Department of Computer Science

Submitted in part fulfilment for the degree of MEng

Developing Social Story Software for Autistic Children

Alex Hodder-Williams

21 May 2020

Supervisor: Tommy Yuan

ACKNOWLEDGEMENTS

With thanks to my project supervisor Tommy Yuan and student supervisor Simon O'Keefe for their support and understanding throughout the project.

Further thanks to the support and time of my family, and to Daniel Tilbrook for his generous help throughout the quarantine period.

STATEMENT OF ETHICS

All participants involved in the testing and evaluation were provided with a consent form (Appendix G), and informed that they could withdraw at any time. Anonymity was conserved within the evaluation and testing stage, with users referred to via a number if required. The Google Forms document (used in evaluation), was set up to record responses anonymously.

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

Executive summary

The aim of this project work is to design, implement and evaluate an Android application that provides functionality for a split user group consisting of children with autism and their supervisors. The application will provide the supervisors with the potential to create and edit social stories (an intervention technique sometimes used to help teach skills to children with autism), and the children the chance to read stories assigned to them, typically under supervision. This application is based on a shell prototype created during a 2012 dissertation [1] and discussed and evaluated in a 2013 research paper [2].

The motivation for this project is to create a technology that will streamline the process of creating social stories, thus helping children with autism improve their communication and behaviour in social situations. Children with autism also appear to have a natural affinity for computers, [3] and when using technology are often more motivated [4] therefore the use a mobile application may provide better results for the social story intervention technique. Further motivation stems from the portable nature of mobile devices, meaning that social stories can be created and used in a wider range of settings.

The methods used during this project all aimed to be iterative to ensure the flexibility of the product. Functional requirements were set out as user stories, that increased in detail throughout the project. The development method used was the Kanban method, which is a specific framework of an agile work environment that uses a board to document efficiently document the implementation process. Rapid prototyping was used to design the user interface, an iterative design process of fast mock-ups.

The evaluation and testing of the system produced positive results, fulfilling the functional requirements defined by the user stories. The non-functional requirements, generated through the literature review, were assessed through a standardised questionnaire method called the ‘User Experience Questionnaire’.

The ethical, social, and professional issues surrounding the creation of this application involve the misuse of the final product, in creating social stories that hinder rather than improve an autistic child’s skills. Other ethical issues involve the use of participants in the testing and evaluation stages, of which consent forms were provided (Appendix G).

There may be commercial and legal issues surrounding the trademarked specific ‘Social Story’ technique (a formalised version of social stories), however as this application is simply a builder of social stories, and doesn’t include any trademarked material the issues should be minimal.

1 Introduction

1.1 Background

Autism is a lifelong developmental disability [5] that influences the development of various skills, and can produce various effects such as repetitive behaviour and difficulties when dealing with change.

Intervention techniques aim to alleviate some of these difficulties and develop skills such as social or language. Social narratives are an intervention technique that can be used to improve the social or language skills of the readers and can also be used to alleviate issues with certain situations, for example going to the dentist or lining up at school.

This project aims to implement an Android application that will provide carers and parents of autistic children the ability to create, edit and store social narratives on their device. It will also provide the functionality for the reading of these stories by the autistic children they have been designed for. This application will build upon a previous shell design, with evaluation and improvements suggested in a research paper [2].

1.2 Motivation

The motivation for this project is to ease the creation of social stories, by providing a streamlined and portable application that may be able to replace paper or desktop versions. This allows the intervention technique to be more easily and effectively used in a wider variety of locations; therefore, improving the lives of the autistic children that read the stories and those of the supervisors and carers that look after them.

Motivation also arises from autistic children's natural affinity for computers [3], and increased motivation and focus when using technology [4]. In addition, as younger children find touchscreen interfaces easiest to use, [4] a mobile application appears a good solution for implementing a successful intervention strategy.

The widespread nature of mobile devices provides the motivation for a mobile application. The motivation for an Android specific application is due to three factors: Android takes a 47.5% of market share in the United Kingdom at the time of writing [6], with hardware that is typically cheaper and a more limited range of Android applications providing autistic intervention services [4].

1.3 Report Language

Research has been published on the preferences in language used to describe autism [7], which is supported by the National Autistic Society. The research shows that although there is no single preferred term, positive and assertive language should be used. Throughout this report I shall follow these guidelines and use terms such as autistic child or individuals with autism when referring to these individuals.

I will use carers, parents, and supervisors to refer to the supporting individuals that work with these autistic children.

‘Social narratives’ or ‘social stories’ will be used when referring to the broader intervention technique, whereas Social Stories (capitalised) will refer to Carol Gray’s formalised technique.

2 Literature review

This project requires a brief overview of the current research into autism, and how the usage of social stories can help children with autism. This project also requires review of previous work in creating social story software, alongside consideration into how autism may affect traditional human-computer interaction (HCI) principles.

2.1 Autism

As this project relates directly to children with autism, understanding autism is important in making suitable design choices and ensuring that the final product is effective in helping this group of people.

2.1.1 Overview

The National Autistic Society define autism [5] as “a lifelong developmental disability that affects how people perceive the world and interact with others”. Autism is often referred to as ASD, meaning autism spectrum disorder. Autism is referred to as a spectrum disorder due to the range of types and severities that can occur.

2.1.2 Typical Impairments

Autistic people struggle with the interpretation of verbal and non-verbal language [5]. Children with autism [8] find difficulty with understanding non-verbal communication such as facial expressions and tone of voice. The result of these impairments is a lack of developed social, communication and language skills.

They also struggle with the recognition of other people’s feelings, alongside having difficulty conveying their own emotions. These make it difficult to form friendships, especially in children.

Those with ASD engage in repetitive behaviour and often have very restricted interests [9]. They may also find a change of routine difficult.

2.1.3 Treatments and Therapies

Due to the spectrum nature of ASD, there are a variety of techniques used to improve the life of individuals that are affected. Therefore, choosing the correct approach is challenging and there is no one best treatment. It is important not to think of these treatments as a cure.

There are behavioural, psychological and educational therapies that are also used to help those with ASD to reduce challenging behaviours and learn social, communication and language skills [9]. These therapies often use interventions to help build communication interaction skills. There are various intervention approaches recommended by the National Autistic Society, such as PECS (Picture Exchange Communication System) and TEACCH (Treatment of Autistic and Communication Handicapped Children) [10].

2.1.4 Technology with Autism

There has been research to show that the use of ICT can have a positive effect on young children with autism, for example the use of ICT aided the improvement in the student's ability to recognize and draw emotions [11]. It is clear to see that due to the nature of autism, specific technologies should be adapted towards the individual's needs and that ICT can provide assistance with individuals capabilities even in serious cases of ASD [12].

Furthermore, autistic individuals appear to have a natural affinity for computers and may benefit from the repetition of exercises that is possible though technology [3].

2.2 Social Narratives

Social narratives are an intervention technique aimed to support individuals with autism through social situations. Social Stories™ are a formalised version of social narratives, recommended by the National Autistic Society.

2.2.1 Introduction to Social Narratives

The empirical evidence for the effectiveness of social narratives is limited, with various conclusions from scientific reviews. A peer reviewed study analysing the use of social stories in teaching social skills to children with ASD [13] examined literature showing that social stories can effectively teach social skills to children with ASD, however stated that sufficient experimental control wasn't fulfilled. The paper goes on to state that whilst 'the emerging literature regarding social story is promising, more evidence is clearly needed to establish its effectiveness as a viable intervention approach for individuals with ASD'. Social stories remain a popular intervention method, with positive anecdotal success, and are recommended by the National Autistic Society as a method of improving autistic individuals social understanding and safety [14].

2.2.2 Introduction to Social Stories™

Social Stories are a specific format of social narratives Carol Gray created and trademarked in 1991 to help autistic people improve self-care and social skills, help with reacting to a particular situation or change in routine and some behavioural strategies [14]. Carol Gray's specific format suggests the inclusion of three types of sentences within Social Stories: descriptive, perspective and directive [15].

Social Stories help to remove ambiguity from certain activities and bring structure into these individuals lives, however as the content typically requires adaptation to the individual it is difficult to create 'blanket' stories that can be applied to all.

2.2.3 Current Available Applications

There are a range of applications that can be used to create social stories available to the public, both as computer software and mobile applications. Some of the available software is specifically designed for the creation of social stories whereas some provide functionality that allows makeshift stories to be created. An example of the former is ‘Special Stories’, an app available on both Android and iOS. ‘Special Stories’ is a positively reviewed application that allows users to create social stories. Unfortunately the application is behind a paywall and I am therefore unable to access and evaluate, however it looks to be very promising in providing functionality for users to create social stories and claims to have been designed with ASD experts and in collaboration with parents, professionals and teachers. An example of an application that can be used to create makeshift social stories would be ‘Click n’ Talk’, which allows users to attach text and voice to individual images and organise these in a photo album.

A social story prototype has been proposed and evaluated in [1] [2], and shows a shell software for computers that can be used to create basic social stories. This prototype story builder was developed and evaluated with ASD specialists from the York City Council. The evaluation of this prototype suggested some improvements that could be made [2], for example branching stories where decisions could be made by the user at designated question pages. This would help to show consequences of some actions. Another improvement suggested is the implementation of a text-to-speech reader within the program.

2.3 HCI

An important part of human-computer interaction is learning about the users and their context [16, p. 191]. In this project the user group of the final product is split, and will consist of children with ASD, accessing a small portion of the system, and adult supervisors who will be using the majority of the features available. Therefore, the user interfaces will need to be designed with the different users considered.

2.3.1 Use of Scenarios

Scenarios are stories that aid design processes. They are simple but flexible and powerful [16, pp. 201-203] and help the design process through simulating a walkthrough of users’ interactions with the system. The more detailed the scenario, the more real the events seem and the more effective they are for allowing the formulation of a good system for interaction. These scenarios also help the developer to catch potential problems with the interaction process before they occur.

2.3.2 Software for Children with Autism

When designing software that may be used by children, and especially those with autism, it is important to be careful with design choices.

There are recommendations for UI design with websites for people with ASD regarding presentation, navigation, interaction and personalization [17]. Simplicity and clarity within graphics and layouts are key recommendations, using sans-serif fonts with few elements on the screen. They also recommend allowing customisation and personalisation for individual users, due to the unique requirements of these children.

2.3.3 HCI principles of mobile design

Simplicity is a key principle of interface design [18], and is even more important in mobile user interface design due to the reduced screen size. Simplicity can be achieved by using a consistent mobile user interface design, to avoid the disorientation of the user [18]. Furthermore, mobile devices typically have less computational power, the simpler the layout of the user interface, the more efficiently the application will run.

Mobile devices do not have the physical hardware existing as in a desktop computer (I.E mouse and keyboard), therefore the design must consider behaviour such as pop-up keyboards and how it may affect the user interface.

Multitasking within a single window of a mobile device is unusual (though technically possible) due to processing power and screen space, therefore users must switch to another application to complete a separate task. This means that on return to the original application, the system must respond quickly and display the correct information, thus ensuring efficiency and productivity of a system.

3 Development Methods

This project is primarily a software engineering project, and therefore development methods must be considered and applied to improve the quality of the project.

3.1 Waterfall

The waterfall development method is the most traditional software development method [19] and works in strict linear phases: Requirements, Design, Implementation, Verification and Maintenance. Each stage must be completed before the next can begin.

A theoretical advantage of this method is that stakeholders [20] agree on the requirements prior to design, streamlining the design and implementation process. However often requirements are poorly defined due to the gaps in knowledge between the developers and the customers (and further customers not always understanding what they require), and therefore the final product is not correct.

I do not believe that the linear nature of the waterfall method is suitable for this project.

3.2 Agile

“Agile development is an iterative, team-based approach to development” [20] and uses the method of sprints to develop components of the application. This methodology allows the customer to be more involved in the production of the product, which would be useful in this project as feedback from expert users will be critical in implementing a suitable system and the iterative nature gives flexibility to the project.

However as stated in the definition agile development is team-based and therefore following all explicit parts of the agile methodology does not seem suitable for this project as there are parts that are irrelevant for solo development.

3.3 Summary

As I am a relative beginner with Android development, particularly with a project of this size, I feel that an iterative approach makes the most sense as it will allow me to complete smaller tasks while becoming more comfortable and further split the project into suitable deliverables. As discussed, there are features of agile development that are relevant to the task, therefore I have decided to use a framework of Agile called the Kanban method. While originally a workflow management method, it has become a popular framework in agile software development [21]. The theory is to keep a board of tasks that need completion, are ongoing and are completed. An example of my Kanban board is shown in the figure below. This method will allow

me to keep track of my development and complete productive work in the bursts of time that I will have during development.

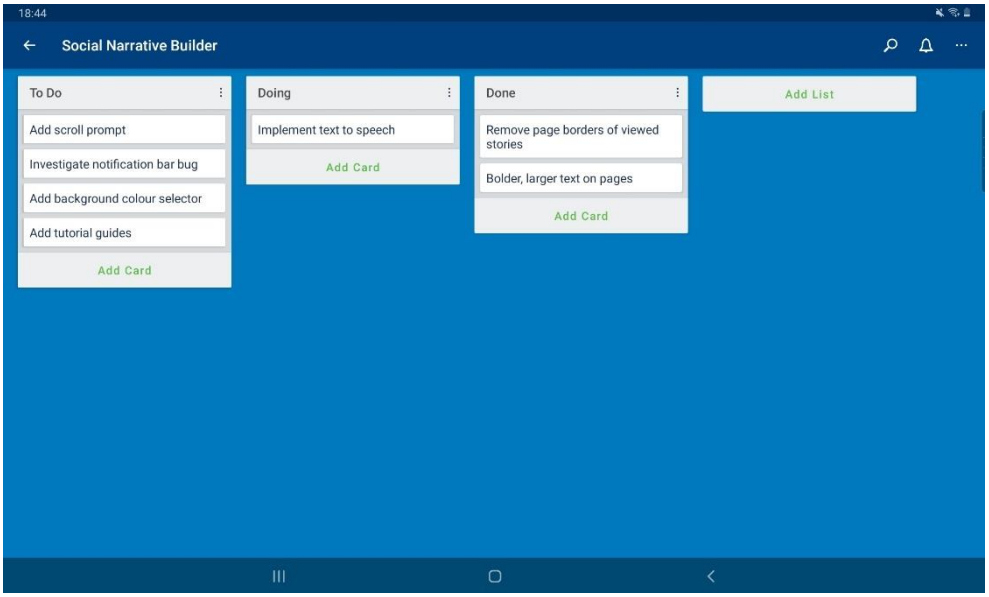


Figure 1 - Kanban Board

Unfortunately, due to the coronavirus situation, it was difficult to involve users throughout the development process, and I made the decision to bring them in to help later in the implementation timeline when the system was nearing completion. The downside to this approach is that it would risk wasted time in developing features that need to be changed or removed, nevertheless I believe it to be the most suitable option available for development.

4 Requirements

Due to the agile iterative based approach employed in this project, requirements collection is an ongoing process throughout the development of the system. To document functional requirements, I have used the format of scenario style user stories, as these are easily expanded to encompass the new requirements created for the system.

4.1 User Stories

High level user stories are further useful as they can be easily understood and verified by stakeholders without technical knowledge to ensure that the system provides the correct functionality.

These user stories will also help when testing the system throughout the iterations, and further evaluating the system with potential users.

Some of these user stories are based upon the previous iteration of the project [1]. The user stories presented are the final user stories, after all the iterations of development have been completed.

User Story ID	1	**Use Case Name**	Child Sign In
Description	Child loads the app and signs into their individual profile, in the presence of a supervisor.		
Actors	Child Supervisor		
Assumption	There is an existing profile for child.		

Table 1 - Use Case 1

User Story ID	2	**Use Case Name**	Adult Sign In
Description	Adult loads the app and signs into their individual password protected profile.		
Actors	Supervisor		
Assumption	There is an existing profile for the supervisor.		

Table 2 - Use Case 2

User Story ID	3	**Use Case Name**	Create Child User
Description	A child can create a new user for themselves (under supervision), selecting a name and an avatar.		
Actors	Child Supervisor		
Assumptions	-		

Table 3 - Use Case 3

User Story ID	4	**Use Case Name**	Create Adult User
Description	An adult can create a new password protected user for themselves selecting a unique name and entering and confirming a password.		

Actors	Supervisor
Assumptions	-

Table 4 - Use Case 4

Use Case ID	5	**Use Case Name**	Create Story
Description	An adult creates a custom social story called ‘A walk in the park’, creating two pages with different images, text and sounds and assigns it to a child. They name the social story ‘A walk in the park’ and set the background colour to green.		
Actors	Supervisor		
Assumptions	Adult is signed in		

Table 5 - Use Case 5

User Story ID	6	**Use Case Name**	Edit Story
Description	An adult edits a social story after a test reading, deleting a page and changing the contents of a different page.		
Actors	Supervisor		
Assumptions	Adult is signed in and a story exists to edit		

Table 6 - Use Case 6

User Story ID	7	**Use Case Name**	Delete Story
Description	An adult deletes one of their unused stories.		
Actors	Supervisor		
Assumptions	Adult signed in, and a story exists to delete.		

Table 7 - Use Case 7

User Story ID	8	**Use Case Name**	Preview Story
Description	An adult previews a story they have created for test purposes.		
Actors	Supervisor		
Assumptions	Adult signed in, has an existing story to read.		

Table 8 - Use Case 8

User Story ID	9	**Use Case Name**	View Feedback
Description	An adult views feedback and statistics for a story they have written.		
Actors	Supervisor		
Assumptions	Adult signed in and there is an existing story that has been read by a child		

Table 9 - Use Case 9

User Story ID	10	**Use Case Name**	Read Story
Description	A child reads a story with a supervisor, at the end of the story they can choose whether to give optional feedback.		

Actors	Supervisor Child
Assumptions	Child has an assigned story.

Table 10 - Use Case 10

User Story ID	11	**Use Case Name**	View Tutorial
Description	A user would like to view the tutorial for the system.		
Actors	Supervisor Child		
Assumptions	-		

Table 11 - Use Case 11

4.2 Non-Functional Requirements

Although these user stories can replace the need for formal functional requirements, they cannot represent the non-functional requirements that are useful in describing the characteristics and qualities that the system aims to display.

NF 1 Usability defines how easy the product is to use. Due to the potential users, it is important that the app (especially the child side) is easy to use. I have selected suitable usability sub-requirements that further help to define the qualities I wish for the final system to display [22].

NF 1.1 Learnability defines how easy it is for a first-time user to complete basic tasks on first use.

NF 1.2 Efficiency defines how quickly a user can reach their goal, navigating through the app.

NF 1.3 Memorability defines how easy it is for a user to be able to use the system after a period away.

NF 2 Portability defines the different devices and operating systems that a system can be successfully used in. For this project, the application is created to work on Android devices, working both on tablets and phones.

NF 3 Security defines how effectively the system employs standard security protocols. Some elements of security (such as adult password protection) are also formalised in the functional requirements through user stories.

5 Design

Before any implementation, I aimed to complete as much design through prototyping as possible to allow feedback and improvements prior to implementation.

5.1 User Interface

Rapid prototyping is the method of producing fast and simple mock-ups of a system that can be validated with users/stakeholders [23]. Rapid prototyping also fits well with the agile methodology I set out at the beginning of development, following a similar method of build, test, adjust and repeat. Unfortunately, due to the situations of this summer I was unable to work with users on the prototypes, however it still gave me the foundation to begin implementation.

The rapid prototyping method allowed me to efficiently create a basic user interface (UI) that would have the potential to fulfil the requirements that I had set out at this time. This prototype then allowed me to create the initial layout of a UI flow diagram which was updated throughout the project (Appendix A).

To generate this prototype, I sketched out some basic screens on paper, considering a mobile device screen size and typical layout, to develop a basic theme. I then moved to Figma, a simple prototyping software, to develop a higher fidelity prototype closer to reality with links between the pages to provide me with a feel of how app navigation may work and make changes to improve the user experience. This higher fidelity prototype is shown in the appendix (Appendix B).

5.2 Data Storage

Before any implementation would occur, I knew that I would need to implement a data saving methodology into my app. This would store information such as users account details and stories. Initially I planned to follow a similar method to the shell prototype in using xml files, using either Shared Preferences [24] or simply internal storage of the Android device. However, this would become increasingly complicated as more features were to be required through the process and thereby make the system less extensible.

After researching Android storage solutions, I made the decision to use relational databases, due to their advantages of being easily updated, allowing tables or columns within tables to be added as the program grows larger. As Android implements SQLite, a database system that is embedded into the end program, it was the obvious choice for implementing this relational database.

Designing the database was the first task. The database had to be designed in a way that would be extensible and allow future updates without becoming bloated and overcomplicated. The final database diagram is shown in the appendix (Appendix C) and was generated using a software called DBeaver.

Originally, the database did not provide the functionality of sound file links to be stored in the pages table, and the statistics table also did not exist. I further needed to rework the database to improve security, changing adults usernames to be unique and change the relationship between stories and their owners (adults) to be through the foreign key of an adult's unique ID rather than their name. Before these changes there was a bug where an adult could be created with the same name as a previous existing user and access the stories of a different adult.

6 Implementation

This chapter will document and describe the iterative development process that created the final system. Agile documentation standards suggest efficient, simple documentation to account for the flexibility that the agile work method gives the system, and prevents the writing of outdated documentation [25].

Implementation followed the same iterative approach of developing and testing to build up the program. In Android development, you create layout resource files that contain the layout of each UI screen, and activities handle runtime logic of data and layout modifications. Android development primarily supports Java or Kotlin, of which I opted to use Java due to having previous experience in it.

6.1 Android Conventions

I have followed Android convention for app development throughout most of the application with a few key decisions where I have broken these guidelines. These Android app guidelines attempt to enforce consistency across Android devices. However, the Android user experience differs to that of other systems (primarily iOS), and users of this app may be using Android infrequently, such as in the classroom, while using an Apple device day to day. I have therefore made the decision to break some conventions to promote usability (NF 1) and learnability (NF 1.1) of the app.

Broken conventions are as follows:

- Forcing landscape mode – I made the decision to force the user into landscape mode as I felt the layouts are more understandable and the stories make most sense when presented in landscape mode, therefore creation in landscape mode ensures consistency.
- Displaying back buttons as part of the UI to users – back buttons in Android apps are provided by the Android system at the bottom of the phone, however as not all users will be native to Android I made the decision to break this convention to improve usability.

6.2 Method

I used Android Studio as the IDE for the development of this application, with the Android emulator environment built in for testing, alongside a Samsung Galaxy S6 as a physical test environment. An open source database browser called ‘DB Browser for SQLite’ was used for examining the generated database for behavioural testing. I also made the decision to only use the Java and Android libraries, with no additional plugins, to keep full control over the system and to ensure

future extensibility, in the case of plugins not staying up to date with Android updates.

6.2.1 Implementation Process

The implementation process began with translating the features from the shell prototype [2] into the Android environment. First creating the necessary layout files within the Android studio environment before implementing the logic of switching between user interfaces. After the activities were created, I implemented the necessary features to allow account creation and sign in logic for both adults and children. This required the implementation of the designed database. After the account logic was completed, the basic story system was set up and implemented, with just text able to be saved. After testing with text, the functionality of adding images was added to the system, using an Android intent to access the devices gallery. The gradual addition of features with supplementary testing continued, adding a background colour chooser, sound files and sample sentences.

6.2.2 Implementation Issues

There were only two significant implementation issues that arose during development. There were many minor issues due to my lack of familiarity with the Android framework, and in some cases structuring code incorrectly that had to be reworked. The two major issues were as follows:

Scrolling lists – I had issues displaying a different string in a ScrollView, to the data that was returned on selection. The solution involved creating a custom RecyclerView class alongside a new data type class which would store pairs of strings. This was required to allow the display of data in the view, which when selected returned the id behind the data. The use of this was in the story selection screens. For example, it allowed the title of the story to be displayed to the user, but on selection returned the id of the story to allow for queries about the story in the next activity.

Foreign key implementation – SQLite within Android has a slightly strange implementation method, and I made initial errors while setting up the database (not enabling pragma keys), meaning that my cascading deletion of elements within the database was not working correctly. This meant that deleted stories were sometimes still displayed but not accessible, for example within statistics due to the setup of the database. This was not an error I had caught early enough meaning there were unexpected behaviours.

6.2.3 Exception Handling

As the database stores Uniform Resource Identifiers (URIs) for image and sound resources, if files are removed or moved within the

device, the system will not be able to access the resource in the original location. Therefore, it is important to handle these situations. In the case of images, I created a ‘missing resource’ image that would be displayed to the user, asking them to replace said image. Sound files were simply not loaded in, and the user would need to replace the sound file if required.

6.3 Additional Features

Text-to-speech was a feature that was suggested within the evaluation of the story builder shell [2], due to the argument that a computer voice would allow the children to focus more on the story and to help those children whose reading skills are more limited. Fortunately, Android provides a library for text to speech. I chose a voice that was of not too high quality, to keep the ‘robot’ feel that was sought after in the evaluation [2], and that had a female British accent. This feature was added after iteration 2 of user testing.

A more detailed statistics viewer was another feature requested within the evaluation, as supervisors were interested in seeing individuals responses to stories [1]. This was implemented using SQL queries, and data was displayed in a table to the user. Below is an example of the statistics viewer page.

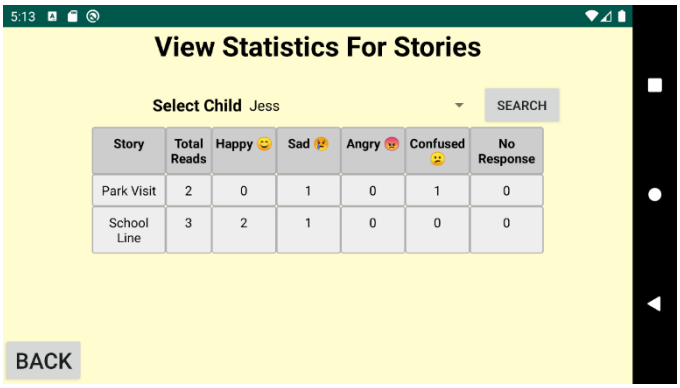


Figure 2 – Statistics Page User Interface

6.4 User Testing

The original plan for the development process was to have a user involved throughout, however this was not possible due to circumstances discussed in chapter 3.3. Therefore, a user with experience of using social stories was brought in towards the latter stages of implementation for testing purposes within the iterative cycle.

I completed three iterations of testing with this user, with the following feedback and improvements made.

6.4.1 Iteration 1

ID	Description	Changes Made

1	Layout too busy and complicated within the ‘Create New Story’ page.	Split the ‘Create New Story’ page into three separate activities and layouts.
2	No autofill prompt in password box.	Added autofill attribute in layout file
3	App crashes on ‘Edit Page’ button when no page selected.	Added a test case for if selection is empty.
4	Preview button has incorrect functionality.	Fixed the button’s onclick function to pass the correct parameters.
5	No way to exit the story upon completion.	Changed the next page button to finish the story on the last page.
6	Unclear user interface in initial login screen for the child.	Spread the buttons out, to make the UI clearer.
7	Should include a popup when cancelling changes to confirm that you would not like to save.	Used the ‘Dialog’ class in Android to create a popup with confirmation buttons.
8	‘Read Story’ and ‘Edit Story’ buttons crash when no story is selected (like ID. 3)	Added a test case for if selection is empty.

Table 12 - User Testing Iteration 1

6.4.2 Iteration 2

ID	Description	Changes Made
9	Adult Initial UI difficult to understand.	Renamed buttons to display functionality more clearly.
10	Prompt the user about scroll functionality on lists.	Implemented the attribute of showing the scroll bar initially then fading out, as Android standards dictate.
11	Story Reader, text should be larger and bolder.	Changed display text attributes and changed the background to improve contrast.
12	Provide some information or a tutorial about creating social stories.	Provide a link to an external site with information about tutorials.

Table 13 - User Testing Iteration 2

After these improvements were made, I also implemented the text-to-speech feature and sample sentences functionality. I also implemented the ability to add sound to a story after this iteration.

6.4.3 Iteration 3

The feedback for the text-to-speech and sample sentences was positive.

ID	Description	Changes Made
13	Create New Story page should prompt for a title to be entered, rather than current display of 'New Book'.	Cleared the loaded edit text if the story was new to ensure that the autofill attribute of the EditText object is displayed to the user.
14	Found it unclear about how to add sound to a story.	Changed the wording of the buttons and introduced a heading to the UI.
15	Feedback appears when previewing a story.	No change made, decided this functionality was useful to ensure that the story creators could see how the story would appeal to users, however ensured that feedback given was not saved to the database.
16	Statistics page, text was difficult to read on dark background. Statistics not initially filled which is counter intuitive.	Made background lighter and refreshed the table with initial search parameters immediately.
17	User did not like either background theme.	Changed the child colour to a lighter blue, with white text and changed the adult colour to a paper/cream colour with black text.
18	Child Initial UI, dark text clashed with background.	Changes to background colour, (ID 17) fixed this issue.
19	Make link to social story (ID 12) more clearly a hyper link.	Changed text colour and added underline to meet standard hyperlink styling.

Table 14 - User Testing Iteration 3

6.5 Changes from the prototype

The structural changes to the UI flow from the prototype were based on the feedback generated from the user testing. This involved expanding the Story Creator page into multiple screens, as shown below, as users found the interface to be too cluttered and confusing.

Further minor changes were generated as a result of Android layout capabilities; however, these did not affect any structure or logic of the system.

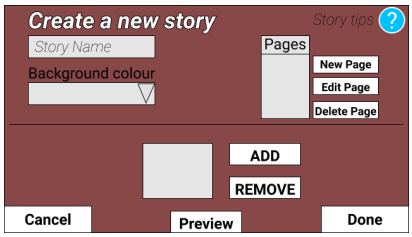


Figure 3 – Create Story prototype UI

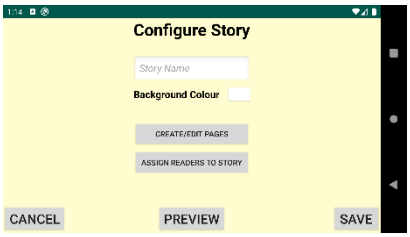


Figure 4 – Configure Story UI

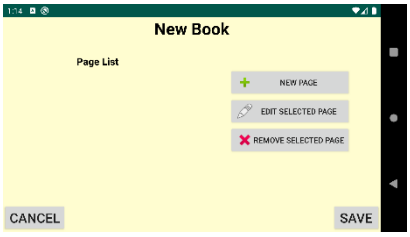


Figure 5 – Configure Pages UI

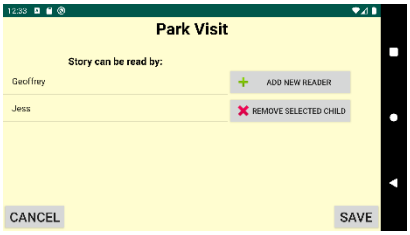


Figure 6 – Configure Users UI

6.6 Tutorial

The last step of the implementation of the application, before deploying it to a wider range of users for evaluation was to create a basic tutorial into how to use the app. This step came last so that any screenshots and information provided would be correct and up to date.

The tutorial is made up of annotated screenshots of the less self-explanatory user interfaces. The annotations include writing and arrows to explain features, as shown in the figure below.

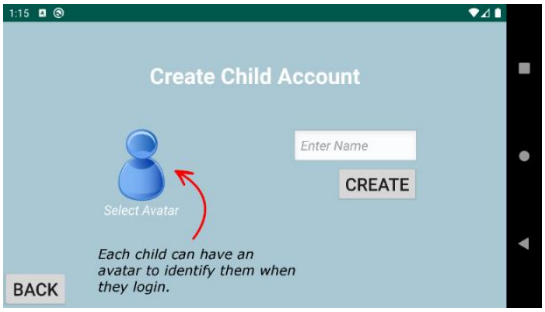


Figure 7 – Annotated Tutorial Image

This was then implemented using an Android view type called ImageSwitcher, which provides functionality for switching between images with natural animations. These images had a corresponding caption to add more context. The result of this implementation was the following tutorial page.

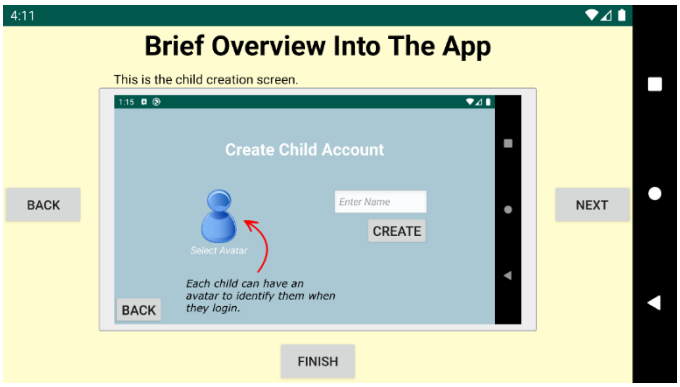


Figure 8 – Tutorial UI

6.7 Security

Security is a concern with this application. The required password protection of the adults account has been implemented; however, the passwords are stored in the database in plaintext, which is a security risk if the device is lost and rooted (this means that a user would be able to access the internal storage of the device). Unfortunately, Android does not provide a convenient method for storing data securely on the physical device, compared to iOS which provides 'KeyChain', a method that secures users data.

I made the decision that for now, plaintext does the required job, as the password is there to prevent the child from accessing the wrong part of the app. In the future, it would be prudent to look towards more secure options such as storing online (unfortunately reducing the accessibility of the application as it would require an internet connection during login). An option to increase the security but remain offline would be to encrypt the keys, however again the decryption logic must be stored on the device and is therefore still accessible to a perpetrator, although at a larger cost of time.

7 Testing

7.1 Testing Approach

Testing of the final system is of critical importance in a software engineering project to ensure the correctness of the product and meeting of the functional requirements defined in chapter 4.1. Testing was employed throughout the implementation process; however, it is possible for bugs to be missed or later introduced in an area that does not get tested. Therefore, it is important for final concrete testing of the system to be completed. I decided to use the black-box testing approach to test this system.

7.2 Black-box Testing

Black-box testing is the testing of a system where the tester does not know about the internal structure of the product, therefore the tester is external. To complete the black-box testing of the product the user stories were used. There were two testers (a student and an adult) who have no understanding of the inner workings of the software, one working on an emulator (API 29) and the other on a OnePlus 3t (API 28).

Black-box testing was undertaken with release 1.3.

7.2.1 Results

The results of the black-box testing were all positive, meaning that all the functional requirements have been met by the software with no bugs detected.

User Story ID	User 1 result	User 2 result
1	Pass	Pass
2	Pass	Pass
3	Pass	Pass
4	Pass	Pass
5	Pass	Pass
6	Pass	Pass
7	Pass	Pass
8	Pass	Pass
9	Pass	Pass
10	Pass	Pass
11	Pass	Pass

Table 15 - Black-box Testing Results

User 2 also had some additional comments about the software: they were concerned that on login all the children's names could be viewed and that the children could create new accounts (with no deletion method) meaning that many accounts could be created.

8 Evaluation

8.1 Evaluation Approach

To gain a final evaluation of the project, I originally planned to meet the evaluators and present them with the device with the app installed, then ask them attempt to complete some simple tasks as defined by the user stories. After this I would ask them to explore the app to further test out other functionalities of the app. I would then ask them to fill out a standardised questionnaire. However, as meeting in person was no longer possible, I decided to simply ask the user to test the app for as much time as they have available, before filling out the questionnaire. Although not an ideal test environment, the app was evaluated on a range of devices. This did highlight a bug, that remains to be solved, where the tutorial page images did not load on their phone (due to the anonymous nature of the questionnaire it is not possible to find the device and operating system that this occurred in to find the root of the issue).

8.2 Evaluation method

Due to the online, external evaluation that users would be undertaking, I decided to use the User Experience Questionnaire (UEQ) [26] as it translated nicely into an online form and further has benchmark tools written [27] allowing a good quality comparison of the results. The UEQ questions are shown in the appendix (Appendix E). The UEQ produces results in 6 categories, with definitions provided [28]: attractiveness (‘Overall impression of the product. Do users like or dislike it?’), perspicuity (‘Is it easy to get familiar with the product and to learn how to use it?’), efficiency (‘Can users solve their tasks without unnecessary effort? Does it react fast?’), dependability (‘Does the user feel in control of the interaction? Is it secure and predictable?’), stimulation (‘Is it exciting and motivating to use the product? Is it fun to use?’), and novelty (‘Is the design of the product creative? Does it catch the interest of users?’).

The categories of importance to this project, are perspicuity, efficiency, and dependability as these relate to the non-functional requirements defined in Chapter 4.2.

Evaluation was undertaken by 5 users, 4 of which were new to the product (the other had helped within user testing in Chapter 6.4). They evaluated release version 1.3.

I created this questionnaire using Google Forms and did not store email addresses to provide anonymity. In addition to the UEQ questions, I added the option for additional comments to be left. All the testers have experience teaching children with autism and have used social story intervention techniques in some capacity. However, due

to only having five evaluators, the results are variable and somewhat unreliable.

8.3 Evaluation Results

The data was gathered through Google Forms, provided as a .csv file. The raw data is show in the appendix (Appendix D).

8.3.1 UEQ Results

The raw data was then transformed using the UEQ data analysis tool, found at [28], producing a result for each question. The transformation is required due to the randomization of positive and negative terms for items in the questionnaire, +3 is the most positive and -3 the most negative. This transformed data is also shown in the appendix (Appendix E)

The results generated from this transformed data are shown in the table below. The UEQ validation tool tells us: ‘Values between -0.8 and 0.8 represent a more or less neutral evaluation of the corresponding scale, values > 0,8 represent a positive evaluation and values < -0,8 represent a negative evaluation.’

The variance for my results is high due to the lack of participants in the evaluation, something that future evaluation and development would likely aim to solve. Perspicuity scores highly, and strongly relates to the non-functional requirement usability (NF 1) therefore the app appears to have a solid foundation of layout style to promote easy usage. Novelty is the worst of the UEQ scales, however, is still a positive evaluation. This suggests that additional features would promote the quality of the system.

UEQ Scales (Mean and Variance)		
Attractiveness	1.667	0.36
Perspicuity	2.300	0.42
Efficiency	1.900	0.99
Dependability	1.650	0.83
Stimulation	1.800	0.48
Novelty	1.150	1.02

Table 16 – UEQ Results

The data analysis tool also provides benchmarking capabilities. This tool compares your results with those collected from 452 studies with other products to produce a relative quality benchmark, shown in the figure below. This graph is useful as it provides context with other typical software solutions. The results are extremely positive with all properties classified as at least ‘good’ with perspicuity and stimulation both classified as excellent. However, they provide a good foundation for areas in which the system can be progressed.

The results show success regarding the non-functional requirements of usability (NF 1) and learnability (NF 1.1), through an excellent perspicuity score. They also show good results for efficiency (NF 1.2), through the efficiency score. The non-functional requirement of security (NF 3) appears to be met through a good dependability score, however as mentioned in Chapter 6.7 there are some security issues with the product. In terms of the practical security aspect, (in preventing the child from gaining access to the adult portion of the app), this result shows a clear success.

Memorability (NF 1.3) is not technically assessed by the evaluation, as users do not return to the application at a later date, the perspicuity score suggests that memorability is almost irrelevant as the application was straightforward to use. However, it would have been useful to have achieved a concrete evaluation of this requirement.

Portability (NF 2) is not assessed by the UEQ.

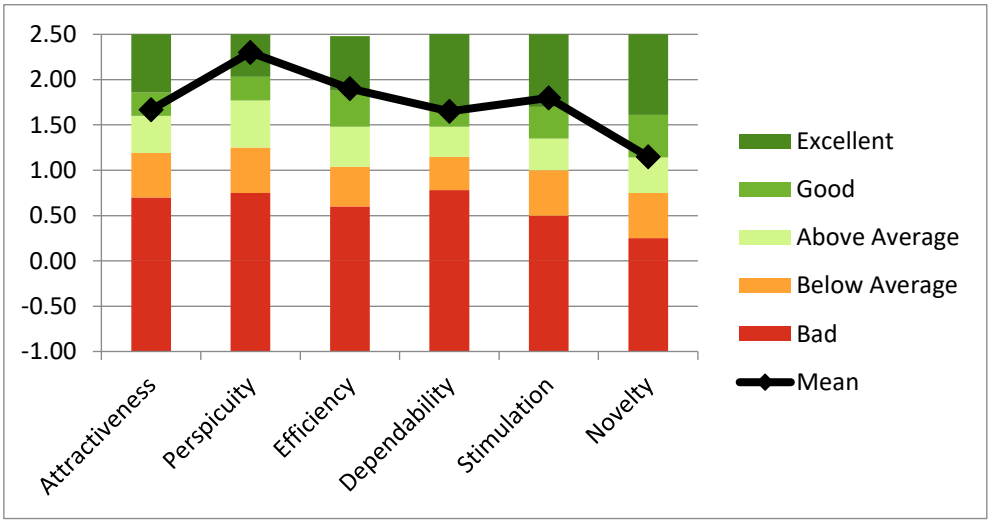


Figure 9 - Graph showing benchmark results

8.3.2 Additional Comments

Additional comments were provided by some of the users, as seen in the raw data (appendix D) and were mainly positive.

One user had found a bug with the tutorial page that had not been found during testing. I found the bug to be related to a memory exception, as large images were loaded at a high quality and took up too much memory on older devices. This bug was not found as black-box testing was completed both on an emulator (running a Pixel XL on API 29), and on a OnePlus 3T (API 28), which are both relatively powerful machines and therefore did not run out of memory. The fix to this was simple, moving the files to a different resource directory that ensured the correct quality and image size of the loaded resources.

This fix has been tested with a Samsung S6, which also displayed the found bug and passed, therefore is assumed solved.

9 Conclusion

9.1 Project Summary

This project aimed to create an Android application that would be suitable for creating social stories to help teach skills to individuals with ASD, building on a previously proposed prototype. The system provides a portable tool for parents or carers of these individuals to use in a wider range of settings than a desktop program would allow.

A literature review examined research related to the project and helped to support the stated motivation and further helped define the non-functional requirements of the application. Functional requirements were defined as user stories, which were used to help design and test the system.

Design of the system involved rapid prototyping and database design. Implementation of the system followed, using an iterative agile development framework called the Kanban method. This framework involved implementation and test iterations to build the application from the ground up, with an expert user producing feedback towards the end of the implementation process. The tools used during implementation were the IDE ‘Android Studio’ and a database tool called ‘DB Browser for SQLite’.

Testing of the system was achieved through black-box testing of the functional requirements with two external users, all tests passed. Evaluation of the system was achieved through a standardised software questionnaire, and the results were extremely promising despite the relatively small number of participants (n=5).

9.2 Future Application Work

There are various routes that the software could take in the future. An interesting option that would solve the security issues mentioned, and create an even more flexible environment, would be to move the database into an online server. This would mean that multiple applications could access the stories, such as desktops, iOS, and Android. It would require a restructuring of the current database, likely with a many-to-one relationship between the children and adult accounts to make the adult accounts the ‘owners’ of the children (this could potentially be extended to a many-to-many connection to allow parents and carers to write and edit stories for the same child).

The buttons used in this program use the standard Android theme, and therefore the appearance of the system is very plain and does not appear polished. Although this is an area that could be improved, it is important that the applications standards of usability and learnability are maintained.

Personalisation of child user layouts has been found to be important for autistic individuals [17], and is a possible feature to be added to child accounts. Further personalisation of individual stories, such as moving where the text and images are displayed on the page, could be a useful step for the application to further give control to the user. This is possible to implement within Android using fragments, which can be used as a portion of a user interface. The SQLite database may need to be extended to store these personalisation preferences, or they could be saved within the internal storage, potentially using a SharedPreferences file.

Another advantage of working with fragments would be the option to create a more tablet friendly version of the application to improve efficiency. Currently the app is designed for a smaller mobile screen, for example the change illustrated in chapter 6.5 (through figure 2, 3, 4 and 5). The figure below shows an example of how this could improve the efficiency of an app and is taken from the Fragments documentation page [29].

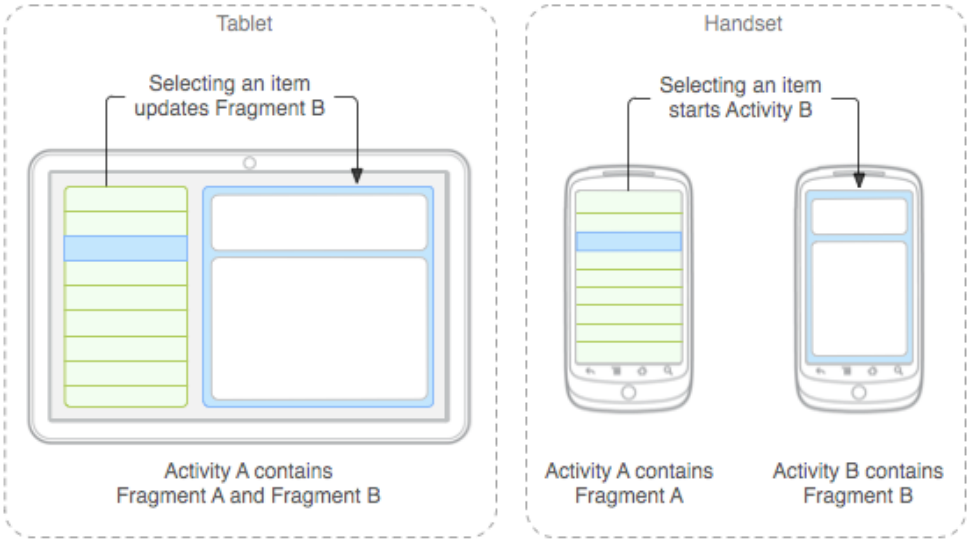


Figure 10 - Example of fragment use

Further extensions to the application include features discussed within the original shell application review [2]. A potential extension would be the inclusion of branching stories using question pages, allowing the stories to be presented to children with choices and consequences. Other requested features were spell checking and formatting. Spell checking is implemented within the Android text input environment, however the formatting of this text (such as bold or italics) is not supported, which may prevent supervisors from customising their stories as they may like.

A further extension discussed [2] is the ability to export the stories as a pdf file or even print directly. Although a motivation for this project

was to make social stories more accessible through the use of mobile devices, it is not always possible to have the same device everywhere therefore this is a suitable extension to the application.

9.3 Future Evaluation Work

No evaluation has been conducted with autistic children, as discussed in the ethical statement, however in the future, this evaluation could help to improve the application. This evaluation would need to be conducted with the suitable professionals, and extreme care must be taken at every step.

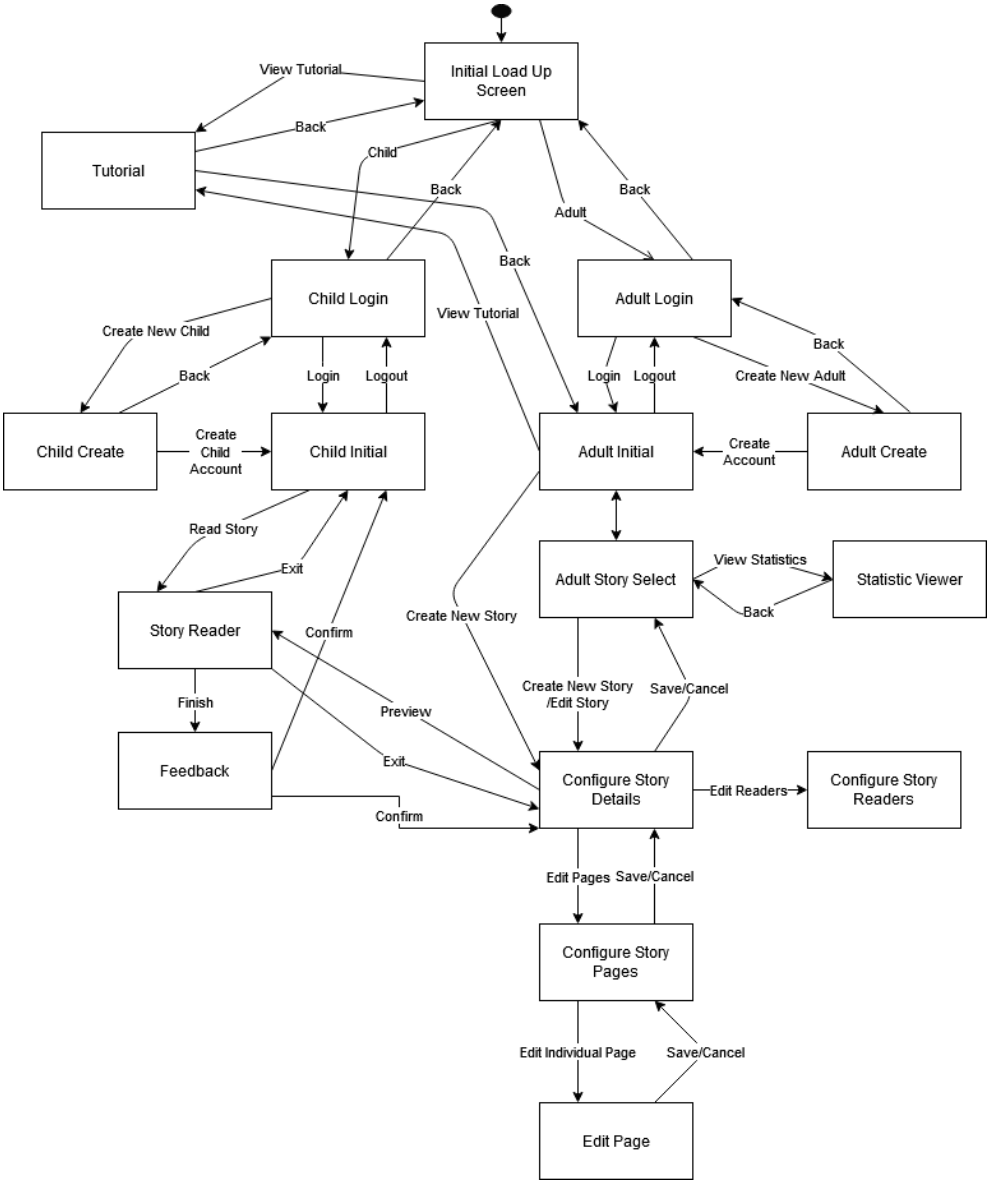
The results may be able to improve the user experience for these autistic children, and thereby may improve the effectiveness of the intervention techniques. This would improve on the major motivation of the project, in improving the social skills and lives of autistic children and therefore the lives of the parents and carers.

9.4 Conclusion and Reflection

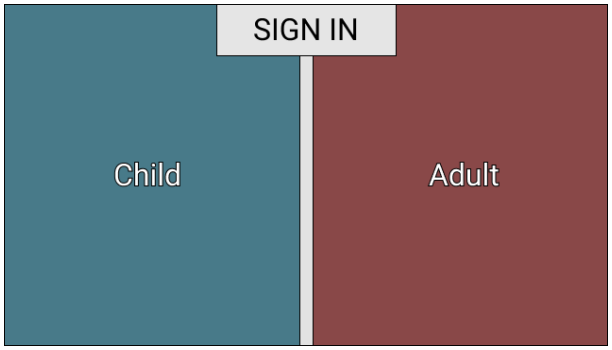
As discussed, the results gained through the evaluation show good evidence of success in achieving the non-functional requirements usability (NF 1), learnability (NF 1.1) and efficiency (NF 1.2). The results show that users believe that security (NF 3) is met, as the program does prevent users accessing stories that they do not own. However, the security of the program is a slight concern, and as discussed in Chapter 6.7, the solutions are not overly straightforward. On reflection, the security of the product should have been more thoroughly tested to ensure the meeting of the requirement. The non-functional requirement of portability (NF 2) has not been evaluated through any results, and although the system was tested throughout implementation with devices of different sizes, by using an emulator in Android Studio, the physical devices may have different behaviours.

Testing with different devices is not always possible, however the black-box tests should have been carried out using a range of machines, from tablets to small mobile phones and for devices of different specifications regarding processing power and memory. This would be more likely to catch various bugs that may exist that I am unaware of, especially as this is the first application I have created. For this reason, I would ensure that more testing was completed, potentially with the addition of live-action unit tests to test activity behaviours.

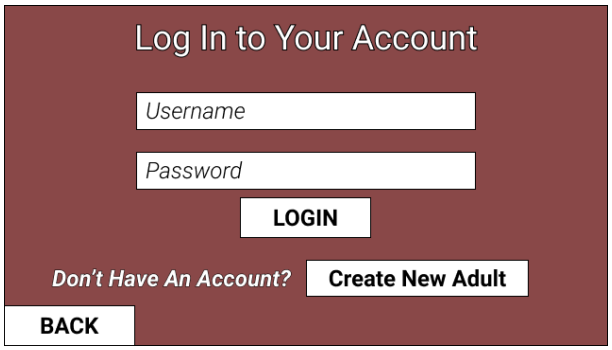
Appendix A: User Interface Flow Diagram



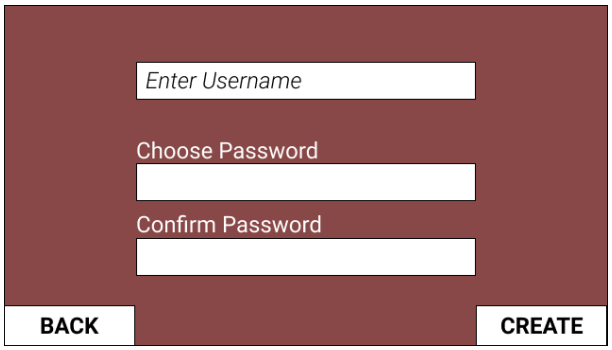
Appendix B: User Interface Prototype



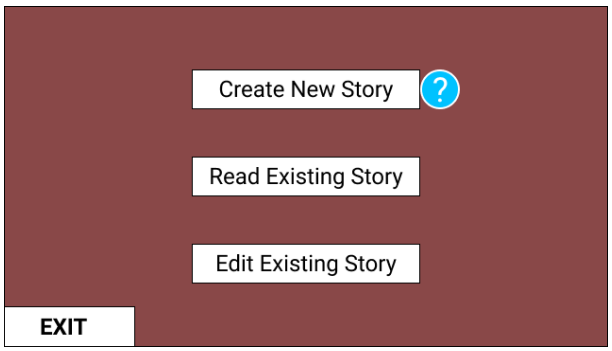
UI 1 - Sign In



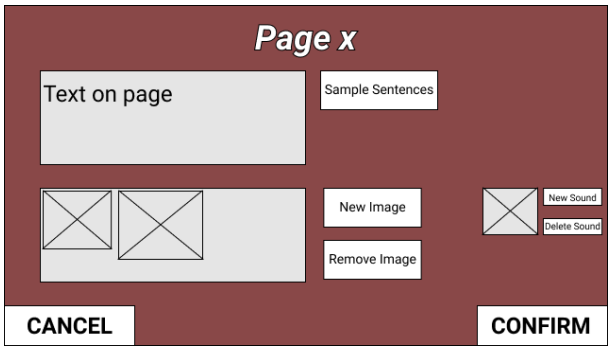
UI 2 - Adult Login



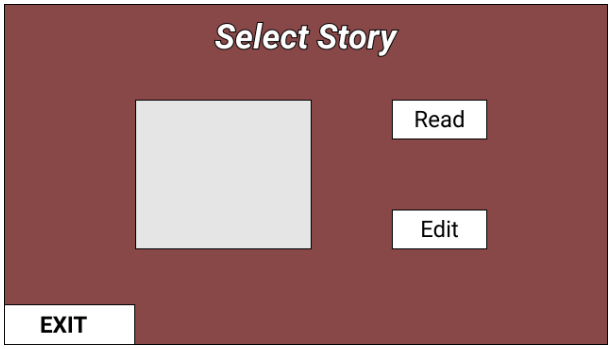
UI 3 - Adult Create Account



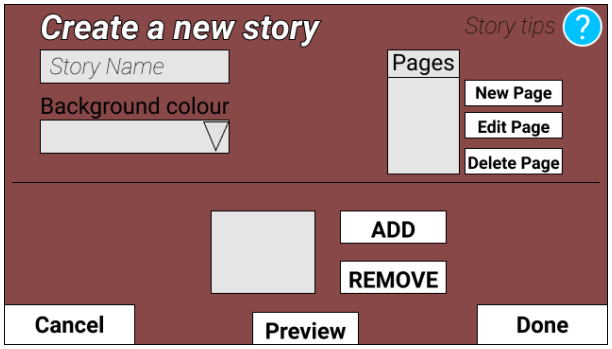
UI 4 - Adult Initial



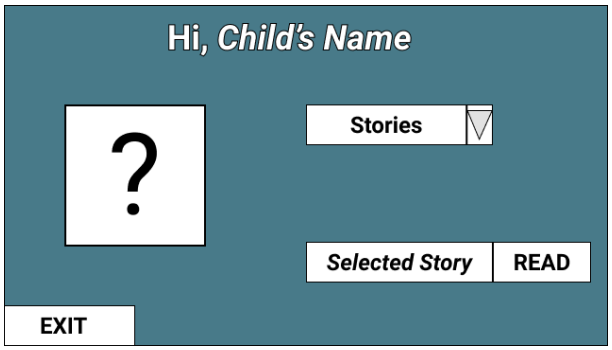
UI 5 - Page Editor



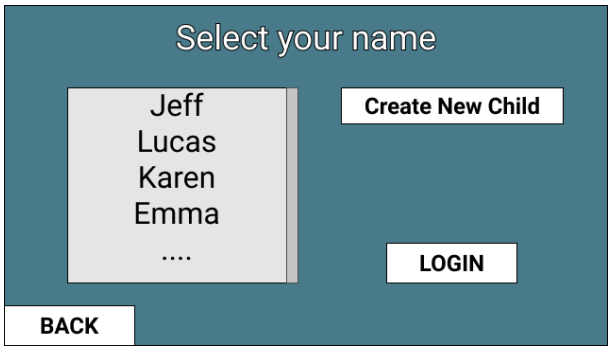
UI 6 - Select Story To Edit/Read



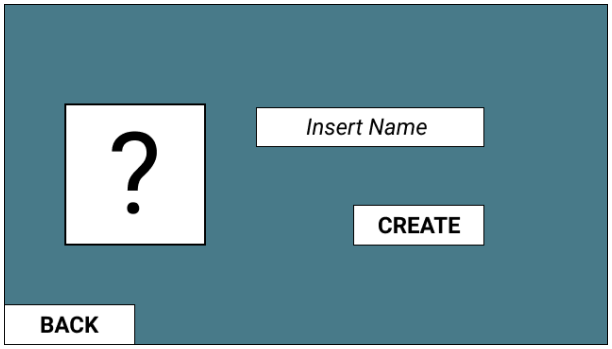
UI 7 - Create New Story



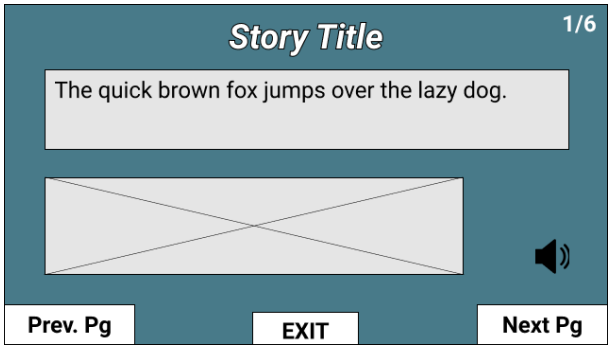
UI 8 - Child Initial



UI 9 - Child Sign In

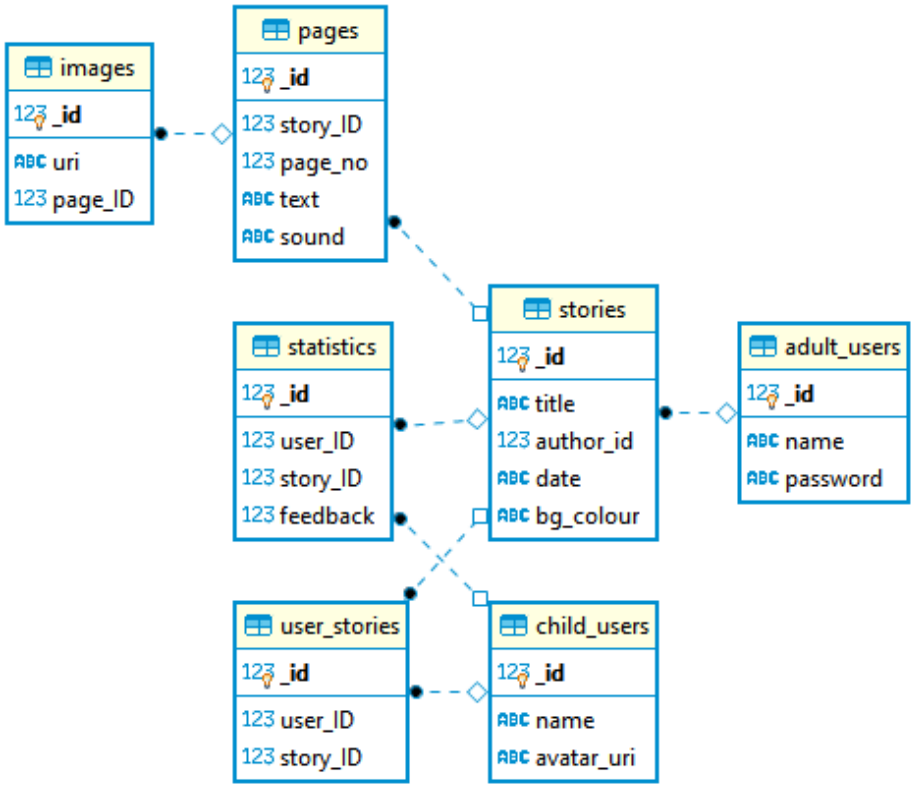


UI 10 - Create Child Account



UI 11 - Story Reader

Appendix C: Relational Database



Appendix D: Raw Data from Evaluation

Timestamp	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Question 7	Question 8	Question 9	Question 10	Question 11	Question 12	Question 13	Question 14	Question 15	Question 16	Question 17	Question 20	Question 21	Question 22	Question 23	Question 24	Question 25	Question 26	Any additional comments
2020/05/14 6:27:16 pm CET	6	7	2	1	1	6	7	7	2	1	7	1	6	7	7	7	2	7	1	6	2	2	2	7	Really easy to use. Can see this being very useful in a range of settings. Would definitely recommend!
2020/05/15 9:00:08 pm CET	5	6	4	6	2	6	6	7	2	3	6	1	7	4	4	6	2	7	1	7	2	2	2	6	Clear and simple and easy for children to access. Fast for staff and parents to create stories.
2020/05/18 6:19:12 pm CET	5	6	3	1	2	4	5	5	6	5	4	2	7	5	4	5	3	4	2	6	3	5	3	4	The "how to" section appears to just show blank screens for each of the parts. Making a social story on the app works well though!
2020/05/18 6:40:33 pm CET	6	7	4	1	1	5	6	7	1	1	7	1	7	6	5	6	3	7	1	6	1	6	2	5	
2020/05/18 7:24:08 pm CET	6	6	2	2	2	5	5	1	1	3	6	1	5	6	5	5	3	5	2	5	2	2	3	4	Set up instructions easy to follow,pleasing to the eye and straight forward to use.

Appendix E: Transformed Data from Evaluation

Items																									
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
2	3	2	3	3	2	3	3	2	3	3	3	2	3	3	3	2	2	3	3	3	2	2	2	2	3
1	2	0	-2	2	2	2	3	2	1	2	3	3	0	0	2	2	2	2	3	3	3	2	2	2	2
1	2	1	3	2	0	1	1	-2	-1	0	2	3	1	0	1	1	0	2	0	2	2	1	-1	1	0
2	3	0	3	3	1	2	3	3	3	3	3	3	2	1	2	-2	3	3	3	3	2	3	-2	2	1
2	2	2	2	2	1	1	-3	3	1	2	3	1	2	1	1	1	2	2	1	2	1	2	2	1	0

Appendix F: Questions

	1	2	3	4	5	6	7		
annoying	○	○	○	○	○	○	○	enjoyable	1
not understandable	○	○	○	○	○	○	○	understandable	2
creative	○	○	○	○	○	○	○	dull	3
easy to learn	○	○	○	○	○	○	○	difficult to learn	4
valuable	○	○	○	○	○	○	○	inferior	5
boring	○	○	○	○	○	○	○	exciting	6
not interesting	○	○	○	○	○	○	○	interesting	7
unpredictable	○	○	○	○	○	○	○	predictable	8
fast	○	○	○	○	○	○	○	slow	9
inventive	○	○	○	○	○	○	○	conventional	10
obstructive	○	○	○	○	○	○	○	supportive	11
good	○	○	○	○	○	○	○	bad	12
complicated	○	○	○	○	○	○	○	easy	13
unlikable	○	○	○	○	○	○	○	pleasing	14
usual	○	○	○	○	○	○	○	leading edge	15
unpleasant	○	○	○	○	○	○	○	pleasant	16
secure	○	○	○	○	○	○	○	not secure	17
motivating	○	○	○	○	○	○	○	demotivating	18
meets expectations	○	○	○	○	○	○	○	does not meet expectations	19
inefficient	○	○	○	○	○	○	○	efficient	20
clear	○	○	○	○	○	○	○	confusing	21
impractical	○	○	○	○	○	○	○	practical	22
organized	○	○	○	○	○	○	○	cluttered	23
attractive	○	○	○	○	○	○	○	unattractive	24
friendly	○	○	○	○	○	○	○	unfriendly	25
conservative	○	○	○	○	○	○	○	innovative	26

Appendix G: Consent Form

Address removed from form for privacy reasons.

Participant Consent Form

I, _____ , agree to take part in Alex Hodder-Williams's experiment, in connection with Developing Social Story Software for Autistic Children. I confirm that my participation is entirely voluntary. I understand that there will be no renumeration for the time I spend. I understand that all data gathered from the study will be treated in a confidential fashion: all identifying information will be removed and the data will be archived in a secure location and used only for the purposes of this project. I understand that there are no known risks to participation in this experiment and that I am free to withdraw at any time.

Signature of Participant:
Date:

Researcher's Contact Details:

Alex Hodder-Williams
ADDRESS REMOVED
ahw519@york.ac.uk

Supervisor's Contact Details:

Tommy Yuan
tommy.yuan@york.ac.uk

Bibliography

[1] A. Rugeviciute, *Story Builder for children with autism,* University of York, 2012.

[2] T. Yuan and G. Zhong, “A Computer-Based Story Builder for Children with Autism,” in *Proceedings of 2013 3rd International Conference on Computer Science and Network Technology*, Dalian, 2013.

[3] D. Moore, Y. Cheng, P. McGrath and N. J. Powell, “Collaborative Virtual Environment Technology for People With Autism,” *Focus on Autism and Other Developmental Disabilities,* vol. 20, no. 4, pp. 231-243, 2005.

[4] National Autistic Society, “Using Technology,” National Autistic Society, [Online]. Available: https://www.autism.org.uk/about/family-life/using-technology.aspx. [Accessed 20 05 2020].

[5] National Autistic Society, “What is autism?,” National Autistic Society, [Online]. Available: https://www.autism.org.uk/about/what-is/asd.aspx. [Accessed 28 01 2020].

[6] statcounter, “Mobile Operating System Market Share United Kingdom,” statcounter, April 2020. [Online]. Available: https://gs.statcounter.com/os-market-share/mobile/united-kingdom. [Accessed 17 05 2020].

[7] L. Kenny, C. Hattersley, B. Molins, C. Buckley, C. Povey and E. Pellicano, “Which terms should be used to describe autism? Perspectives from the UK autism community,” *Autism,* vol. 20, pp. 442-462, 2016.

[8] National Autistic Society, “Children on the spectrum,” [Online]. Available: https://www.autism.org.uk/~/media/nas/about-autism/family-life/children-on-the-autism-spectrum-pdf-leaflet.ashx?la=en-gb. [Accessed 2020 01 28].

[9] National Institute of Mental Health, “Autism Spectrum Disorder,” National Institute of Mental Health, March 2018. [Online]. Available: https://www.nimh.nih.gov/health/topics/autism-spectrum-disorders-asd/index.shtml. [Accessed 15 02 2020].

[10] National Autistic Society, “Position statement: therapies and interventions,” National Autistic Society, [Online]. Available: https://www.autism.org.uk/get-involved/media-centre/position-statements/interventions.aspx. [Accessed 15 05 2020].

[11] G. Charitaki, “The effect of ICT on emotional education and development of young children with Autism Spectrum Disorder,” in *International Conference on Communication, Management and Information Technology (ICCMIT 2015)*, Prague, 2015.

[12] A. Drigas and J. Vlachou, “Information and Communication Technologies (ICTs) and Autistic Spectrum Disorders (ASD),” *International Journal of Recent Contributions from Engineering, Science & IT (iJes),* vol. 4, no. 1, p. 4, 2016.

[13] S. Sani Bozkurt and S. Vuran, “An Analysis of the Use of Social Stories in Teaching Social Skills to Children with Autism Spectrum Disorders,” *Educational Sciences: Theory & Practice,* vol. 14, 10 2014.

[14] National Autistic Society, “Social stories and comic strip conversations,” National Autistic Society, July 2018. [Online]. Available: https://www.autism.org.uk/about/strategies/social-stories-comic-strips.aspx. [Accessed 2020 01 30].

[15] C. Rowe, “The Stanley Segal Award: Do Social Stories Benefit Children with Autism in Mainstream Primary Schools?,” *British Journal of Special Education,* vol. 26, pp. 12-14, 1999.

[16] A. Dix, J. Finlay, G. D. Abowd and R. Beale, Human-Computer Interaction, Harlow: Pearson, 2004.

[17] N. Pavlov, “User Interface for People with Autism Spectrum Disorders,” *Journal of Software Engineering and Applications,* vol. 07, pp. 128-134, 1 2014.

[18] R. Alnanih and O. Ormandjieva, “Mapping HCI Principles to Design Quality of Mobile User Interfaces in Healthcare Applications,” *Procedia Computer Science,* vol. 94, pp. 75-82, 12 2016.

[19] Synopsys Editorial Team, “Top 4 software development methodologies,” Synopsys, 28 March 2017. [Online]. Available: https://www.synopsys.com/blogs/software-security/top-4-software-development-methodologies/. [Accessed 26 February 2020].

[20] M. Lotz, “Waterfall vs. Agile: Which is the Right Development Methodology for Your Project?,” 05 July 2018. [Online]. Available: https://www.seguetech.com/waterfall-vs-agile-methodology/. [Accessed 26 February 2020].

[21] D. Radigan, “Kanban,” ATLASSIAN, [Online]. Available: https://www.atlassian.com/agile/kanban. [Accessed 26 February 2020].

[22] altexsoft, “Non-functional Requirements: Examples, Types, How to Approach,” altexsoft, [Online]. Available: https://www.altexsoft.com/blog/non-functional-requirements/. [Accessed 14 03 2020].

[23] M. De La Riva, “What Is Rapid Prototyping In UX? A Step-By-Step Guide,” 23 April 2019. [Online]. Available: https://careerfoundry.com/en/blog/ux-design/rapid-prototyping-guide/. [Accessed 02 March 2020].

[24] Android Developers, “SharedPreferences,” Google, 27 December 2019. [Online]. Available: https://developer.android.com/reference/android/content/SharedPreferences. [Accessed 03 May 2020].

[25] S. Ambler, “Core Practices for Agile/Lean Documentation,” Ambysoft Inc., [Online]. Available: http://www.agilemodeling.com/essays/agileDocumentationBestPractices.htm. [Accessed 01 May 2020].

[26] B. Laugwitz, T. Held and M. Schrepp, “Construction and Evaluation of a User Experience Questionnaire,” in *USAB*, Graz, 2008.

[27] M. Schrepp, A. Hinderks and J. Thomaschewski, “Construction of a Benchmark for the User Experience Questionnaire (UEQ),” *International Journal of Interactive Multimedia and Artificial Intelligence,* vol. 4, no. Regular Issue, pp. 40-44, 2017.

[28] UEQ, “User Experience Questionnaire,” [Online]. Available: https://www.ueq-online.org/. [Accessed 19 05 2020].

[29] Android Developers, “Fragments,” Google, 27 12 2019. [Online]. Available: https://developer.android.com/guide/components/fragments. [Accessed 20 05 2020].