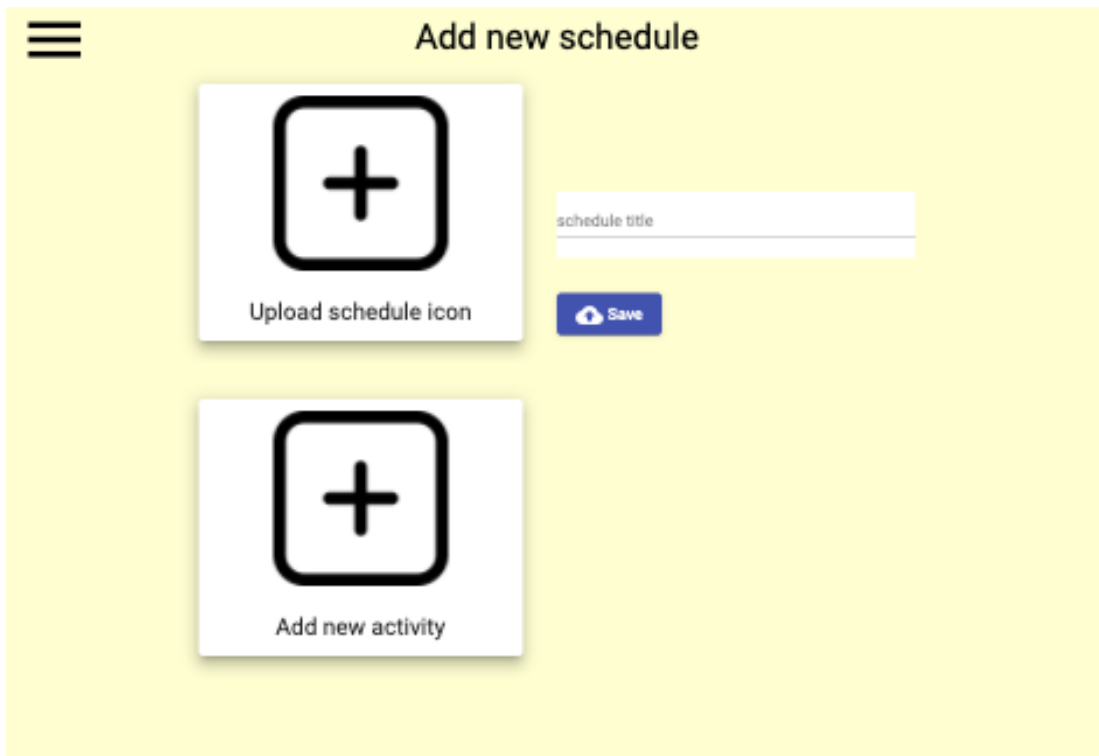


Figure N.16: Page 1 of the template to add a new schedule

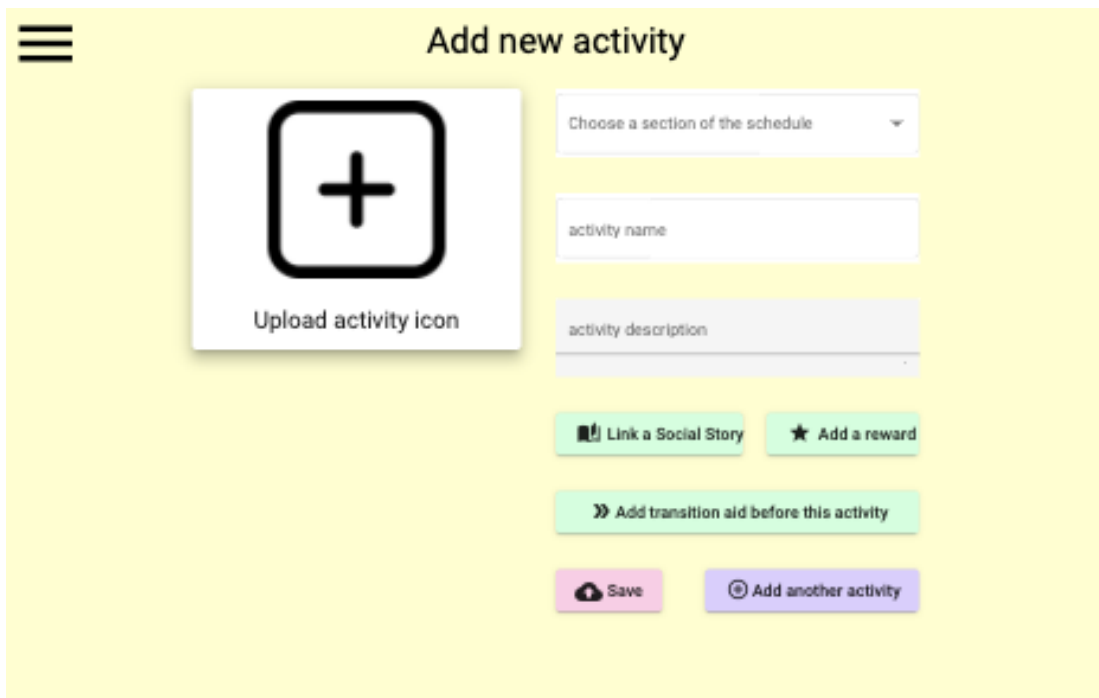


Figure N.17: Template to add an activity to a schedule

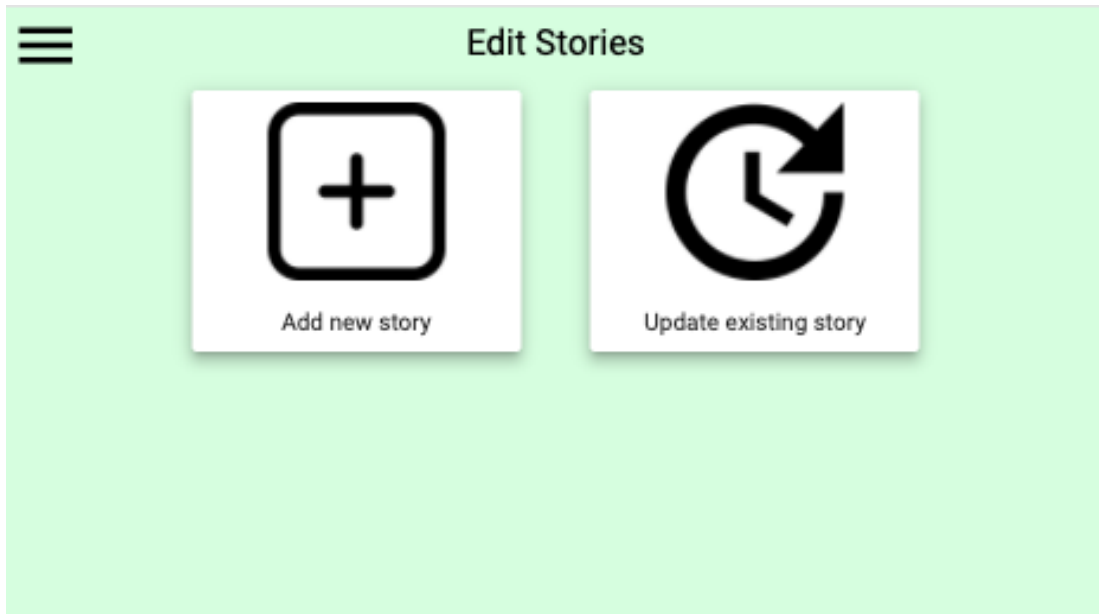


Figure N.18: Options to edit Social Stories

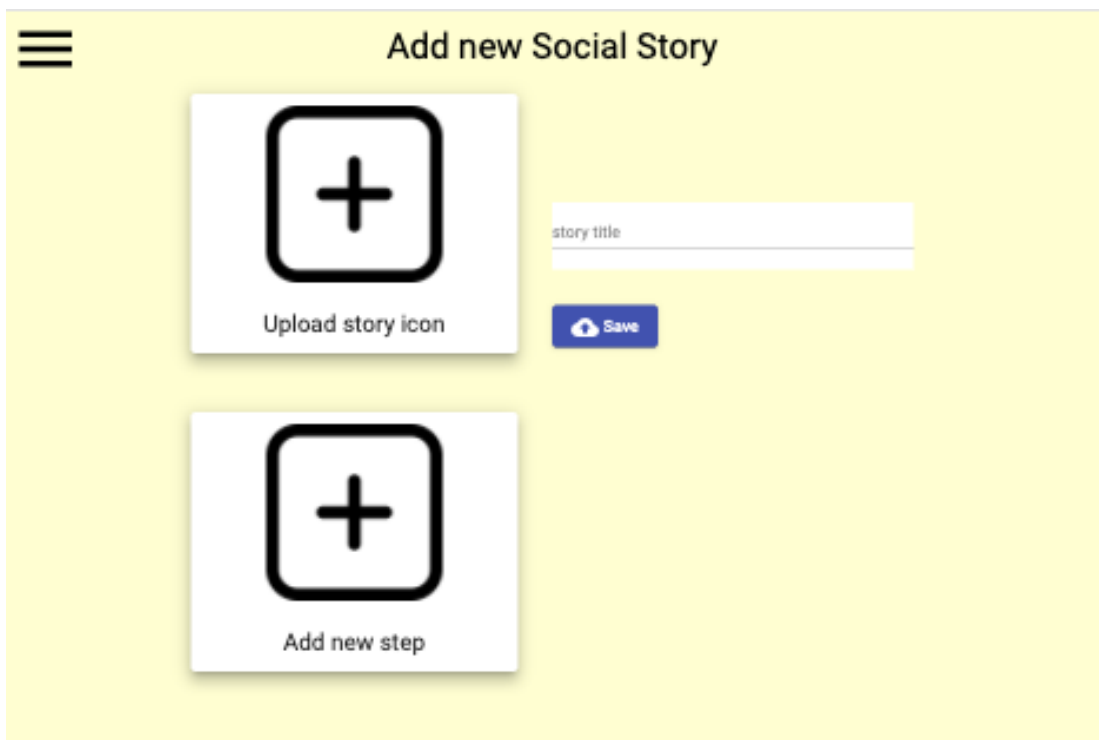


Figure N.19: Page 1 of the template to add a new story

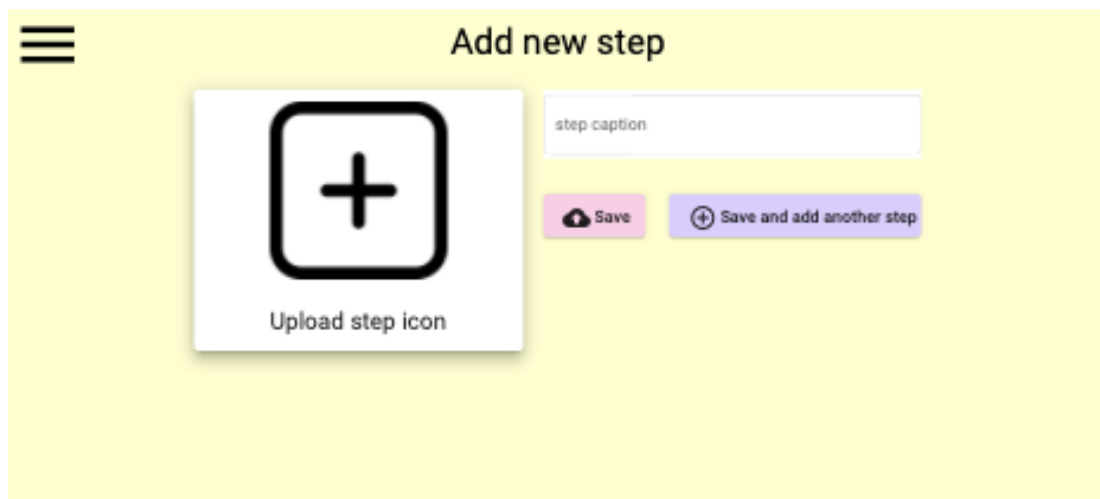


Figure N.20: Template to add a step to a story

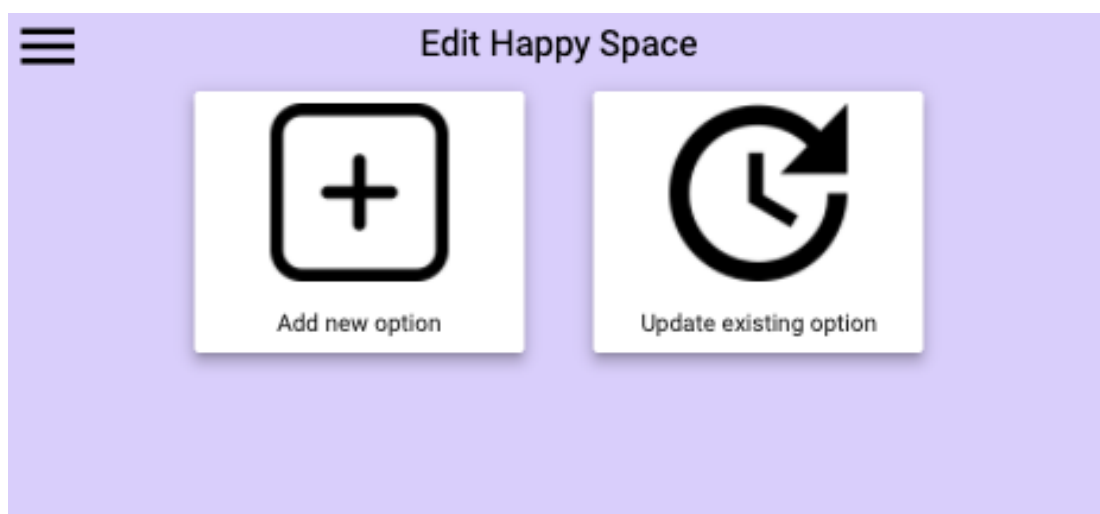


Figure N.21: Options to edit Coping Strategies

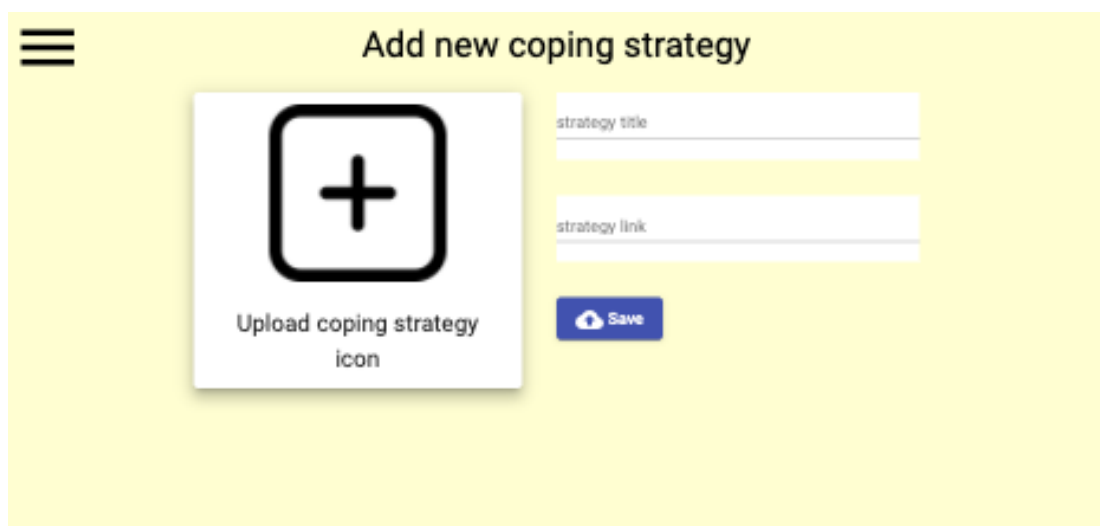


Figure N.22: Template to add a new coping strategy (just videos in this prototype)

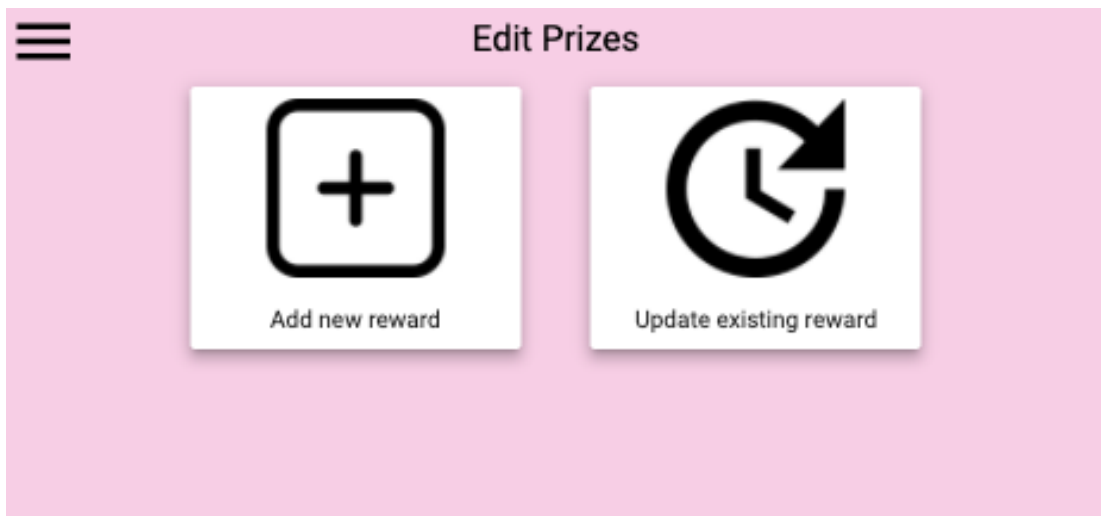


Figure N.23: Options to edit Prizes

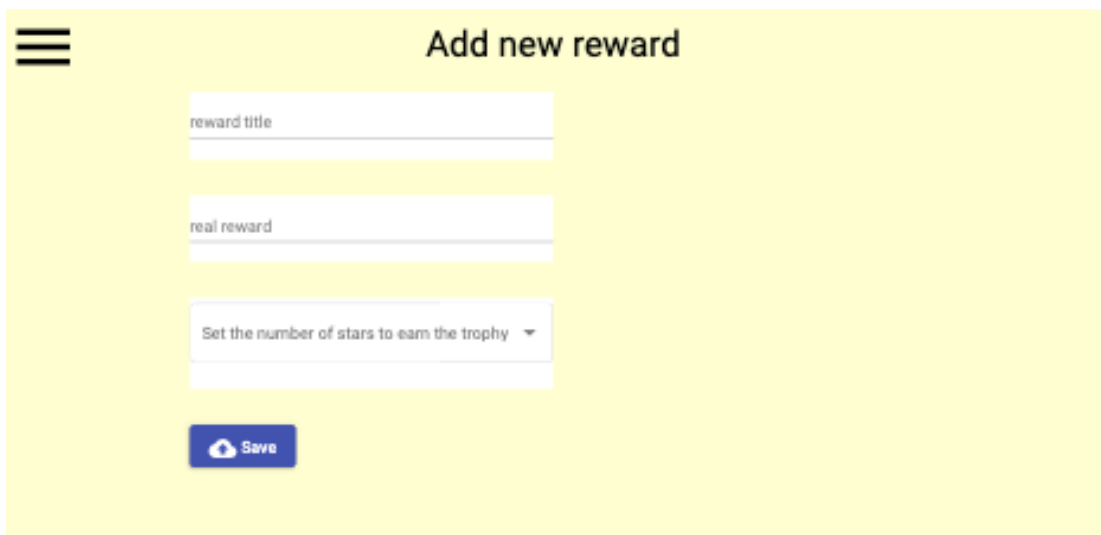


Figure N.24: Template to add a new prize