EXPLORING THE DESIGN, DEVELOPMENT AND EVALUATION OF AN APP FOR AUTISTIC CHILDREN IN A MUSEUM SETTING

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ABSTRACT

This thesis seeks to address the potential of using touchscreen-based services in the museum setting for children with autism. One of the main aims is to examine whether a museum-based app as a mediating tool can enable groups of children with autism to have an engaging experience within a museum environment.

This research employs a case-study methodology, and the design of the interface is theoretically informed by adopting a Participatory Design (PD) approach. This thesis contributes to the development of a conceptual framework which aims to identify various factors that can contribute to the active participation of children with autism in technology design process. A qualitative approach has been adopted and data were collected from different angles and diverse sources. Video recordings, field observations, questionnaires, focus group, and a think-aloud protocol provided insights into how the museum visit was perceived through the *What's Bristol?* app by a group of children with autism.

The results of this study provide important insights into pupils' actions and interactions with the museum through the *Whats Bristol?* app. Evidence suggests that a museum-game app can be viewed as a tool to provide opportunities for children with autism to participate in museum-related activities and to interact with the environment with positive outcomes. Through a series of activities and a specific goal, the app acted as a bridge to guide the pupils by focusing on specific exhibits in the gallery. This, then, offered some control over the environment and created an atmosphere that encouraged active participation, focus, and an interest to complete the game. Overall, the findings from this study support the idea that the use of technology-based museum activities can contribute to the inclusion of children with autism as long as their special needs and abilities are met. To achieve this, partnerships with specialists from different fields are an important aspect of providing high quality services and provisions. This study aimed to shed light on an overlooked area of research and to inform future policy and services provided by museums. This, in turn, will help young people with autism access museums in a supportive and inclusive way.

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Ευχαριστώ πολύ

Statement of Original Authorship

This copy has been supplied on the understanding that it is copyright material and that no quotation from this thesis may be published without proper acknowledgement. No portion of the work referred to in the thesis has been submitted in support of an application for another degree of qualification of this or any other university of other institute of learning.

Publications

Magkafa, D., Newbutt, N. and Palmer, M. (2020) "*Implementing co-design practices for the development of a museum interface for autistic children*". In: Kapralos, B., Brooks, A., Branhnam, S. and Jain, J., eds. (2020) Recent Advances in Technologies of Inclusive Well-Being. Springer, pp. 1-15. [In Press].

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Abbreviations

ABA	Applied Behavioural Analysis
ADHD	Attention Deficit Hyperactivity Disorders
APPS	Applications
AR	Augmented Reality
ASCs	Autism Spectrum Conditions
BERA	British Educational Research Association
DDA	Disability Discrimination Act
FAS	Foetal Alcohol Disorder
GDPR	General Data Protection Regulation
HCI	Human Computer Interaction
HCI	Human Centred Design
HFI	High Functioning Autism
ICT	Information and communication technologies
OCD	Obsessive- compulsive disorder
PD	Participatory Design
PECS	Picture Exchange Communication Systems
PDD-NOS	Pervasive developmental disorder not otherwise specified
PDA	Pathological demand avoidance
TEACHH	Teaching and Education of Autistic and Related Communication Handicapped
TD	Typically Developing Children
SIT	Sensory Integration Therapy
UCD	User-centred design
VR	Virtual Reality

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Chapter 1

Introduction

1.1 Background

Autism Spectrum Conditions[1] (ASCs) are pervasive behaviour-defined developmental conditions, signs of which seem to emerge in early childhood. The term ‘spectrum’ refers to a wide degree of symptoms and a distinctive set of behavioural problems based on the score of standardised intelligence tests. ASCs range from ‘classic’ autism, with limited abilities, to high functioning autism (HFA), with adequate verbal communication skills and cognitive development (American Psychiatric Association, 2013). This group of complex conditions of brain development is characterised by difficulties in reciprocal social interaction and communication and by marked repetitive behaviours and restricted interests (Frith, 2003; Wing and Gould, 1979). In the past three decades, the focus of mental health professionals and researchers has shifted towards the need to identify evidence-based interventions for ASCs populations. A variety of interventions are available, ranging from behavioural to educational, which

[1] This thesis uses the term ‘autism spectrum conditions’ (ASCs) instead of using the clinical term ‘autism spectrum disorder’ (ASD) which is associated with medical interpretations and has a negative connotation. As this thesis adopts the social model of disability, the term ‘ASCs’ is preferred to describe people diagnosed with autism, as it is more respectful of neurodiversity. Further to this, the term used throughout the thesis is ‘children with autism’ and not ‘autistic children.

mainly seek to address the core issues of autism and increase an individual's competencies (White *et al.,* 2007; Volkmar *et al.,* 2005).

The aim of this thesis is to explore how state-of-the-art technologies can provide various benefits for children with autism (Grynszpan *et al.,* 2014). Due to recent technological advances, touchscreen devices have become an area of interest for researchers as a way of improving the skills of children with autism (Murdock, Ganz and Crittendon, 2013). The rationale for this is that portable touchscreen devices such as iPads and Android tablets are widely available and provide several affordances that make them appealing. Touchscreen devices are defined as "viable aids" (Kagohara *et al*., 2013, p.154), and they have been shown to make a positive contribution to addressing the core difficulties experienced by children with autism. Thus, possibly improving their quality of life (aiming for happiness) and outcomes.

In the literature, empirical evidence has documented that the use of touchscreen applications tend to be effective for children with autism to improve any language difficulties (Heimann *et al*., 1995), empower cognitive development (Strnadova, Cumming and Rodriguez, 2014), enhance adaptive functioning (Kagohara, 2010), or help with social skills (Fletcher-Watson *et al*., 2016). Specifically, the intrinsic advantages of these devices, such as their portability and the easy-to-use touchscreen interface combined with audio and visual output, make them a promising tool to help such children when they are in a controllable and predictable environment (Fletcher-Watson, 2014; Kagohara *et al*., 2013). In addition, a suitable technology program might be able to reduce the need for face-to-face communication, which some children find difficult to deal with (Goodwin, 2008). Within this context, there are commercial applications that aim to support children with autism by targeting specific areas, such as life skills (e.g., Choiceworks), academic skills (e.g., Autism iHelp), communication (e.g., Proloquo2Go), and entertainment (e.g., Duck Moose) (Fletcher-Watson e*t al.,* 2016). The increasing number of smartphone/tablet applications has resulted in several well-known autistim organisations and relevant magazines worldwide (e.g., Autism Speaks, National Autistic Society, Autism Parenting, Autismapps) providing additional information regarding the most appropriate applications that can target a range of skills across different areas.

Regarding the use of touchscreen devices, to date, only limited research has explored how children with autism engage with a handheld device outside of formal educational settings (Mechling, Gast and Seid, 2009). This might be because equipment has been available in schools as a way to provide immediate feedback to the children (direct users) (Fletcher-Watson, 2014). However, the shift towards inclusive practices has stressed the importance of assessing such programs “in general education settings and in the contexts of varying instructional arrangements” (Pellicano, E. and den Houting, J. (2022) Annual Research Review: Shifting from ‘normal science’to neurodiversity in autism science. Journal *of Child Psychology and Psychiatry* [online]. 63 (4), pp.381-396. [Accessed 15 June 2022].

Pennington, 2010, p.246). Within this context, Ploog *et al.* (2013, p.319) state that “the majority of the available programs have not been developed specifically for this population”; as a result, some programs show configuration issues and limitations. When programs are poorly designed and fail to consider the children’s special needs, the inevitable pitfalls can lead to a reduced appeal and a lower level of engagement (Malinverni *et al*., 2017). This, in turn, can cause children with autism to generate negative feelings, like frustration (Ploog *et al.*, 2013). These shortcomings may be attributed to a) limited use of inclusive design approaches and little or no account being taken of best practices when guiding the design of such technologies (Malinverni *et al*., 2017; Ploog *et al.,* 2013; Millen, Edlin-White and Cobb, 2010), or b) a lack of understanding and consideration of the needs of children with autism, contributions, and interests in the design process of digital platforms (Benton *et al*., 2012; Brown *et al.,* 2011).

While there has been some progress in testing the applicability of software programs for children with autism, their participation in the design process by applying user-centred design methods has not yet been fully explored (Zervogianni *et al.*, 2020; Davis *et al.,* 2010). Indeed, from a design perspective, the way an interface is designed can have an impact on the behaviour and attitude of children with autism when they are interacting with the platform (Rogers, Sharp and Preece, 2011). Hence, there is a need for a shift towards a more inclusive approach (Zervogianni *et al.,* 2020; Parsons and Cobb, 2011). That means that it is important to consider the involvement of children with autism and other stakeholders when designing technologies and determining the best ways of applying them. Therefore, this study aimed to address some of the gaps in knowledge by involving children with autism in the development of a touchscreen software program for the context of this research.

Research has indicated that opportunities for social inclusion for children with autism are likely to strengthen positive behaviours. In addition, an involvement in recreational pursuits enables such children to have a greater sense of community integration, while it improves their quality of life and increases their social skills (Little *et al.,* 2014; Patterson, and Pegg, 2009). In this regard, a museum visit is considered a pleasant way to spend their leisure time. As scholars claim, museums primarily have a didactic function (Hein, 1995; Falk and Dierking, 1992); they are active institutions where visitors are motivated to gain knowledge, to observe, and to learn through play and exploration (Semper, 1990). Tactile and kinaesthetic experiences through touching and bodily action are conducive to maintaining children's attention.

In the field of museums, there seems to be an increasing awareness of the need for inclusivity. This concept was introduced by Sandell (1998), who claimed that museums can tackle social disintegration through representation, participation, and access. Within the concept of inclusion, museums have sought to reach a more diverse population, while priority has been given to the delivery of accessible provisions in such a way as to respond to the needs of a diverse range of people (Black, 2005). This ongoing commitment by museums is highlighted by the American Association of Museums (2019), which suggests, "Diversity, equity, accessibility, and inclusion in all aspects of museum structure and programming are vital to the future viability, relevance, and sustainability of museums". In support of this stance, museums embrace new adaptive practices on promoting community cohesion and advancing their services for people with physical or intellectual impairments.

Museums have focused on developing a greater understanding of how best to support and accommodate the needs of children with autism. Specifically, efforts have been made to provide a less stimulating environment through sensory-friendly educational programs and activities (Deng, 2015). Further, museums have provided material and resources, such as equipment (e.g., tactile sensory bags), visual stories, specific hours, and separate activities (Freed- Brown, 2010). These ground-breaking provisions seem to have created a level of comfort for visitors with autism and have contributed to their active involvement in museum activities, thus fostering a sense of belonging to the community (Mulligan *et al.,* 2013). As the representation of the autism community is a new element in museum research, to date, little attention has been paid to the question of what impact a co-designed museum-game app might have on the museum engagement of children with autism. Therefore, it is within the context of museums and children with autism that this thesis aims to explore whether a co-designed game application can foster interactions and novel experiences within the museum environment.

1.1.1 Rationale and Scope of the Research

Building on previous work on museums and autism, the goal of this doctoral research was to explore the influence of technology on interaction and engagement in children with autism within the museum environment. Previous research has suggested that children with autism are familiar with touchscreen-based applications and so are more motivated to interact with them because such applications scaffold social interaction in an accessible way. To date, several steps have been taken to develop inclusive activities and services for visitors with autism in museums, however, "The accessibility of museum provisions for people with intellectual disabilities remains a challenging issue" (Magkafa and Newbutt, 2018). To address this, the transformation of museums - not only their physical setting but also the digital one - is necessary to integrate equitable digital services for this audience. However, although the integration of multimedia systems has come to play a popular role in the museum field, the adoption of touchscreen devices for children with autism is a relatively unexplored topic. Langa *et al.,* (2013), were the first to highlight the importance of the use of web-based museum resources to strengthen the experience for families, with an emphasis on preparing children with autism before the visit.

Beyond the studies investigating the role of touchscreen-based programs in schools or in home settings, there has been limited research on evaluating digital software programs for children with autism on external outings; indeed, a better understanding of the ways such children engage with an interface and the forms of interactions generated within a physical environment such as museums are still lacking. To broaden the knowledge on this topic, it is important to explore the interrelationship of a portable device and museum exploration for children with autism, while observing their interactions within the museum environment.

Taking into account the affordances of technology, it is hoped that the approach followed in the present study will show the potential of a portable device as a medium to support and enhance the experience of a museum visit for children with autism; it aims to assess what impact this form of visit might have on children's exploration and engagement with the physical environment. Considering that children with autism can experience difficulties navigating an app in intimidating environments, such as museums, this study endeavours to gain insights into how digital services shape new forms of engagement in children with autism. It also gives insights into how museum practitioners could integrate such technologies to provide them with better accessibility and new opportunities for interaction with the museum exhibits. It is recognised that there is no guidance for visitors with autism on how to design and use an application in a museum environment, and therefore, this issue is addressed by the present research. A set of recommendations are developed for museum professionals and technologists to design museum digital platforms that can support such visitors. This thesis seeks to address this gap in knowledge based on the principles of a participatory design approach and the participation of children with autism in the process.

1.2 Research Questions

The overarching goal of this research is to address gaps in the knowledge in this field by developing an interactive museum software program that can serve the needs of children with autism. The aim is to explore the perceptions and experiences of children with autism and what can be afforded through the use of a tablet as an intermediary tool to facilitate their participation during a museum visit. In particular, this study is concerned with gaining an understanding of how and why children with autism might use a portable device as part of the exploration and whether such devices can improve their engagement with the environment. To do this, this research focuses on the design of a software program for use by children with autism during a visit to a museum.

The objectives of the study are outlined below:

- produce a literature review providing an in-depth understanding of the impact of interactive devices on the behaviour of children with autism
- explore theoretical contexts and design requirements for the design of a platform for children with autism
- develop a set of design guidelines that are in alignment with the existing literature in the field
- develop and design a practical museum-based application centred on the existing design guidelines and suggestions of children with autism
- develop a case study methodology to gain an empirical understanding of the use, uptake, and in situ experiences of children with autism in a museum setting
- evaluate the platform as a new form of supporting children with autism within the museum environment
- analyse and synthesize the findings to establish the platform's value to experiences in museums.

To achieve this, the study sought to answer the following research and sub questions (RQs) in addressing current gaps in knowledge:

1. How might the involvement of mid-to-high functioning children with autism inform the design process of a museum-game application?
   1a. What are the benefits of the effective involvement of children with autism in the design of a museum-game app and what adaptations need to be considered throughout the whole design process?
2. Does the use of a co-designed game app contribute to bridging the gap between physical and digital spaces to prolong and encourage independent and social interactions in a museum environment?

1.3 Definitions

Key terms used throughout the thesis are defined as follows:

Autism Spectrum Conditions (ASCs)

The term 'autism spectrum conditions' or ASCs refers to a lifelong developmental disability, and it is described by a triad of impairments in three main domains: a) social interaction, b) communication, and c) rigid and repetitive behaviours (American Psychiatric Association, 2013; Wing and Gould, 1979).

Touchscreen device

The term 'touchscreen device' or 'touch screen device' is used to refer to a computer display screen with a graphical interface that allows the users to interact with a computer by touching certain areas of the screen rather than using a mouse or other such devices. The term was first described in the mid-1960s (Walker, 2012).

Application (app)

'Application', most frequently referred to as an app (hereafter 'app'), is described as a type of software program that is designed to perform a specific task but that is not part of a computer's operating system software (Techopedia 2019). Applications are designed to run on mobile devices such as a smartphone or tablet computer.

End-user

The term 'end user' is generally understood to mean a person that uses a software program or a hardware device (PC Glossary, 2019). Specifically, it refers to how the program is designed to fit users' needs.

Social inclusion

In the literature, there seems to be no general definition of 'social inclusion' in the context of museums. Social exclusion and inclusion are complex concepts depending on the field within which they have been applied (Sandell, 2003). Sandell (2003) claims that for cultural organizations, the importance of "social inclusion and exclusion have been fluid, evolving and problematic” (p.45). In museums, the concept of ‘social exclusion’ has been used to describe the marginalization of disadvantaged and marginalized groups among museum visitors. In the United Kingdom, this issue has seemed to gain a central point; this is reflected by the establishment of a Social Exclusion Unit in 1997 in which priority was given to ‘tackling’ exclusion.

1.4 Overview of Autism Spectrum Conditions (ASCs)

Autism spectrum conditions (ASCs) are a heterogeneous group of neuro-developmental disorders characterized by a range of levels of difficulties. Individuals with ASCs experience difficulties across several areas, including reciprocal social interactions (Wing and Gould 1979) and speech and communication (Scott *et al.,* 2002) along with markedly restrictive and repetitive actions and stereotypes (Baron-Cohen *et al*., 1993). Due to a Theory of Mind deficit (Baron-Cohen, Leslie, and Frith, 1985), individuals with ASCs may have difficulty in understanding other people’s beliefs, emotions, and thoughts. These core features can affect individuals differently with varying degrees of behavioural severity; the range of symptoms from mild to severe impairments reflects the heterogeneity of the conditions (Geschwind and Levitt, 2007).

Wing (1979) identifies a difficulty for individuals with autism regarding how language is used. Individuals with autism may have limited or non-verbal language and, if spoken language is developed, may be restricted to the repetitive use of words and sounds in what is known as echolalia (Boucher *et al.,* 2012). Those individuals who develop speech often have difficulties in their use of language, which can affect various aspects of communication, such as turn taking, and it can result in them having only a limited vocabulary.

It is acknowledged that social contacts and interaction with others appear to be limited (Dawson *et al*., 2004). Individuals with autism may be unable to initiate a conversation or practise social orienting and social seeking. Furthermore, the literature documents that when social situations occur, the interaction needs to be structured in such a way that accommodates their needs (Schilbach, 2016a). It has also been argued that even if they initiate interactions with others, they may manifest stimulus selectivity, which often results in them responding to multiple environmental cues (Koegel *et al*., 2012).

Executive function is an umbrella term for functions involving self-regulation and mental control, which has been associated with autism (Ozonoff *et al.,* 1994). Core symptoms include repetitive and stereotypical patterns of behaviour, highly focused interests, and limited flexibility (rigidity). These can be displayed either through compulsions or repetitive tendencies, such as hand-flapping, jumping, and repeating words, and/or inflexible adherence to routines and sameness, such as negative responses to changes in schedule (Stoner *et al.,* 2007; Bodfish *et al*., 2000). In addition to the core difficulties associated with ASCs, a range of secondary conditions are commonly displayed. Individuals with autism often experience sensory sensitivities to particular stimuli and can have a form of hypersensitivity or hyposensitivity (Wing, Gould and Gillberg, 2011).

As the level of manifestations can be highly heterogeneous and can be exhibited in a variety of combinations, autism can be classified as high or low functioning, and it can be located within the broader field of spectrum disorders according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5). This means that some individuals may exhibit a high level of intellectual disability and limited speech (Charman *et al.,* 2014), while others may present an average level of intelligence and have no language delay yet still experience difficulties with social interaction and repetitive behaviours (American Psychiatric Association, 2013). A diagnosis is made when specific features of autism, or what is known as the core 'triad of impairments' (Wing, 1979), are detected together. The existence of abnormal social development and interaction, language difficulties, and restricted behaviour patterns are the core characteristics for a diagnosis of autism to be made.

A reliable behavioural diagnosis is reached in early childhood, that is, within the first three years of life (Happé, 1994; Baron-Cohen and Bolton, 1993) when developmental delays mean the child does not achieve developmental milestones (Kishore and Basu, 2014). The pattern of their behaviour, speech, and language may not emerge normally, or, in some cases, the children first manifest normal development and then show a regression of skills (Baron-Cohen *et al.,* 1993). There is no specific cause of autism;

however, several lines of research support the idea that genetic factors are likely to be included in the aetiology of autism. This view is also supported by family studies, which have found that a concordance rate in twin pairs (identical) was about 60% (Wing, 1979; Folstein and Rutter, 1977).

Epidemiological research in autism has shown that the current prevalence of ASCs has been identified as being substantially higher than was estimated over the past three decades (Nassar *et al.,* 2009; Scott *et al.,* 2002). To date, based on studies published by the Centers for Disease Control and Prevention (2017), reported rates are as high as 1:68, while until a decade ago, the prevalence rate was closer to 1:88 (Baio, 2014). Government agencies like the Department of Health have reported that approximately 1 in 100 children can meet the criteria for ASCs in the UK (Department of Health, 2010). As such, the rise of autism among children characterizes this disorder as the most rapidly growing neurodevelopmental disorder (Centers for Disease Control and Prevention 2017). Autism has long been reported as being more common in males than in females, with a widely cited ratio of 4:1 (Fombonne *et al.,* 2011); however, large-scale epidemiological studies have highlighted a decreasing male predominance, suggesting instead a ratio of between 2:1 and 3:1 (Baxter *et al.,* 2015; Mattila *et al.,* 2011). This lower gender ratio may be due to a better representation of females in recent years, as, historically, there were disproportionately small numbers of females being recruited into research studies (Jensen *et al.*, 2014). A number of factors might account for the increased rates of autism over the past 15 years. These include a greater awareness and rate of detection, the broadening of the diagnostic criteria, and new assessment instruments. It is also due to changes in the research methodologies and increased awareness among professionals and parents (Russell *et al*., 2014; Williams, Higgins and Brayne, 2006; Baird *et al*., 2006).

1.5 Contribution to knowledge

This study explores the use and effectiveness of a museum-based app for children with autism, which has been evaluated in a museum setting. However, technology is evolving, and technology-based platforms seem to be well-suited to the preferences of children with autism (Kagohara *et al.,* 2014). Therefore, understanding their interests and motivations in terms of the design of a museum interface is one of the goals of this research, and it helps inform the design process and contributes to filling this gap in the literature. This study seeks to draw democratic models of participation by placing the voices of children with autism at the forefront of the design process of a museum app. This will help provide a better understanding of the factors that can influence the practice of the co-design process and identify the needs of children with autism from their inputs.

The impact of museum software programs on visitors has been investigated in museums over the last twenty years. However, the use of these tools bears scope for wider exploration. This research contributes new knowledge to the field by exploring the impact of a co-designed app on the visit to and exploration of a museum by children with autism. Central to this thesis is the need to identify whether children with autism can be engaged and motivated to explore a museum space through a technology-mediating tool and how this occurs. Addressing such questions has the potential to help museums and designers in the field of autism understand how technology can be designed and used to provide an enhanced museum experience. Instead of focusing solely on how to create museum programs for children with autism, this study represents a step forward in understanding how to provide a museum visit through stimulating the children with autism to be engaged with multiple objects.

Therefore, this thesis sets out to report how a digital platform was developed based on the input and feedback of children with autism while the emphasis is on the process of engaging them in the design of the platform. What makes this study novel is that it followed a child-orientated approach in which the partnership among stakeholders from diverse backgrounds was considered necessary. In this study, different stakeholders, such as teachers, children with autism, designers, and the researcher, were all engaged in and contributed to the design of the platform. Throughout the development process, the design team participated in a series of meetings and had direct contact with the school to identify and address the needs of the children who were involved in this study. This work, which is exploratory in nature, is multidisciplinary and makes a contribution to fields such as inclusive design, technology for children with autism, and museums. **Figure 1** demonstrates how these areas interlink with each other under the same research scope. In this new era of developing technology-based interventions, this study is the first to examine the digital practices needed to help promote the inclusion of children with autism in a museum setting.

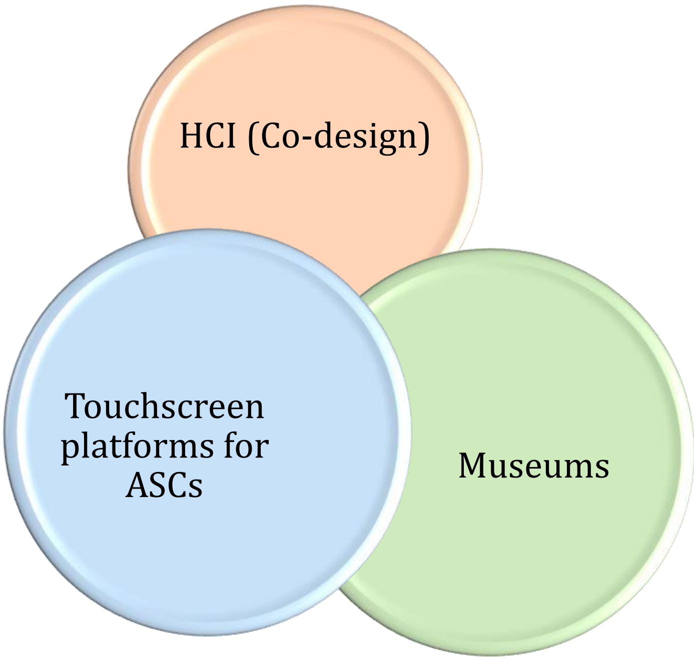

Figure 1 The intersection among several disciplines.

1.6 Thesis Structure

This thesis presents in detail the findings from an exploratory case study that investigated the use of a museum-based app by a group of children with autism. This section outlines how the structure, and the content of the thesis are organised. It shows the several steps the study followed, how it progressed throughout the time of the research, and how each chapter informed the others. It describes how the research evolved from defining the needs of the children with autism who participated in this study in terms of the development of a museum-game app to focusing on the platform's evaluation in the museum as a research site. The thesis is divided into eight chapters, including the introductory chapter. The outline and flow of each chapter are illustrated in **Figure 2**.

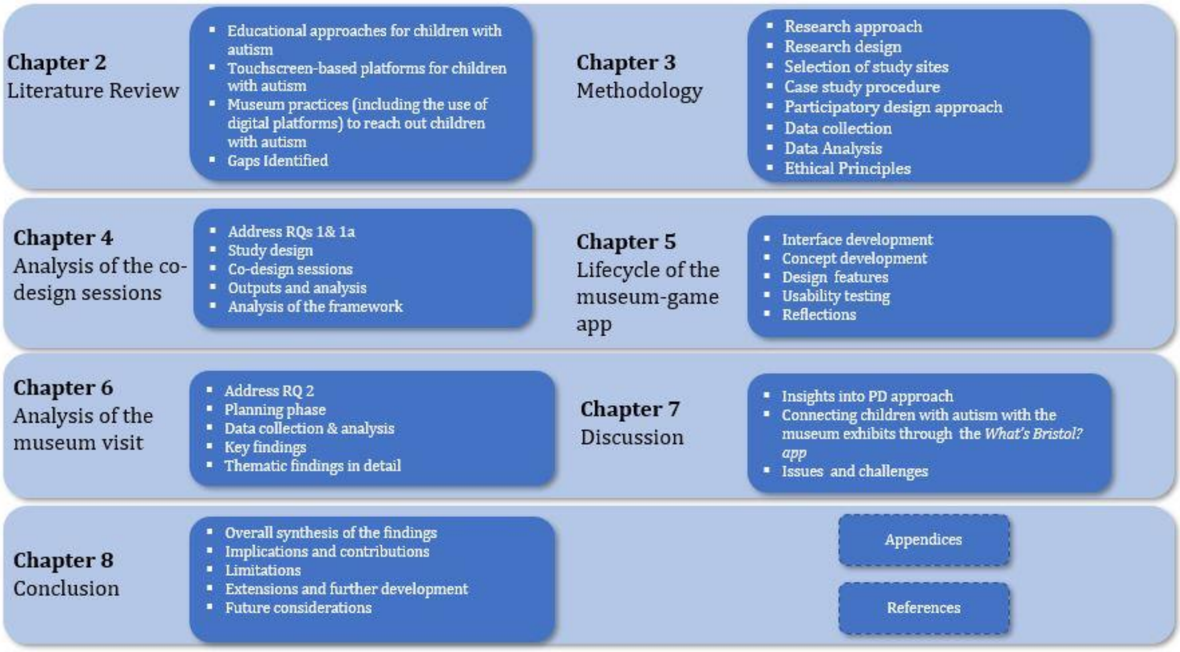

Figure 2 A breakdown of the thesis structure.

Chapter 1, the current chapter, introduces the central point of this research. It briefly provides an overview of the background research whilst presenting the research questions the thesis intends to address. It establishes the scope and rationale of the study and defines the key terms used within the thesis. A brief context of autism is provided. Finally, it concludes with the contribution the study makes to knowledge and to the research community.

Chapter 2 provides the main focal points of this study, and it is divided into four parts. The central focus of this part is a review of studies examining the potential of technology-based programs, in particular, of touchscreen-based apps as educational strategies for people with autism. This chapter also evaluates the effects of the use of technology for children with autism.

The second part discusses the concept of participatory research and draws attention to studies that have used this framework in the field of autism and technology. It presents a synthesis of the literature pertaining to the involvement of children with autism in the technology design process. Following this, the work offers a review of the literature on museums and inclusivity. Research on the effectiveness of non-digital programs and activities for visitors with autism is considered important to determine whether these initiatives can contribute to the inclusion of children with autism within the museum setting. This chapter also reviews studies relevant to the provision of digital services within the walls of museums for children with autism and the potential benefits of such services as a means of supporting their integration. To conclude, the last section presents the main gaps in knowledge that emerged from the literature review.

Chapter 3 discusses the research approach applied in this work. It begins by referring to the ontological and epistemological aspects that justify the philosophical stance of the study. The theoretical approach adopted by this study draws on the constructivist paradigm to capture the construction of meaning by different stakeholders within the real world. This chapter is followed by a discussion of the rationale for choosing the case study as a research method and it establishes its limitations. It then describes how the participatory design (PD) approach was adopted to inform the technology design process. It provides the rationale of the methodological framework and delineates the process of involving the children with autism in the design process (hereafter referred to as 'pupils with autism' or 'pupils') as well as presenting the techniques used to obtain the data for the research. Following this, a description of the context of the research sites in this study is presented. This chapter also provides detailed information about the background of the special educational needs school involved in the study and the museum where the evaluation of the app took place. The information of the pupils with autism involved in this study, such as confirmed Statements of Special Needs, age, and sex, is also presented.

Next, the chapter provides details of the methods and tools employed in the data collection in the evaluation of the app in the museum setting. An analysis of the techniques used for the research is presented. In particular, it describes the approach followed in the analysis of the collected data and the tools used to provide rounded and detailed information of the data, both visual and verbal. Finally, a discussion of the ethical procedures undertaken to secure the rights of the pupils with autism is described.

Chapter 4 describes the analysis of the data obtained in the co-design sessions conducted with two groups of pupils with autism prior to the conceptualization and development of the interface. This part addresses the research questions RQ1 and RQ1a and seeks to generate the ideas and preferences of the pupils with autism with the aim of informing the design of the interface as part of the design cycle. It discusses the themes and implications revealed during this process. Finally, the key aspects uncovered from the co-design sessions resulted in the development of the proposed framework. The various elements integrated in the framework are presented and discussed.

Chapter 5 describes the design and development of a novel museum-based touchscreen app, called *What's Bristol?* It builds upon the previous findings taking into account the feedback from the involved groups. This chapter details the iterative design of the app with an evaluation by a group of pupils with autism. The design process is presented in detail and begins with the initial development of the app through several prototypes to its final prototype. Qualitative results from the usability testing evaluation in the school are also reported.

Chapter 6 begins by briefly delineating the steps taken to set up the museum visit and prepare the pupils regarding what to expect from the visit. The main focus of this chapter is presenting the generation of data as a result of the museum visit experience. It presents and analyses the pupils' behaviours, attitudes, and interactions with the museum and the platform from different angles including a) the researcher, b) the teachers, and c) the pupils. The data presented and analysed in this chapter are derived from different sources, such as questionnaires, video data, focus-groups, a think aloud protocol, and observation notes. The chapter contributes evidence for the remaining research question of the study, that is, RQ2.

Chapter 7 provides firstly a discussion of the findings from the participation stage of the research and continues with the findings from the analysis of the data as presented and analysed in the previous chapter (6). This chapter considers the role of a portable device as a mediating tool to motivate a group of children with autism to feel engaged during their museum visit. It also discusses the issues and challenges that arose during the museum visit.

Chapter 8 summarizes the outcomes of the results outlined in the previous chapters and then re-addresses the research questions by making links to the literature. The limitations and challenges of the present work, the implications for stakeholders, and the integration of technology for children with autism in museums are discussed in detail. The concluding chapter thus provides insights into the contribution to knowledge and indicates directions for future research.

1.7 Summary

This chapter sought to introduce the background of the thesis with the focus on exploring the role of a digital platform for children with autism in the museum setting. The motivation that led to the examination of this topic was discussed, and the research questions and objectives were established. The purpose of examining these and the contribution to the field of knowledge were articulated. This chapter also provided some context to the definitions used in this study and gave a brief overview of autism and the core difficulties commonly experienced by children with autism. The following chapter gives a review of the literature that focuses on the educational strategies, the use of technology-based programs for children with autism, the participatory design framework for designing technology for this target group as well as the literature on museums, autism, and technology.

Chapter 2

Literature Review

Introduction

This chapter provides a detailed review of the relevant literature pertaining to the research focus of this study, which is grounded in three different areas of research. The relevant aspects of each field are discussed. The first section begins by outlining the shift in attitudes from a medical paradigm towards the emergence of the neurodiversity movement. The fundamental elements of the neurodiversity paradigm are also discussed. The following section presents an overview of the strategies used to aid children with autism in the development of a variety of skills in real-life situations. The review critically analyses the benefits and limitations of the use of computing technology as a tool to support and improve certain skills in children with autism. Because of the nature of the study, a particular emphasis is placed on the use of touchscreen-based applications.

The second part is concerned with the literature relevant to the concept of the participatory design approach and the involvement of children with autism in the technology process. This chapter also reviews museum strategies for promoting inclusive and accessible programmes for such children. It considers the power of digital platforms as engagement tools between visitors with autism and the museums. Each part of the review provides a summary, while the final section concludes with an overview highlighting the key gaps in knowledge that will be addressed in this thesis.

2.1 Shifting from a medical-based thinking to neurodiversity

The importance of the early detection and assessment of autism lies in the fact that individuals with this condition can access early evidence- based approaches to address the core challenges (Zwaigenbaum *et al.,* 2009). Early intervention can make a difference by increasing individuals' competencies and develop outcomes, either in the short or long term. The literature highlights that interventions are likely to help individuals with autism to reach their potential and thrive; however, it is unclear what this means in practice (Leadbitter *et al.,* 2021).

Until the 1990s, understanding of autism was rooted within the medical paradigm, also known as the medical model of disability (Llewellyn and Hogan, 2000). Autism research and intervention approaches have connoted, in the past, a negative emphasis and aimed to identify 'what's wrong' with individuals with autism or understand autism as a disorder (Pellicano and Houting, 2022; Dinishak, 2016). The common approach was to consider treatments that aim to bring an individual's abilities into the accepted norm and make a child with autism less autistic, resulting in a 'normal' child (Lovaas, 1987; Ferster and DeyMyer, 1961). For example, Lovaas (1987, p.8) offered "some hope for recovery" of children with autism through intensive behavioural treatment while Ferster and DeyMyer (1961) have suggested that an educational approach can change the behaviour of such children in a controlled environment. Describing autism with medicalised terminology such as 'recovery', 'cure', and 'treatment' has long been the predominant paradigm in this field. The deficit view was largely focused on searching for the individuals' deficits and weaknesses and applying treatments to change the individuals' difficulties and enhance functioning (Pellicano and Houting, 2022; Dinishak, 2016; Prizant and Field-Meyers 2015). However, this deficit-based approach to understanding autism was problematic and any intervention with an explicit or implicit attempt to teach normative behaviour or 'cure' autism is no longer acceptable (Happe and Frith, 2020). As critics argue, many intervention programmes have supported dehumanising attitudes that perceive disability as inferior to non-disability and lack empirical evidence of what constitutes 'normal behaviour' (Pellicano and Houting, 2022; Leadbitter *et al.,* 2021; Bottema-Beutel *et al.,* 2021).

The actions of autistic self-advocacy started in the mid-1990s, when there was a shift within the world of autism theory, research, and practice and how autism was perceived through the lens of neurodiversity (Leadbitter *et al.,* 2021). Neurodiversity as a social justice and civil rights movement is closely aligned with the social model of disability. From this theoretical movement, the neurodiversity paradigm rejects the deficit view of autism and acknowledges that the variations of humans in functioning and neurological development are natural (Leadbitter *et al.,* 2021). Proponents of neurodiversity recognise the inherent strengths of individuals with autism and emphasise that human variations are related to social and environmental factors that influence the lives of people with autism (e.g., social model of disability) (Dinishak, 2016; Oliver, 1996; Oliver, 1990).

The concept of neurodiversity has resulted in the emergence of new ethical debates that have had an impact on the focus of autism research and how individuals with autism are supported in practice (Pellicano and Houting, 2022; Leadbitter *et al.,* 2021). There was an evolution of moving beyond medical-based language and adopting more person-centred and individualised support (Cassidy *et al.,* 2020; Crane *et al.,* 2019). A person-centred approach highlights the importance of self-determination and autonomy, which means that all individuals with autism are treated equally and empowerment and inclusion in all decision-making help them to take control of their lives.

2.1.1 Educational interventions for children with autism

It is acknowledged that autism has lifetime effects for children with autism and their families in society, such as social, educational, economic effects, and those on their well-being (Knapp, Romeo and Beecham, 2007). Individuals with autism are more likely to have fewer educational opportunities compared to typically developing children (Office for National Statistics, 2004). Issues with simple practical living skills, such as being in public spaces or using public transport, can also have an impact on the quality of their life. Furthermore, interaction with other people and low rates of friendship have been reported as one of the major problems (Orsmond, Krauss and Seltzer, 2004). Another issue is the ability to live independently, and additional support by the family members or carers is considered necessary (Wing, 1992). Thus, with the high rates of autism and the challenges associated with daily life, considerable efforts have been made in supporting people with autism across multiple domains.

Happe, (1994) states that the outcomes from behavioural therapies are likely to have beneficial effects in “reducing problem behaviours, teaching coping skills and maximizing potential by concentrating on assets and talents” (p.110) of each child. These strategies aim to facilitate development by focusing on areas of behaviour in which children with autism are less competent than their non-autistic peers. With this in mind, several intervention programmes have emerged since the early 1990s to help individuals overcome challenging behaviours, and these have led to some positive outcomes. The concept of evidence-based approaches has become widespread in many fields, such as psychology, education, and medicine (Dunst *et al*., 2002). In fact, researchers in the field of autism have focused on identifying evidence-led practice to support people’s developmental outcomes.

The nature of the intervention ranges from behavioural, cognitive, educational, and assistive technologies, to medical. Some strategies are designed to target the core of the condition while others target specific areas of functioning. The outcomes from these approaches vary greatly based on the severity of autism in each child (Webster *et al.,* 2004). There is evidence that behavioural approaches adopt various techniques and focus on developing the social functioning of children with autism and decreasing problematic behaviours (Reed, 2014; Lovaas, 1987).

The current standard of intervention approaches includes strategies such as Applied Behavioural Analysis (ABA) (Lovaas, 1987), Teaching and Education of Autistic and Related Communication Handicapped children (TEACHH) (Mesibov, *et al.,* 2005), Sensory Integration Therapy (SIT) (Ayres, 1972; 1979) social stories (Gray, 1994b; Gray and Garand, 1993) and Picture Exchange Communication Systems (PECS) (Bondy and Frost, 2003). These approaches are designed to provide strategies for social interaction, communication, and environmental structure to encourage appropriate behaviours.

As technology has become prominent, technology-based programmes have been developed as a way of addressing the needs of people with autism. Their potential to provide an organised and structured visual environment has opened a new world in the field of autism, and numerous studies have considered the effects of the use of technology-based interventions (Stephenson and Limbrick, 2015). Participants in these studies were taught to make requests for desired items, to express their emotions using digital images, they were encouraged to do activities and their learning of life skills was supported (Fletcher-Watson, 2014; Kagohara *et al.*, 2013; Moore and Calvert, 2000). As a result of these studies, technology-based programmes were identified as being beneficial, motivating, and safe. They have been used primarily as assistive tools (augmentative and communication devices) to help individuals become communicatively competent, while others were designed as prompting devices to initiate and maintain certain behaviours (Goldsmith and LeBlanc, 2004).

From this research, there is evidence that with appropriate support and instruction, technology-based programmes can provide help in various ways, and children with autism can benefit from developing their skills through repeated exposure to new concepts. However, to maximise the potential of such programmes, a careful consideration is required to ensure that the varied needs of such children are addressed in a meaningful way. As a result of their effectiveness, technology-based interventions may be promising tools that can improve the autonomy and the lives of children with autism. Since the use of technology for this target group is the main scope of this thesis, the impact of these programmes is a topic of detailed discussion.

2.2 The enablers and barriers of computer technology for children with autism

This section looks at the attributes of computer technology that enhance and expand the skills of children with autism at all levels, while it also addresses their limitations. As the focus of this thesis supports the view of inclusivity in various contexts, from designing an inclusive interface to providing support and equal opportunities in a museum environment, this study is closely associated with the principles of social models of disability. The aim is to explore published evidence-led practice regarding the use of state-of-the-art technology for children with autism to delineate the various skills that have been successfully taught to them.

Before exploring examples of technological software for use with children with autism, this thesis considers the work by Florian and Hegarty (2006), who discussed the pedagogical roles of technology in supporting the education of children with special educational needs. Florian and Hegarty (2006) argued that information and communication technology (ICT) can be defined as inclusive and can act as an equalizer in overcoming barriers for all students, especially those with disabilities. They pointed out that the use of technology in the field of education provides the conditions for children to have new opportunities to learn, to participate, and to have equal access to the curriculum for all.

Florian and Hegarty (2006) identified six ways in which technology can be used:

(1) 'Used to tutor': This programme represents a type of teaching, with the technology focused on individualized computer-based learning programmes to meet the particular needs of children.

(2) 'Used to explore': Exploratory learning environments allow children to engage with the material and have control over their learning. This type of learning is based on constructivism and emphasizes helping learners to construct knowledge collaboratively.

(3) 'Applied as tools': This type of learning is related to the skills required for using the tools of technology, such as electronic hand-held devices, spreadsheets, and word-processing programmes.

(4) 'Used to communicate': Assistive technology devices are used to help children communicate. These include voice recognition software, voice synthesizers, and electronic language boards.

(5) 'Used for assessment purposes': Computer-based systems can be used as a means of systematic and cost-effective assessment, while more recent versions provide suggestions for intervention for specific types of learning.

(6) 'Used as a management tool': Computer-based programmes can help teachers manage responsibilities, such as developing individual education plans designed to address identified learning difficulties. For example, the Internet is a popular management tool for special educational needs professionals.

The distinctions made by Florian (2004) suggest that the use of software programmes for learners with special educational needs can be considered powerful educational tools when integrated with adaptability to meet different ways of learning, thus supporting inclusive learning. Based on these distinctions, this thesis is concerned with the category called 'used to explore' as this type of technology aligns with the aims and objectives being considered. Proponents of such technologies argue that technology can be seen as a means of engaging with teachers and students, so they become co-learners and are responsible for constructing their own knowledge (Reed, and McNergney, 2000). Therefore, this thesis is interested in exploring the potential of technology-based programmes to allow children with autism to explore their abilities and construct their own meaning of their actions.

Various programmes have been used extensively for children with autism to support various aspects of education, communication, entertainment, and social skills (Grynszpan *et al*., 2014; Bernard- Opitz *et al.,* 2001; Moore and Calvert, 2000). Researchers have focused on evaluating the benefits of such technologies as educational tools for children with autism (Fletcher-Watson, 2014; Heimann *et al.,* 1995). While, for many years, instructional video modelling (Dowrick, 1999) was the main way to teach skills to children with autism, in the last two decades, technology has gone beyond this, and a variety of different systems have been developed. These include computer programs (Ploog *et al*., 2013), virtual environments (Parsons and Cobb, 2011; Parsons and Mitchell, 2002), hand-held and touchscreen devices (Clark, Austin and Craike, 2015), speech-generating devices (Van der Meer *et al*., 2010) and robots (Pennisi *et al.,* 2016). Due to their potential, such programmes have started to play an empowering role in how children with autism can use them to provide a path to independence and social and functional competence daily (Fletcher-Watson, 2014). It is evident that digital environments and computerised learning have certain characteristics for interaction that make them popular with and appealing to children with autism for various reasons. These include the following:

- A structured and predictable environment seems to accommodate their special needs and be less threatening because of their desire for sameness and predictable rules (Moore *et al.,* 2000; Powell, 1996).

- The tasks and expectations are clearly defined and can be repeated by providing prompts and reinforcement. These features are likely to capture the attention of children with autism and make them eager to use these technologies (Moore *et al.,* 2000).
- Through technology-based programmes, children can interact effectively with the technology itself in a relaxed manner, thus leading to better learning outcomes.
- Children with autism show a strong affinity with and attention to visual processing and computer-based tasks (Parsons and Cobb, 2011). This results in a heightened interest in visual tools. The use of visual media via electronic devices includes dynamic features, such as video, audio, and buttons to allow the user to move from one task to the next (Stromer *et al.,* 2006). As such, all these features are likely to motivate children with autism to respond efficiently and allow engagement through repeated imitation (Bernard- Opitz *et al.,* 2001).
- Tasks through computer-based programmes are delivered with a low degree of interaction with others and allow children with autism to work at their own pace (Powell, 1996).

While substantial benefits have been reported regarding the use of technology, there appears to be insufficient research exploring the unintended consequences of technology in learning environments for children with autism. There is some evidence to support the view that potential challenges when using technology can ultimately result in negative outcomes (Spitzer, 2014). Given that one of the core characteristics of autism is restricted and repetitive patterns of behaviour, children with autism may be particularly susceptible to problematic interaction with technology. For example, Ramdoss *et al*., (2011) have outlined how technology use may exacerbate existing problems by developing certain stereotypical behaviours. Limited interaction between a child with autism and the teacher or carer has also emerged as a concern as it may result in increased social isolation (i.e., interacting only with a device and not with other people) and anti-social behaviour (Ploog *et al.,* 2013; Ramdoss *et al.,* 2011; Bernard-Opitz *et al*., 1990). Furthermore, as children with autism may have a tendency to spend excessive time using technology, this could encourage challenging behaviours (e.g., feeling upset or anxious) maintained by computer access, and limited ways of responding to various stimuli (Ploog *et al.,* 2013; Mazurek and Wenstrup 2013; Powell 1996).

Spitzer (2014) criticized more broadly the ways computer technology is used in classrooms by highlighting concerns regarding its detrimental effects. He advocated that "the less you experience and think for yourself (by having IT do it for you), the less you learn'" (p.83) and raised the issue that the excessive use of technology for non-course-related activities is likely to have longstanding consequences for children's learning behaviour, and skills. To support his argument, he introduced the term 'neuroplasticity' and referred to research that pointed towards a more plastic brain. In particular, neuroplasticity refers to the capacity of the brain to change in response to experiences and environmental stimuli (Weyandt *et al.,* 2020); his views support the notion that an increased cognitive load can achieve better learning outcomes. However, it is apparent that his arguments are about education in general and are not particularly focused on children with special educational needs such as autism; nonetheless, his work and views are relevant to this thesis as they have their roots in the field of autism and technology.

In the context of learning technologies, Antle's (2013) work critically reflected on children's engagement with technology and re-introduced the important role of the body in knowledge construction. Grounded in the embodied cognition paradigm, this approach incorporates the notion that cognition is not only related to the mind, but acting-in-the-world as a means to support cognitive development (Ackerman, 2004; Dourish, 2001). This claim is supported by empirical research which has indicated the benefits of embodied interaction in promoting exploration, collaboration, and meaning-making in learning (Malinverni and Pares, 2014). However, Antle, (2013) acknowledged concerns regarding children's engagement with technology. As she claimed, learning environments are designed from a technology-driven perspective and do little to embrace the embodied cognition paradigm; thus, they have a negative impact on supporting children's learning and development.

> "The impact of inadequately researched, understood, and designed applications and technologies has had a vast, if largely undocumented, effect on today's children". (Antle, 2013, p.30)

Through this statement, it is clear that the integration of appropriate adaptations is needed to create inclusive technologies; this will encourage human interaction and varied experiences, both of which are crucial for bringing to fruition the potential of social learning and development. Antle's views have engendered a shift from a positivist epistemology to a focus on a constructivist perspective, in which embodiment changes how interaction is perceived. In other words, this stance suggests that central to interface design is a fundamental shift regarding how we understand the interaction and how "physicality supports cognitive development" (Antle, 2013, p.31). Meaning-making construction is central and is influenced by action-centred skills, interaction, and knowledge, which are all embodied in specific contexts and situations (Harrison *et al.,* 2011) as "the body and the mind are inseparable in the roles they play in much of cognition" (Antle, 2013, p.31). Through this approach, designers can broaden their knowledge of how to support children's interaction, play, and learning since children are active agents who construct learning by doing.

Views on embodied interaction influenced the present thesis as they are used to explain how the use of technology is applied and viewed throughout this PhD project. In line with the research presented here, a central aspect is how knowledge is actively constructed through the combination of personal and contextual resources. Therefore, this approach entails appreciating the value of subjective forms of knowledge and developing a tool that supports hands-on explorations with technology specifically for children with autism. The present study aims to explore a museum visit that is designed to facilitate tangible and embodied interaction as well as physical exploration. In doing so, the design of a museum game app is informed by the existing design principles, whilst a participant-led approach involving those children with autism will shape the design of the app. This approach has a twofold meaning; first, the pupils' input is considered appropriate to inform the design of the app while it will help them better navigate the device and their surroundings. Adopting this approach, the purpose is to encourage embodied interaction in the design of the app by merging the physical with the social world.

Having discussed the opportunities and challenges of technology-based programmes, the next section draws on evidence-based studies about the role and use of touchscreen-based apps as a recent, rapidly growing technology to support the acquisition of social skills and communication for children with autism.

2.2.1 The potential of touchscreen-based programmes for children with autism

Advances in digital technology have seen a shift in emphasis from traditional desktop computers to the newest form of portable touchscreen electronic devices such as iPads, iPods and other tablet applications (from now on 'apps') (Clark *et al.,* 2015). Within the last ten years (2009-2019), the accelerated growth of smartphone/tablet devices and their widespread adoption in different fields have become a point for research to evaluate developmental capabilities in children with autism (Valencia *et al.* 2019; Murdock *et al.,* 2013; Kagohara *et al*., 2013). Research into touchscreen devices is a major area of interest and is constantly being developed with the intent of supporting, engaging and facilitating a variety of skills among children with autism.

Given the potential of touchscreen-based applications, a wide array of tablet and smartphone apps have been designed with different characteristics and capabilities in the area of autism and have been made commercially available. Nevertheless, concerns and risks have emerged about how children can navigate these apps effectively (Kim *et al*., 2018). This has led health organizations, such as the American Psychiatric Association, to develop tools and offer resources for mental health professionals to help guide the patients to make the best decision about the use of an app (see https://www.psychiatry.org/psychiatrists/practice/mental-health-apps). Interestingly, web portals such as Autism Speaks (2018) and Autism Apps (2018), review and offer a list of handheld electronic devices for people with autism, classifying them by category, review rate, and age range. The main categories include fine motor skills, games, language, literacy, maths, social skills, and speech.

Fletcher -Watson and her team have created a list of conventional iPad apps that could be beneficial for children with autism (Dart, 2020, **Figure 3**). The wheel is divided into four main categories: communication, education, life skills, and fun. It is subdivided into categories by recommending apps for children, teenagers, or adults according to what the apps are intended to achieve. The wheel does not offer more information about the age range or the cognitive abilities of the users but rather maps out a variety of skills that can be taught to individuals with intellectual disabilities. The evaluation was made by Fletcher -Watson and colleagues and intended for children with autism instead of adults. However, her intention was not to provide a comprehensive review, but a visual representation of useful apps based on her personal opinion as a researcher in the field of autism.

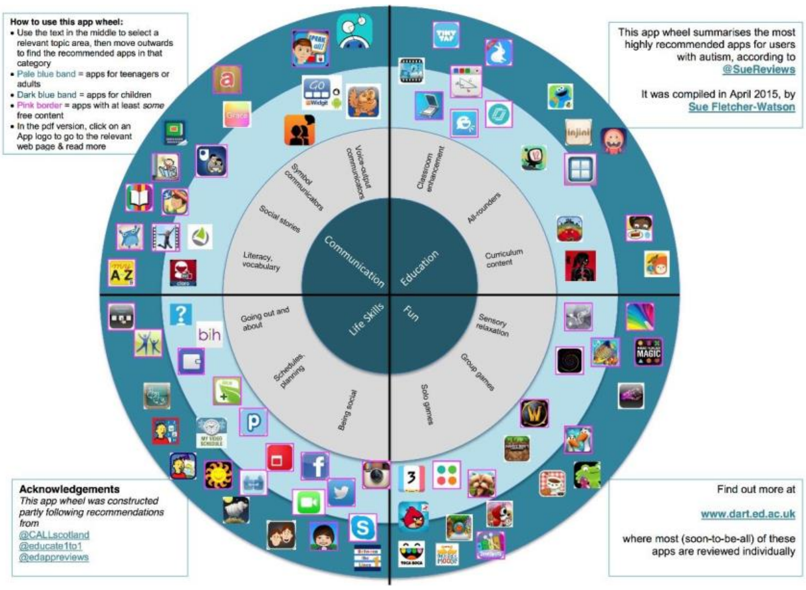

Figure 3 Summary of applications that can potentially be useful for people with autism.

Despite the growing availability of touchscreen devices and autism-focused apps, a significant number of these have not been validated to help inform about their potential when used with children with autism (Zervogianni *et al*., 2020; Ploog *et al*., 2013). Information also remains scarce about how these apps have been designed or whether they have been specifically developed for and informed by children with autism (Zervogianni *et al*., 2020; Fletcher *et al*., 2016). The approaches taken to design apps targeting children with autism show that their needs were not considered. Therefore, there is an opportunity to create more inclusive products that involves an understanding of the diversity of children with autism. This can be achieved by following a human-centred approach in which the attention is centred on enabling such children to participate equally in the design of the apps, and from that, to evaluate these programmes with users and other stakeholders. The lack of evidence that commercially digital technologies are effective led a group of researchers to explore further this issue. BETA sought to co-develop a framework with the autism community and other autism-related professionals providing the parameters for the decision-making in relation to the choice and use of digital services. This highlights that evidence is considered important (Zervogianni *et al*., 2020).

While inclusive design is something to aspire towards, it has been shown through systematic reviews that autism-orientated apps have value in providing a range of support to children with autism (Valencia *et al*., 2019; Koumpouros and Kafazis, 2019; Stephenson and Limbrick, 2015; Zakari *et al*., 2014; Kagohara *et al.,* 2013). They have provided encouraging evidence about the feasibility of delivering educational programmes and modifying and enhancing skills in social cognition for children with autism. However, overall, relatively little empirical evidence exists concerning the efficacy and validity of these apps, and the authors stress the need for more research on examining their actual use and impact (Fletcher-Watson, 2014; Murdock, Ganz and Crittendon, 2013). Emerging research suggests that the features of touchscreen devices (such as tablets) compared to those of desktop devices seem to be particularly effective in addressing the children's complex needs (Valencia *et al.,* 2019; Fletcher-Watson, *et al.,* 2015; Ploog *et al*., 2013). Tablets and iPads have several advantages as they are compact, portable, enable efficient storage and the presentation of visual supports (Murdock, Ganz, and Crittendon, 2013); these technologies are also rapidly advancing in terms of size, functionality, and real-time applications (Koumpouros and Kafazis, 2019).

The adoption of an inclusive design process through user involvement is considered to be important and critical when designing technology for pupils so that the product can address their special needs (Fletcher *et al.*, 2019). For example, Hourcade, Bullock- Rest and Hansen (2012) iteratively developed multitouch tablet applications with 26 children over a broad range of the autistic spectrum (ages 5-14), the lead teachers of the classrooms, special education staff, and parents. A consultation with a local support group for adults with autism was also conducted. The platforms aimed to engage children with autism in social activities and encourage them to collaborate, express themselves and understand emotions. The activities for the design of the applications took place in two school settings and video recordings were used to document the process and their impact on children's behaviour. Hourcade, Bullock-Rest and Hansen (2012) focused on making the design of the programmes simple and predictable with a visual medium, while seeking to reduce the possibility of user mistakes to avoid the potential frustration arising from using the system.

Three different applications were developed: 1) a drawing application that targeted turn-taking, sharing, and collaborating through collaborative storytelling 2) a music authoring application that gave the children the opportunity to create and share something with others, and 3) a visual puzzle that aimed to prompt communication, collaboration, and visual spatial thinking. The results demonstrated that the drawing application helped the researchers elicit pupils' perceptions and interests. The authors observed that the activities that the pupils were asked to perform encouraged them to initiate social interaction, promote a greater likelihood to express emotions, and increase their appreciation of social activities. This study was important for its contribution to exploring not only the impact of those applications but also their design, which considered the children's interests and views. However, a limitation was the small number of participants (n=2) who informed the design of the applications, while the remaining children participated in a formative evaluation of the applications' impact. Although this research deals with the design of multitouch tablet applications, there is no information about how the pupils were engaged with the activities or how the input of individual participants informed the design of the apps. It would also have been of value to hear the pupils' voices as well the teachers' perspectives; however, this was not provided.

There are studies in this field that tend towards adopting a human-centred approach, however, the voices of children with autism are not yet significantly placed at the centre of existing research. Similarly, Escobedo *et al*. (2012) developed an augmented reality (AR) application called MOSOCO to help children with autism practise social skills in real-life situations. The app included features to encourage children with autism to make eye contact, to help them participate in conversations, to enable group interactions and shared experiences, and to maintain spatial boundaries. The study was conducted in a school during scheduled lunch and play breaks with three children with autism aged between 8 to 11 years old who had limited social skills but demonstrated age-appropriate functioning. Data were collected through video recordings, field notes, and interviews. The conclusions gained from this study suggested that MOSOCO had a positive impact on children's interactions with each other, reassuring them regarding what they should or should not do. Children were motivated to practise their social skills while behavioural issues were reduced in real-life situations. However, this study failed to give any details about the children, which would have provided contextual data and, hence, offered a better understanding of the exploratory nature of the study. While this study considered pupils' perceptions, it would be useful to explore the experience of teachers and other members of the school staff with these tools to support these activities. Moreover, the design of the app is based on the application of classroom-based social skills training. Thus, these results cannot broaden the understanding of the app's general applicability across a range of populations.

Existing literature has looked at the use of touchscreen devices as a means of increasing play skills and interaction with peers. For example, a study by Murdock, Ganz and Crittendon (2013) explored the efficacy of touchscreen devices by using an iPad play story to increase play skills and dialogue. In this study, four children with autism were enrolled in the study in a local autism centre. The iPad play story consisted of a series of video clips and featured toy figures that produced interactive dialogue. The data sources were video recordings, and the play dialogue utterances were coded to identify whether the dialogue was delivered during play or not. Moreover, the classroom teachers were asked to fill out surveys in relation to the validity of the intervention.

The outcome of this study indicated an increased level of play dialogue and play with toys. The authors also reported that the pupils seemed to be engaged and they were able to produce their own play utterances. They noted that while one participant displayed a strong ability during the baseline assessment, he did not perform well upon the intervention programme. However, the authors did not offer possible indications of his performance. This study is limited in terms of the demographics of the pupils. The pupils included in this programme had similar abilities and language levels and this restricts the generalisability of the results. It would be interesting to examine whether the proposed programme is effective in other natural settings as the noise level of the classroom discussed by the authors made it impossible to provide accurate data through the video recordings.

Joint attention is one of the explicit priorities of early educational strategies as it is considered to be one of the hallmark characteristics of autism. The work of Yuill, Rogers and Rick (2013) provides evidence that tablet apps can support co-creating activities in family groups. The study focused on exploring the potential of a drawing iPad app to encourage group collaboration, co-creation, and play. The authors developed an app, called 'MultiDraw' with various integrated features, such as a single finger drawing tool, a colour palette, and an eraser. The main task of the users was to create a figure drawing into two phases: one on a tablet template (digital format) and then on paper. Following the completion of the final body part of the figure (individually), the four iPads are placed at the centre of the table and users need to pass their devices. In this phase, group decisions should be made about the character's name and sound effects (**Figure 5**). This task aimed to support shared attention and shared ownership. Findings were collected using a large sample of families (93 family groups) and in-depth observations in a smaller sample of the users. The study was divided into two phases: one in a communal space, a science fair and the second in a private place either at home or in a laboratory.

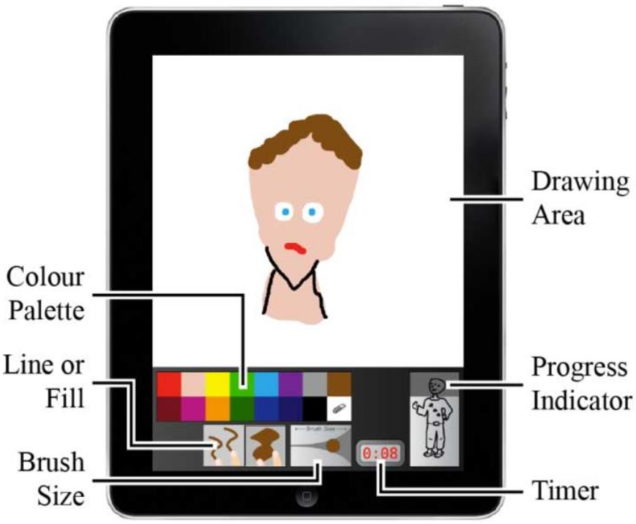

Figure 4 A screenshot of various features of the app using MultDraw.

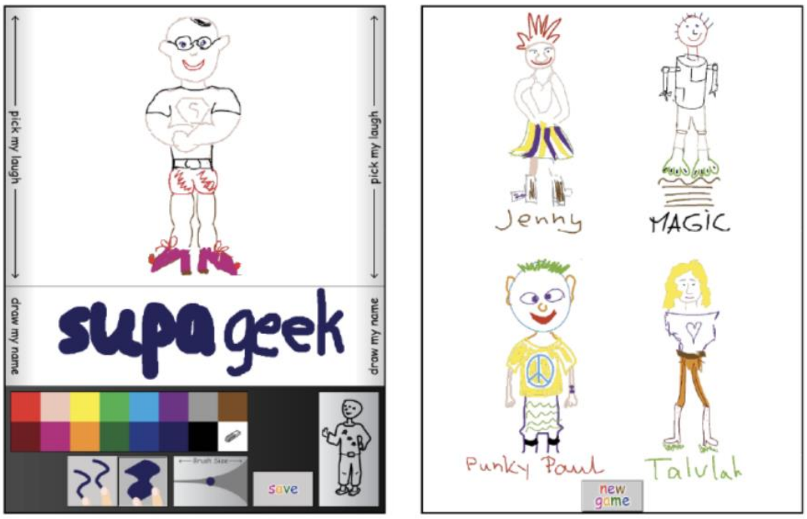

Figure 5 Screenshots of the app working on collaboratively naming the character and viewing the gallery with other co-created figures.

The resulting pieces of work were presented as qualitative data in the form of snapshots and field notes for the first stage of the study, while video recordings were used to evaluate the groupwork on the tablet and paper. The results from Yuill, Rogers and Rick's (2013) study, from both phases, showed similar patterns in terms of the children's behaviours, and it was concluded that the iPad was very popular with both the parents and the children. The findings revealed high levels of enjoyment, while the pupils expressed a preference for making drawings using the tablet rather than on paper. The authors highlighted that using the app was the preferred option because of its ease of use and its novel features. They showed a growing interest in involvement and enthusiasm, as they could edit, share, or improve the drawing with sounds or animations. Through the work of Yuill, Rogers and Rick (2013), it can be seen that the use of various digital features can help children to be creative as they can develop further or manipulate their digital products. In addition, the various workflow transitions between individual work, shared attention and decision making allowed for mediated group interaction, and thus, provided an immersive experience.

However, in the Yuill, Rogers and Rick (2013) study, there is limited participant information, and the methodological approach is weak, as there were no diverse sources of evidence. Instead, the study mainly relied on gathering data through observation and video recordings to evaluate the interface. Nevertheless, a systematic approach that focuses on using multiple and diverse sources and that considers the views of parents/teachers and their children when evaluating a platform would provide a more comprehensive view and test the validity of the interface. Using a variety of sources allows for data consistency through the convergence of multiple perspectives. This is something that this thesis will try to obtain.

Overall, a common theme that emerged from these studies is that children with autism can initiate play and interact effectively when using entertainment-based technologies. The findings are consistent with the work by Hourcade, Bullock-Rest and Hansen (2012), Murdock, Ganz and Crittendon (2013) and Yuill, Rogers and Rick (2013) who found that tablet technology offers opportunities for enhancing group work and allowing interaction between the children. To create effective apps for children with autism, some researchers have focused on the design aspect of game-based platforms and examined the effectiveness of various embedded features. As reported, a gaming approach contributes to maintaining motivation to complete a task and can be customised to suit the needs of children with autism.

As an early example, a study by Bauminger *et al.*, (2007) aimed to help children with high functioning autism improve their communication skills via storytelling using a multitouch tablet called 'Story Table'. The scenario is set within the context of a museum visit which the pupils are invited to create and narrate stories to say what happens next. Children aged 9 to 11 years were recruited for this study. In terms of the methodology, the pupils were tested before and following the intervention, which lasted 20 minutes and took place three to four times per week for three weeks. The results indicated that the 'Story Table' produced positive effects on communicative skills as the pupils were motivated to create and tell stories. The study also reported an increase in several social behaviours, such as an increase in the amount of eye contact and expression of emotions as well as interest in their partners. However, this study was based on pre- and-post observations; but it may have been more informative to use different sources of data to evaluate the efficiency of the programme.

Using the gaming approach as a basis, other studies have focused on the development of skills such as emotion recognition. Christinaki *et al*., (2014) developed a serious game that aimed to teach children with autism to identify and understand different emotions from facial expressions. The design adopted a game-design framework based on the integration of Kolb's experiential learning model and Piaget's cognitive model. Through this approach, the authors identified six important elements for designing games to teach children with autism emotions, which were taken into consideration when the programme was designed. The elements used were matching, recognition, observation, understanding, generalizing, and mimicking. The tools used to evaluate the programme were a survey, videos, and text notes. The authors concluded that technologies enhance the learning process, which is directly related to the emotional state of children with autism. However, this study was limited in terms of the demographics of the pupils, and it did not provide details on the children's experience and the usability of the game.

Supporting the use of tablet applications to help improve the skills of children with autism, Esposito *et al.,* (2017) developed and evaluated three applications to enhance specific abilities including attention, vocabulary, and imitation which were studied by following an ABA treatment compared with a control group. Thirty participants along with their parents were recruited for this study. The parents participated in a training course to support the child throughout the intervention programme. In testing the programmes, the children received thirty minutes daily practice with the applications in their homes.

Esposito *et al.,' s* (2017) study discussed the features that the game apps included. They developed apps that integrated behavioural strategies, such as levels of difficulty, alarms, rewards and feedback on the children's performance, prompts, and multiple-choice questions. The apps also included an animated tutor to tell the children what they were required to do to avoid errors and sustain higher motivation to use the technology. The content of the apps was presented by starting with simple and then moving on to complex tasks. Positive reinforcement was provided through audio and written praise and when mistakes occurred, prompts were delivered to encourage the user to try again. This work compared the use of touchscreen applications with an internal experimental group and concluded that the children achieved better progress using these programmes. Esposito *et al.,* (2017) concluded that these apps could be used successfully to provide effective educational training similar to behavioural therapy in the learning of adaptive abilities. The authors argued that technology combined with the use of evidence-based game features could have a dual outcome, either as an alternative to standard teaching or as an effective tool to increase the skill levels of children with autism through an individualized programme. The children included in this study followed the ABA treatment and they were familiar with behavioural targets; such competencies could be indicators of the successful use of the apps. It would have been interesting to explore the effectiveness of those apps with children with autism who had not received behavioural interventions. Moreover, the simple design of the apps (with limited features) meant the children did not need to have existing skills, such as cognitive and motor skills, and, thus, they could be appropriate for simply low-functioning children.

Taken together, the different capabilities of touchscreen devices offer several benefits for children with autism to help them address their complex needs. It has been demonstrated that skills such as socialization, joint attention and communication can be acquired through these emerging platforms. The studies have shown that touchscreen technology has been reported to be a useful tool as it provides flexibility, animated representations, visual prompts, reinforcement, and degrees of freedom. The device's portability and easy of use, along with auditory and visual features, can draw the attention of children with autism (Yuill, Rogers and Rick, 2013). It was also reported that the children were likely to enjoy the use of the apps, and some of them even made significant progress.

The studies included in this review employed limited sources of data to identify the effectiveness of such platforms (Murdock *et al.*, 2013; Yuill, Rogers and Rick, 2013; Bauminger *et al*., 2007); however, the use of diverse sources from various angles could offer a better understanding of results and limitations. Moreover, there is a lack of research examining the effectiveness of technologies in different contexts outside of mainstream settings such as schools or group therapies; children with autism find it difficult to apply the practice of social skills to real-life situations outside the classroom (Escobedo *et al.,* 2012). Thus, there is a need for further research to explore how we can develop mobile systems and support children with autism in real-life social situations. One of the main constraints on such a development is mobility, as indicated by Escobedo *et al.*, (2012), as mobile technologies to encourage children with autism to practise their social skills are scarce.

This review has revealed that few studies have reported any details of engaging children with autism in the co-design process or evaluating the technology included in the studies (Fletcher-Watson *et al.,* 2016; Hourcade, Bullock-Rest, and Hansen, 2012). In these studies, feedback was received from a limited number of participants or via proxy users such as schoolteachers (Christinaki *et al*., 2014; Hourcade, Bullock-Rest, and Hansen, 2012). Furthermore, the authors do not provide details of the activities conducted and the ways in which the children engaged with the interface; meanwhile, there is scant information regarding how the children's input was incorporated into the design of the apps. This highlights how the representation of children's voices in the technology design process is poorly addressed. There tends to be an approach emphasizing research done on children with autism rather with them (Parsons *et al.,* 2019; Fletcher *et al.,* 2019).

Due to the special requirements and needs of children with autism, there is clearly a need for research to ensure good practice in design (Fletcher-Watson, 2014). It is argued that including their views, alongside those of designers, therapists, and parents, in the design process is considered good practice in design and creates opportunities for their social inclusion and representation (Parsons *et al.,* 2019; Davidson, 2008). Such input is likely to provide reassurance in the efficiency of the product. Through this process, the designers/researchers can gain a better understanding of the children's preferences and needs and the effect on their motivation; an aspect that this thesis will explore in more depth.

As this study is concerned with the design of an interface, it was important to review the literature in terms of the guidelines that exist related to designing technology programmes for children with autism. However, as this topic is beyond the scope of this research, a synthesis of the core design guidelines as derived from the existing literature that inform the design of an interface is presented in Appendix (A).

The next section provides a context to the design technology and discusses the concept of child participation and the levels of involvement within the field of technology design. An overview of research studies adopting a participatory design approach when designing technology-based programmes for children with autism is provided. It then presents some key debates and challenges in this area of research and concludes with a summary of the issues from the literature which led to one of the research questions of this study.

2.3 Participatory Research

This thesis focuses on the design of an interface, as such, this section will provide an overview of the participatory research and will review the current literature relevant to the participation of children with autism in technology design. This section will draw upon the children's role and will explore the approaches and methods being used in order to inform such technology design.

Historically, participatory research began as a movement for social justice (Cargo and Mercer, 2008; Green *et al.*, 1994) and concerns of equity (Cornwall and Jewkes, 1995) in various fields, such as health research (Rifkin, 1985), technology design (Gould and Lewis, 1985), and social inclusion (Fails, Guha and Druin, 2013). Its central principles are that researchers act as facilitators "to fundamentally question and rethink established interpretations of situations and strategies" (Bergold, and Thomas, 2012, p.1). In practice, participatory research focuses on knowledge for action (Cornwall and Jewkes, 1995) as emphasis is placed on generating knowledge. In all these aspects of research, the intention is to identify the participants' needs, and to ensure that their views are accounted for and valued in the technology design.

The process of co-construction is driven by active collaboration between the participants and the research team (Green, 1994) in which both sides work together to share insights into the knowledge-production (Bergold, and Thomas, 2012). Participatory methodologies are characterized as being "reflexing, flexible and iterative" (Cornwall and Jewkes, 1995, p.1668), with the focus on exploring people's perceptions and knowledge. The central emphasis of this approach is that it entails an iterative reflective process (Heron, 1996) and is based on a constant dialogue and mutual understanding among the participants (Bergold, and Thomas, 2012). However, well-established techniques might not be appropriate, and the researchers need to make the appropriate adjustments and adapt their approaches based on the cognitive skills of the participants (Cornwall and Jewkes, 1995).

2.3.1 Participatory design approach in technology design research

Within the framework of participatory research, there is a growing awareness in the field of Human- Computer Interaction (HCI) that engaging potential users in design activities is seen as an effective practice to develop accessible and usable digital technologies (Simonsen and Hertzum, 2012). The oldest approach is referred to as User-Centred Design (UCD) (Norman and Draper, 1986) and has emerged as a way to better understand what users need in terms of the design of a product. UCD focuses primarily on the development of usable products and interfaces, ensuring that they can meet the needs of the users within the constraints of the design specifications. The involvement of the end-users in the product development process is not considered necessary, and they position themselves as testers (Gould and Lewis, 1985). However, the principles, as proposed by Gould and Lewis, (1985) underline the idea of user involvement. Accordingly, to design accessible technology platforms, the three principles that are of particular importance are 1) an early and continual focus on users and tasks, 2) empirical measurements implying an early use of prototypes and simulations by the intended users and the analysis of their performance, and 3) an iterative evaluation and modification of the product.

Similarly, Participatory Design (PD) is considered to be a specific mode of User Centred Design (UCD) with each approach overlapping with the other. PD is an approach that focused, from the outset, on "mutuality and reciprocity" (Muller and Druin, 2003, p.15). Muller and Druin, (2003) perceived the PD approach as "a bridge between two spaces - the world of technology developers/researchers, and the world of the end-users" (p.15). However, it is apparent that each world has its own knowledge and practices, and this shift seems to be challenging in terms of finding common ground (Kujala, 2003). The nature of PD permits a shift "from helping others to empowering others" (Rogers and Marsden, 2013, p.57) as the opportunity to become equal partners is given. Due to this characteristic, PD is conceived as a well-established strategy for proactively involving users, giving them the sense of empowerment to generate design solutions as part of the development process (Sanders, 2003; Muller and Druin, 2003). It is a cooperative process in which the roles of researchers, designers, and users are interdependent. In this way, the design is driven by the inclusion of the users, while an iterative process is seen as necessary. The involvement of users' input is also highlighted by Sanders, (2003) who considers that exploring what people think, feel, and make provides us with the opportunity to obtain both explicit and tacit knowledge at every stage of the design process (**Figure 6**).

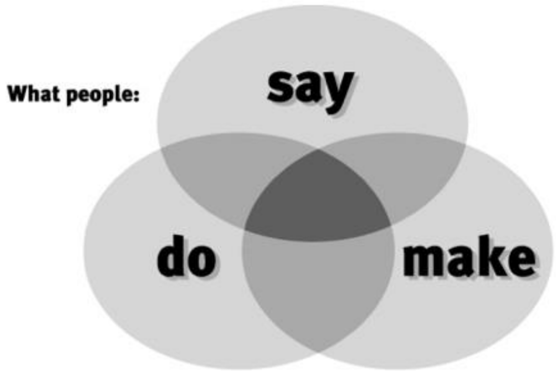

Figure 6 They say, do, make model as adapted by Sanders, 2003.

The combination of the "say-do-make" strategy includes a range of generative tools that enable the researchers to recognize the users' strengths and needs and capture the diversity of their experiences. All these aspects, in turn, help in obtaining a better understanding of and in empathizing with the users who experience the products and services to secure a better future (Muller and Druin, 2003). To achieve this, appropriate techniques are of great value for identifying the deeper levels of user expression. In this way, users can be creative and inspirational to generate new ideas.

Taken together, it appears that the process of co-construction is likely to bridge the gap and give a sense of empowerment to the potential users to generate feedback and ideas. This approach, consequently, helps inform the design of the interface. This interdependent relationship has as a main goal to gain insights into the users' perceptions and shape the technology in various ways.

2.3.2 Participatory research for children in technology design

PD has been well-suited to and deeply ingrained in various communities, such as children (Druin *et al*., 1999), minority groups (Las Nueces *et al*., 2012), and older adults (Blair and Minkler, 2009). Particularly, children's rights and participation have been highly regarded and have gained momentum following the United Nations Convention on the Rights of the Child, which was agreed upon by world leaders in 1989. It encompassed children's rights and the legal support to engage with and be fully involved in all aspects of life, such as family, social and cultural life. Article 12 of the Convention lays out that children have the right to express their views and ideas freely, and further, Article 13 argues that children should have the right to freedom of expression through the media of their choice (Unicef, 2008). Considering these factors, this treaty was the first step towards giving children a voice in decision making in community projects (Hart, 1992).

The enquiry of PD and similar approaches in the field of HCI has become widespread in the area of child-computer design to address children's complex needs (Druin, 2002; Druin *et al.,* 1999). Initial work on children's input into the technology design process was carried out in the early 1970s; however, the direct involvement of children was limited (Druin, 2002) as the emphasis was on how new technologies could influence children's learning. The proliferation of technologies for children in the late 1990s made researchers consider children's contributions. Researchers, subsequently, have advocated a child-centred approach to designing products, and novel work has produced platforms involving children in the design process (Fails, Guha and Druin 2013). A growing body of evidence has demonstrated the value of children's inclusion and has highlighted their abilities to propose their own ideas and be creative over the lifecycle of development (Druin, 2002; Druin *et al*., 1999; Scaife *et al*., 1997; Oosterholt, R., Kusano and de Vries, 1996). Children were capable of informing the designers whether a product could keep them engaged or of what they liked the best (Guha *et al.*, 2004; Scaife *et al*., 1997) and this, in turn, has proved valuable when proposing a new prototype and generating certain design solutions.

Nevertheless, a drawback of this process is that the children may suggest things that cannot be included. Given this, the establishment of guiding rules and an early preparation of what the process will be is highly recommended (Hanna, Risden and Alexander, 1997). Suggestions by other stakeholders, such as teachers, can effectively contribute to the entire process by stimulating the children to offer feedback on ideas (Druin *et al.*, 2001*).* Because children have their own characteristics, culture, and complexities (Druin, 2002), when designing quality technology, it is highly appropriate to "enter their world" (Oosterholt, Kusano, and de Vries, 1996, p.457) and "enable them to tell stories" (Druin *et al.*, 1999, p.6). This approach, in turn, will lead to an accessible technology that is well-accepted by the representative users.

2.3.3 Bridging the gap between the needs of children with autism and technology design

The evolution and rapid growth of technologies for children with autism have had a considerable impact on addressing the challenges related to autism. Alper *et al.,* (2012, p.75) argue that children with disabilities are "at risk of growing frustrated or bored with existing interactive technologies because their needs—intellectual, social, physical, and emotional—are often not well understood or identified". This highlights how the interface design seems to fail to meet the unique needs of this target group as a result of some technology programmes having configuration issues or limitations. Poor interface design may be an important indicator of the programme's quality and may result in a lack of learning, as Fletcher-Watson, (2014) reports. This, in turn, may cause the children to show undesirable behaviours and frustration. As such, these challenges and specific needs necessitate the adoption of a human-centred design (HCD) approach and the direct involvement of children with autism in the design process (Benton and Johnson, 2015).

Since the use of technology has come to the forefront to promote wellbeing and support children with autism, researchers have addressed the issue of involving this target group in the design and evaluation process. As Parsons and Mitchell (2002) reflect, research on the input of children with autism in the development process shows it to be undervalued. However, it is believed that user-centred approaches can be of benefit as "representative users are included in product design and development from the start" (p.437). Consequently, in this context, efforts have been made to consider the PD approach for its use in the field of autism.

Frauenberger, Good and Alcorn (2012) consider PD as a methodological orientation to be as important as the outcome, which is more user focused. Several researchers have advocate that the input of children with autism in the design process is likely to deliver several benefits; namely it will enable their voices to be heard, giving them a sense of empowerment, and boosting their confidence (Benton, and Johnson, 2015; Guha and Druin, 2013). Participating in this way, children with autism are likely to learn new skills and interact by giving their viewpoints and receiving the viewpoints of others (Druin, 2002). From a designer's standpoint, PD is seen as an approach to identify "the acceptance, ownership and the odds of a usable programme" (Frauenberger, Good and Keay-Bright, 2011 p.22), while the input of children with autism seems to be important as designers and researchers lack knowledge about their needs and requirements (Frauenberger, Good and Alcorn, 2012).

Therefore, considering the challenges in the social and communication domains, it is necessary to provide appropriate support; this support can enable the communication of opinions and can be tailored to the varying conditions and needs of children with autism in the process of design (Frauenberger, Good, and Alcorn 2012; Millen, Cobb, and Patel, 2011; Keay-Bright, 2007). To address this, knowledge elicitation techniques have been used to carry out user research and obtain the information needed to inform the design process at different stages (Fails, Guha and Druin, 2012). These techniques include brainstorming, observations, interviews, questionnaires, low-tech prototypes, and sketching (Fails, Guha and Druin, 2012). Such techniques in a child-centred design ensures active participation, engagement and collaboration at various stages of the design procedure, allowing the participants involved to provide feedback and idea generation (Benton *et al.,* 2014; Frauenberger *et al.*, 2013).

Regarding the impact of idea generation, the literature raises practical issues that can have implications. For example, Parsons and Cobb (2014) argue that the inclusion of children with autism can lead them to display challenging behaviours, such as frustration when the outcome is not what they had in mind. Frauenberger, Good and Alcorn (2012) discuss how the practice of co-design can be discouraging for children with autism when activities take place in unfamiliar settings and with adults with whom they have not established a relationship. Difficulties in communication, such as the inability to initiate or maintain conversations, can also have an impact on the children's participation. Design activities necessitate sharing experiences and understanding the thoughts of others while building relationships with other partners is also an essential part of the process. Therefore, a lack of social skills can make the children unable to participate in give-and-take interactions (Frauenberger, Good and Alcorn, 2012).

The literature has discussed the roles assigned to children in the technology design processes from the initial brainstorming activities to the evaluation stages (Goolnik, Robertson and Judith, 2006; Druin *et al.,* 1997; Scaife *et al.,* 1997). These attempts have one specific goal: the participation of children to develop better technologies based on their needs. Druin (2002) highlights that the cognitive level of the participants and the level of involvement play a significant role when designing with children. Based upon this, Druin (2002) identifies multiple levels of children's involvement in the technology research, which can be classified into four discrete roles: 1) user, 2) tester, 3) informant, and 4) design partner, as illustrated in **Figure 7.**

. Each role encompasses a broad range of involvement at differing stages; the child's involvement can range from the minimum, such as passive roles as users after the product has been developed, to being equal design partners throughout the design process. This framework has been widely adopted, and different interactive platforms have been developed specifically for the input of children with autism.

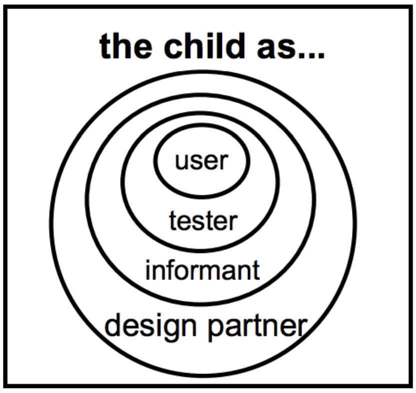

Figure 7 The four dinstinct roles of children's participation in the design of new technologies as defined by Druin, (2002).

- *User*: This role is the most common in the literature of technology design. In this role, the children have no direct impact on the technology design. As users, they are observed by the researchers interacting with the developed technology. From this, the researchers can identify any potential difficulties and improve the product. Parsons *et al.,* (2011) involved various stakeholders in the design of interactive collaborative technologies, including teachers, children with autism, and typically developing children. These programmes aimed to support the social skills of children with autism and to help them make social conversations with their peers. The feedback gained throughout this process is considered invaluable for shaping the content and usability of the proposed technologies.
- *Tester*: The role of the tester seems similar to that of the user; however, the underlying framework dimensions are different. When children are involved as testers, the aim is for them to test initial prototypes while the technology is still being developed before it is released onto the market. The children are observed and/or are asked to provide feedback related to their experiences and their impact on the tested technology. The way the children interact with the prototypes helps to achieve the iterations of the technology while the team add new designs to fit the children's behaviour. However, the children's role is limited as they are not part of the brainstorming phases. An example of this was when researchers designed an annotator tool to support children with autism in design critique (Frauenberger *et al*., 2013). This work enabled the children to express their views in terms of the design of the product (e.g., the behaviour of characters or the mood of a scene) and their interaction with the system.
- *Informant*: In the design informant role, the idea is that children and other proxy stakeholders are involved at various points to maximize the contribution of a diverse input. Their involvement is not continuous throughout the technology development. The children's input can be achieved through observations with existing technologies, or feedback on design sketches and low-tech prototypes. With children involved as informants, the aim is to gain insights into the technology and improve designs by giving them the opportunity to have their own say. In Scaife *et al*.,'s (1997) work, children with autism were involved in redesigning an application. The techniques used for this activity included

sketching materials and artefacts. The authors valued this contribution to the design process and stressed the importance of this design role, which is beyond that of user or tester.

- *Design Partner*: Researchers and children are considered equal partners throughout the entire process. In this role, children contribute to the process at all the stages of the process; this involves consensus participation. To achieve this, the power imbalance between children and adults should be removed. Therefore, Large *et al.,* (2006) questioned the possibility of this cooperation between children and adults and claimed that equal partnership could not be achieved. Techniques, such as using simple language and using first-names, may help to overcome this inequality (Fails, Guha and Druin, 2012). Therefore, Large *et al.,* (2006) proposed a design method called "Bonded Design" in which the role of children falls between acting as informants and design partners, and the children with autism are involved as partners in several phases of the design.

In sum, the adoption of a human-centred design (HCD) approach emphasizes inclusion, with the aim to develop a usable technological product for children with autism. It encompasses various research designs, techniques, processes and methods by keeping the children at the forefront of the design process and decisions making. However, this approach can be challenging when children with autism are at the centre of this process. The literature has stressed the importance of issues in communication and how this can prevent such children from being engaged and informing the design. In tackling these, the research and design team need to be familiar and flexible, using methods that allow the groups with autism to express themselves and contribute to the design process.

For over a decade, studies have considered the importance of the involvement of neurodiverse children in PD and have reported the experiences of children with autism throughout the lifecycle of software development (Spiel *et al.,* 2017; Benton *et al.,* 2012; Fraurnberger, Good and Keay-Bright, 2011; Millen *et al.,* 2011). Within these projects, the roles of children with autism have varied from testers (Frauenberger *et al.*, 2013) to equal design partners (Bossavit and Parsons, 2017; Guha, Druin and Falls, 2008). In these projects, the involvement of indirect stakeholders, such as teachers, parents, and technology practitioners, was considered necessary in those cases where the children were less able to communicate with the research team. In fact, proxy users ensured that the products were appropriate and based on the needs of the children with autism.

An example of embedding PD processes in the research with children with autism is a study by Parsons *et al.,* (2011). The COSPATIAL project aimed to develop interactive technologies for school settings to support the improvement of social and collaboration skills. Knowledge was derived from children with autism (aged about 11years) and a range of specialists, including teachers from three different schools and project researchers. The project identified that the input of children and the involvement of the teachers deepened the researcher's knowledge and "shaped the content, usability" (Parsons *et al.* 2011, p.34) of the technologies. The focus groups played an important role in motivating the children to provide valuable feedback regarding developing a technology tailored to their needs. Furthermore, it seemed that the children performed well in working in teams while the social and communicative demands of the activities were seen to be set at an appropriate level where the children were able to accomplish the required tasks. The series of iterative prototypes, alongside the involvement of the teachers, led to the design changes; however, these changes highlighted a disagreement between the preferences of teachers and children with autism (Parsons and Cobb, 2014). The authors acknowledged this challenge and concluded that decisions need to be made in terms of whose views have a priority and how the integration of various opinions can be successfully obtained.

In the ECHOES project, Frauenberger *et al.,* (2011;2012) attempted to develop a game-based technology program to develop social skills in children with autism. In this study, two groups- a group of typically developing children along with a group of children with autism- worked together and were involved in various design activities for developing social skills for both groups. The study focused on the process of the co-design sessions instead of the outcomes and gave details about how the sessions were structured and what implications emerged. The various design activities enabled the active participation of the children with autism and gave them a voice to express themselves, which resulted in strengthening their participation in the process. Initially, a toolkit of objects was given to the participants to use for imaginative play. Tangible art-based supplies were also incorporated to enable the children to create their own narrative frame. Finally, digital prototypes with the character of the game were provided to help the children to connect with tangible objects in the physical world.

In this project, Frauenberger, Good and Keay-Bright, (2011) suggest that children with autism had a direct impact on informing the design of the ECHOES environment, however, some of their ideas were too complex to be transferred into the design product. The information obtained "have fundamental phenomenological qualities" (p.4) which helped the designers understand the deeper meaning of the input.

Frauenberger et *al.,* (2012, 2011) underlined that the use of a participatory approach involved several challenges that researchers needed to consider. These challenges include managing relationships, regulating challenging behaviours, and carefully interpretating pupils' feedback. Further, the authors stressed the importance of a more holistic and situated design, which means that novel methods could be included to allow children with autism to show their potential. They also noted that the degree of participation is related to the difficulties experienced by children with autism, and this can be an additional challenge in participating in the design. Design activities can lack structure and the ideas coming directly from the children may be in the form of monologues, without any meaning and difficult to understand. The impaired social skills may also result in the inability to consider the contributions of others (Fletcher-Watson *et al.,* 2016). Therefore, it seems that the authors reported only the effects of a PD approach in designing novel technologies rather than taking an iterative approach in the development of a refined product tailored to the abilities of the children involved.

Taken together, it is evident that both studies focused on involving high functioning children with autism; capable of communicating their ideas. They also offer several important suggestions for future research. These encompass the practical challenges when carrying out research with children with autism in situ. Researchers need to consider how children with autism can be engaged and their interest maintained throughout. In doing this, various types of communication channels and activities tailored to the children's intellectual abilities can help overcome unexpected issues and encourage their active participation. The studies also stressed the importance of addressing power imbalances between adults and children with autism and setting out clearly the expectations of each member's role.

With the increased focus on the involvement of children with autism, researchers have proposed frameworks that can increase the likelihood of them being engaged in the technology design process. For example, Benton *et al.*, (2014; 2012) proposed the IDEAS framework; a design approach that scaffolds adults in supporting the involvement of children with autism. This framework has been developed to help researchers plan effective sessions and create a comfortable environment by eliminating potential issues related to the children's characteristics. Specifically, it is designed in a way that eliminates all the factors that might prevent children with autism from being involved in the technology design. The sessions include various stakeholders, such as teachers and researchers. IDEAS is based on TEACCH- a structured teaching intervention approach (Mesibov *et al.* 2005) and involves four steps: 1) understanding the culture, 2) tailoring the process to the individual, 3) structuring the environment, and 4) providing support. To facilitate the structure of the sessions, a visual schedule is provided and the children can tick off the completed activities. In addition, a visual recap of previous sessions and a repeat of the rules help the children understand the overall process of each session. To reduce anxiety and distractions, there are certain factors to consider. These include the following: a) the sessions should take place in quiet and familiar environments such as a school classroom, b) familiar teachers should participate, and c) the structure of the sessions should be consistent.

All these steps facilitate the use of PD methods by putting the emphasis on the target children's abilities and providing the best environment for them to make their own contributions. Children with autism were involved as design partners and the results have shown that this approach seemed to be effective in making the participants feel more comfortable and less stressed, while structured and supportive elements were key features for the involvement of the children in the PD sessions. The children were actively engaged by asking them to generate their own ideas and by their collaboration with their peers leading to agreement on the final product. One specific limitation of this study was that the focus was on high-functioning children with autism, with activities tailored to their skills. As the study did not consider the needs or perspectives of medium-functioning children, this represents a gap in our current knowledge of a class with varied abilities who may be able to contribute to the technology design.

Bossavit and Parsons (2017; 2016) designed an educational game to teach geography focusing on academic skills. Knowledge was produced from the involvement of various key stakeholders fulfilling different roles, to facilitate the design of the game (a designer, a teacher, and a tester team). In this project, children with autism were assigned the role of design-partners throughout the development process that was divided into nine sessions (beginning with an introduction of the environment and going on to its development) and were tasked with creating a game. The participating children included six high functioning children who were split into the designer-team (n=4) and tester team (n=2). Therefore, this study was more exploratory, as its focus was on the programming part. Its purpose was to give some new insights in terms of the children's ability to design scenarios with their own ideas rather than them being the recipients of the ideas of others. The iterative design lifecycle called for the involvement of teachers and children at various stages. In the first session, the teachers' feedback was considered, then the participating children joined the project, and they were asked to sketch their ideas on paper after watching a video with a game idea. The third stage included testing the digital prototype and getting feedback to improve some features of the game. The authors reported that the participants showed great motivation and were focused on the required tasks.

Bossavit and Parsons (2016) reported the positive aspects of directly involving children with autism to contribute on their own terms. Tools such as visual schedules, sheets to sketch ideas on and digital screenshots of the prototype were provided to support the children's dialogue and gain their feedback. However, their level of participation was sustained by using a more informal approach, through the use of a visual questionnaire and dialogue. Sophisticated tools, such as visual schedules and visual recap did not sustain their children's interest. The children also managed to generate their ideas through a prototype, and they showed enthusiasm for the novel technologies used in the project. Their involvement varied; some of them were more motivated and actively involved throughout while others were more reluctant to participate to such a degree. However, all of the various techniques used in the different stages enabled them to foster idea generation and contribute feedback, thus informing the final design of the product. Furthermore, the teacher's presence contributed to the prompting of ideas and feedback. This could suggest that the input of the children with autism is primarily linked to the approach of the researchers. Their involvement and engagement rely on how flexible the overall approach is; children can have different roles across the process without following a strict protocol of undertaking specific activities. Furthermore, the adult's intervention highlights how they can influence and encourage the children's participation by removing certain barriers and helping them to regain their focus. However, the study focused on how the activities shaped the roles of the participants undertaken in each session, while details about the children's feedback and whether their input had an impact on the design outcomes were limited.

In another study, Malinverni *et al.,* (2017) proposed an inclusive model for designing a game for children with high functioning autism aged from four to six years. The purpose of the game was to facilitate social initiation. The proposed model involved knowledge that was derived from a wide number of stakeholders who were all responsible for the final design. The goal of this project was to integrate the opinions of children with autism in the design of the final version and create a game that could meet the therapeutic objectives. The PD enabled the children to suggest ideas about the game's characters, narrative elements and the game features, such as rewards. The evaluation of the product was carried out by using different methods, such as the 'Smileyometer', short-structured interviews, field observations, and an affective grid in which children rated different parts of the game. The findings suggest that the contribution of different stakeholders worked well and facilitated smooth collaboration in an interdisciplinary team spirit. In terms of the evaluation of the effectiveness of the game, the target children were able to initiate communication; however, the study provided limited evidence concerning whether the communication skills were transferrable to other contexts. This study also focused on using the participatory approach with high functioning children. Thus, further research is needed to fully address how the design of a technology could be affected by involving children with lower abilities.

This section has outlined the concept of the PD approach and has focused on research *for* and *with* children with autism. A number of the reported studies focused on the input of children with autism in the technology design. An outcome of this review is that the methodologies employed, the approaches taken, and the roles of the participating adults and children differ across the literature. In addition, it has been shown that several factors can help the children have a direct impact and role during the design process. These include: a) the importance of considering the children's special needs; the methods and approaches for involving children with autism in the design technology should be adapted based on their abilities, b) the need for a clear structure of the sessions verbally and visually that can inform and prepare the children regarding the activities, and c) the active involvement of proxy users such as teachers, therapists or caregivers who can help those who show frustration or who need further explanation, offered by familiar people. Benton and Johnson (2015) have highlighted the need "to focus on the design, social and theoretical knowledge generated from PD work" (p.38) concerning the methods and approaches used in technology design. In the field of autism, the generated knowledge implies the level of severity, the level of adult support as well as the frequency of child's involvement.

Through this review, the input gained by the direct involvement of children with autism was reported to be a useful vehicle for researchers and designers to pinpoint the children' special needs and shape the design of the technology products. The use of various techniques contributed to empowering the children in a variety of ways and made them feel part of the design process. It has been shown that there is a tendency for researchers to focus on the process of co-design sessions and highlight the benefits that this approach offers for the empowerment and contributions of children with autism. However, there is limited consideration of which techniques and aspects seem to be beneficial in engaging these children (Bossavit and Parsons, 2017; Benton *et al.,* 2012) and what the outcome is in terms of the design of the technology programs. In addition, the studies discussed in this review have tended to work with high functioning children with autism (i.e., those without additional learning needs) and who have language skills that are appropriate to providing feedback to the design process. This could suggest there is a need to examine whether children with more complex needs and abilities can have a positive impact on the design of technologies designed for them. In addition, the reviewed studies have considered the impact of a PD approach while the technology design appears to follow only short processes of iteration (in terms of interface design). It would be interesting to analyse the effectiveness of an interface by following an iterative process and gaining feedback from the target children at each stage.

As this thesis is concerned with the design and use of an iPad in a museum environment, the following section discusses the role of museums as community institutions with an emphasis on the shift towards inclusion and diversity. Research about the inclusive practices that museums have implemented for children with autism and their families will also be presented. The study will also briefly review research related to the use of mobile technologies in museums and the potential to create new opportunities to reach out to diverse audiences. Finally, studies focusing on the use of digital platforms for children with autism will be examined.

2.4 Advancing inclusivity in museums

Museums have positioned themselves as educational institutions and community anchors, and, indeed, they play a central role in representing the past, present, and future of the world. As Hein, (1995, p.188) stated, "Museums are primarily didactic in nature" and aim to instil knowledge in the visiting audience. The constructivist perspective as proposed by Hein, (1995) necessitated a change in the relationship between the audience and the museums. To achieve this, the museums changed the way they presented their collections by integrating a range of interpretative new practices into the visitor experience. The sequential changes have included a focus on museums understanding their audiences in greater depth and on fostering experience-centred interactions tailored to people's abilities (Hooper-Greenhill, 1994).

Falk, (2001) describes the museum as a unique environment that offers opportunities for exploring something new and for gaining a glimpse of the past (Hooper-Greenhill, 1994). Through hands-on activities and direct experiences, visitors are exposed to a variety of stimuli that can capture the visitor's curiosity and creativity (Falk and Dierking, 2000). This object-led learning involves a participatory, active mode of learning where visitors stay actively engaged with the museum content and are prompted to use various ways of communication.

The literature indicates that museums can be considered educational institutions as long as the needs and expectations of a diverse population are met (Falk and Dierking, 2000; 2012b). Based on this, museums have been encouraged to respond to the issue of "audience development" (Sandell, 1998, p.410) and to provide an inclusive environment. The concept of inclusion became a topic of interest in the UK in the 1990s under the UK's New Labour government. The new UK policy framework for museums called for major changes in policy direction; An emphasis was placed on reshaping the role of museums in society and re-structuring their actions in such a way as to tackle social exclusion and reach the widest audience possible (DCMS, 1999b; 2000). The policy document *Centres for Social Change,* released by the Department for Culture, Media, and Sport (DCMS):

> Our objective is wider than simply encouraging under-represented groups to come into museum, gallery and archive buildings. If museums, galleries and archives are to make a difference, their goal should be to act as vehicles for positive social change. (DCMS, 2000, p.9)

According to this document, the key principles of an inclusive environment are to create a social change that serves the needs of its community and makes its environment accessible and relevant. Policy responses to inclusivity in museums are evident internationally. The American Alliance of Museums (2014) published a policy statement titled *Diversity and Inclusion*, which highlighted that "diversity of participation, thought and action" was of significance. Inclusion as a concept involves change (Sandell, 1998); it encapsulates the attempts to build partnerships, re-engage with, and provide opportunities for the socially excluded (Tlili, 2008; Sandell, 1998). Fostering inclusion was considered a driver for museums to leverage diversity where people can feel supported. From the standpoint of inclusivity, this meant that removing the prohibitive barriers to public access and developing services that could reduce social exclusion was a primary concern (Kinsley, 2016).

2.4.1 Making museums accessible to visitors with autism

The increased international awareness of equal human rights and diversity under the implementation of the Disability Discrimination Act (DDA) 1995 in the United Kingdom (and similar legislation in other countries) has been perceived as a driver for change to include disabled people in all of the policies (Dodd *et al.,* 2008). Within the context of the legislation, museums have considered various strategies to embed community cohesion and widen participation for visitors with disabilities. To cater for this sector of the population, under the new policy initiatives, museums have attempted to integrate the principles of accessibility and inclusivity in their resources as a matter of equality and compliance. Addressing the variability of the learners and creating an inclusive environment can lead the visitors to undergo advanced experiences and independent interaction with the museum environment.

While museums have become committed to advancing access and implementing inclusive practices for visitors with a diverse range of disabilities, to date, people with intellectual disabilities have been an under-represented group and so have been marginalized regarding museum communities (Deng, 2015; Black, 2005). Accordingly, the ongoing rise of diagnoses of autism (American Psychiatric Association, 2013) has led museums to address health care issues to achieve better integration of children with autism (American Alliance, 2013).

Museum inclusion for visitors with autism is a challenging issue, as it is with people with other disabilities. Since the characteristics of autism vary widely, the integration of multifaceted support to address the children's diverse needs is deemed necessary. Sensory sensitivities and large crowds are raised as major barriers that have the potential to create an overwhelming and stressful experience for children with autism due to the exposure to an overload of distractions (Fletcher *et al*., 2021; Fletcher, 2016; Langa *et al.,* 2013). To ensure that children with autism can participate in and benefit from a museum visit at the same level as non-disabled audiences, several museums across the world (such as in the US and Europe) have embarked on a mission to consider their specific needs. This has been achieved by establishing links with local autism organizations, such as the National Autistic Society, the American Alliance of Museums, and Ambitious about Autism. With their support, museums have attempted to create equitable experiences and develop the best practices so that they can offer a tactile quality museum experience. These efforts have included an individualized supportive environment and sensory-friendly activities, while improvements have been made to the physical aspects of the museum spaces (e.g., signage is simplified, sound and lighting are lowered, schedules are more specific, and pre-visit resources are available). Examples of new programmes aligned to the needs of children with autism can be found in museums around the world with events such as "Morning at the Museum" https://www.si.edu/Accessibility/MATM or "Early Bird" https://www.sciencemuseum.org.uk/see-and-do/early-birds), whereby the museums allow early entry on specific days when the museum space is less crowded. Additionally, other museums offer access to content with special toolkits; for example, in the V&A Museum of Childhood, these toolkits are called “Making SENse Family Packs”. These packs take the form of backpacks and contain a range of sensory toys that can be used throughout the visit as presented in **Figure 8** (see https://www.vam.ac.uk/moc/learning/sen/visiting-autistic-child/).

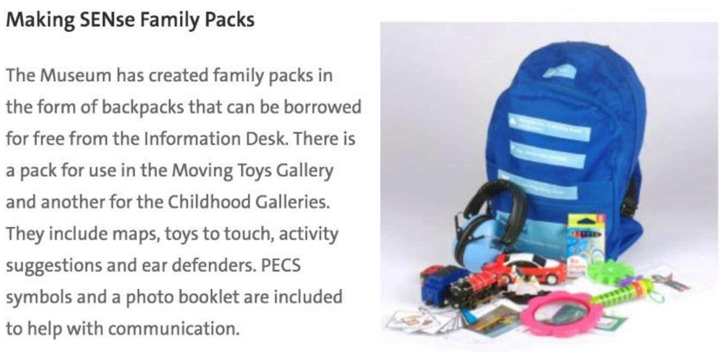

Figure 8 Making SENse Family packs for visitors with autism to V&A Museum of Childhood.

Within the context of widening participation, there is growing evidence that community participation can be enriched through leisure pursuits (Buttimer and Tierney, 2005; Bramston *et al.,* 2002). In this respect, evidence suggests that integration into such community activities provides children with autism additional opportunities (Nicolopoulou and Cole, 1993) to explore new academic concepts, develop skills, and express creativity (Lam *et al.,* 2010; Kinney and Coyle, 1992). Existing scholarship indicates that children with autism tend to be interested in museum activities and perceive positively the unique interactive opportunities available in the museum environment (Hoskin *et al.,* 2020; Woodruff, 2019; Baldino, 2012). The sensory needs of such children can be met through hands-on activities and inquiry-based learning that is at the centre of museum education initiatives. While the concept of inclusion is a widely accepted notion, only a few recent studies have addressed the impact of museum provisions and programmes on promoting inclusive participation for this target group.

Woodruff’s (2019) work investigated families’ concerns and the behaviour of children’s with autism while visiting a museum. In this study, there were fifteen participants:

seven were children with autism, three were neurotypical children, and five were parents. The age range of the children was from 3-14 years. The research was conducted in two museums, both of which were easily accessible and provided similar interactive exhibitions. The author collected qualitative data through pre- and post-visit interviews with the parents, field observations, and 2D art media activities, which were given to the children at the end of the visit. The art activity aimed to examine whether the museum visit had influenced the children to make art based on a specific topic. The findings showed that social narratives and pre-visit orientation materials are considered important intervention practices to improve the museum experience and facilitate opportunities for reflection. Through making art, the children reflected upon their experiences by drawing their favourite objects. However, while the focus of the study was on parents' perceptions of the museum visit, little information was provided about the children's attitudes to their visit revealing what they liked the most and how they interacted with the environment. This lack of information limits the usefulness of the study. In addition, there was no demographic data about the participants; important information that offers a fuller better context of the study.

Museum studies have looked at framing the factors related to a successful and autism-friendly visit for families with children with autism. Langa *et al.,* (2013) explored the motivations and needs of families and the role of web-based museum resources in enhancing museum accessibility. In Langa *et al.,*'s (2013) study, ten pupils with ages ranging from 7 to 11 years old and their parents were selected; the children's conditions varied ranging from low-functioning to mid-range and high-functioning ability. To investigate these aspects, the authors used a questionnaire and a follow-up interview for the families. This study found that the most important motivations for the families to visit museums were to have the opportunities to interact with others, provide a safe environment and offer a range of activities that facilitated the child's independence in exploring the artefacts (Langa *et al.,* 2013). In addition, the parents highlighted the importance of pre-visit web-based materials with tailored information about floor maps of exhibitions and possible activities. The parents' perceptions acknowledged that these additional resources helped in improving museum accessibility. This special information can be perceived as essential toolkits to help the families prepare for the visit and establish clear expectations of the museum experience. However, the authors recognized that it is important to shift towards a child-centred approach and identify the children's motivations and experiences, an aspect that this study will try to address.

Deng (2017) sought to explore how a tailored museum experience influenced the learning and behaviour of children with autism throughout a 6-week access programme. In this study, ten children (nine boys and one girl) aged 8-15 years old diagnosed with high-functioning autism, along with their parents/guardians, were recruited. To create a rich description of the museum experience, data were gathered through a mixed-methods approach, including pre- and post-gallery tour task evaluations, on-site observations, parent surveys, and semi-structured interviews. The findings revealed that the programme contributed to enhancing the children's curiosity through hands-on art-making activities. It created an atmosphere that prompted the children to interact with the museum objects and engage in cognitive activities, which, in turn, led to improved social behaviours. One limitation of this study was that the study focused on children with high-functioning autism, and this limits the possibility of gaining a better understanding of how a group of children with a wide range of abilities might perceive a museum experience. While the combination of multiple sources was intended to provide a holistic overview of the study, it would be interesting to also hear the children's voices.

Scholars have highlighted that museums are conceived as places where opportunities for experiential learning activities are provided; through play-based inquiry, where the children are encouraged to explore their creativity (Henderson and Atencio 2007). A study by Mulligan *et al.,* (2013) examined the effectiveness of a museum programme designed specifically to support children with autism and their families. This focused on exploring whether the specialized materials and programmes promoted community engagement, pleasure, and learning opportunities. The authors collected qualitative and quantitative data to address the research questions of the study through interviews, a survey, and observations. The results revealed a positive attitude where the children showed a high level of active participation, joint attention, and enhanced communication. The parents of the children reported satisfaction with the museum experiences as their children enjoyed exploring the areas of the museum. This work highlights some important programme characteristics which evoked the overall satisfaction; these included 1) being family orientated, 2) having well-trained volunteers and specialized materials, 3) offering opportunities to interact with others, 4) providing exhibits with sensory features, 5) offering hands-on activities, and 6) organizing symbolic play, which was observed to be appealing to the involved children. Mulligan *et al.*'s (2013) work is important in terms of the methodology followed as it attempted to triangulate the findings drawing on the children's experiences.

Overall, the studies reported in this section have focused on the museum activities and programmes children with autism and their families have experienced over the years. It seems that museums worked towards making their resources and services accessible to visitors with autism. The implementation of such inclusive provisions has had a positive impact on building a bridge for children with autism to access places like museums.

In sum, the studies discussed sought to obtain an understanding of the motivations and factors that pertain to supporting the learning, engagement, and social participation of the children with autism in the museum. It can therefore be concluded that a museum visit provides opportunities for children with autism to explore new things, to learn, and to interact, thus unleashing their creative and cognitive skills. Despite the encouraging results, the studies confirm that there is a need to address children's special needs when designing museum programmes.

While there is research on the parents' perspectives, there is little about the views of children with autism when visiting the museum; an aspect that should be taken into account when doing research with this target population. Furthermore, there was not enough data presented regarding how children with autism interacted with the museum space and how they behaved in terms of engagement with the physical context. This information would be beneficial in gaining further insights into how children with autism perceive a museum visit. As Langa *et al.,* (2013) have pointed out, including the voices of children with autism would contribute to improving the museum provisions and increase opportunities for greater community engagement. Therefore, research needs to recognize the right of children with autism to have their voices heard and their diverse experiences and preferences acknowledged. The reviewed studies provided limited contextual data and employed limited techniques to obtain an understanding of how a museum experience was perceived. Furthermore, the issue of what inclusive technologies can offer in a museum environment for children with autism is still an overlooked topic. As museums are committed to creating accessible programmes and provisions for children with autism, this indicates a need to address this gap by exploring the role of digital services in facilitating museum accessibility, enjoyment, and engagement. In the following section the emerging field of museum digital practices is reviewed.

2.4.2 State-of-the-art technology in museums to engage diverse audiences

Digital advances have transformed the scope of museums and have been a motivational driver to shift their traditional character in the realm of audience engagement (Vavoula *et al*., 2009). Traditional forms of museum engagement were not sufficient to cover the expectations and needs of contemporary society (Kumpulainen *et al.*, 2014). To address this challenge, museums have considered new practices to conceptualize ways of engaging their communities, aiding learning and reproducing the museum content (Economou, and Meintani, 2011; Arvanitis, 2010). Novel paradigms of computing have facilitated the integration of a variety of digital platforms into cultural institutions. Arguably, digital technology is viewed as a powerful tool that allows museums, metaphorically, to break through the museum walls and build connections between the collections and the visitors around the world (Economou, and Meintani, 2011). These services have integrated new dimensions to enrich immersive visitor experiences with object-rich collections to expand their network of visitors.

As the mobile app market is continuously growing, it was not surprising to see a rise in the number of apps in the museum industry. By and large, the nature of touchscreen devices offers several features that make them popular. Museum-produced apps as interpretive devices hold great potential to be both easily accessible and practical for use before, during, and after the visit, and to customize the visitor's experience with up-to-date information (Ardissono, Kuflik and Petrelli, 2011). The visitors can take advantage of the mobile features with multimedia techniques, such as video, images, and selective information about the objects they cover (Freeman *et al.,* 2016; Economou and Meintani, 2011). Such platforms foster unique opportunities for interactive experiences with improved search functions, such as gamification, HyperZoom, location-based-services, augmented reality and social network sharing. Another practical feature is the ability to personalize the museum experience based on the visitors' needs (Gammon and Burch, 2008). In fact, museums embrace mobile devices and focus on "how they can meet those visitors in their comfort zones to not only fulfil information needs, but also encourage enhanced exploration, interpretation, and sharing" (Freeman *et al.,* 2016, p.16).

Despite the advantages of handheld devices, it is important to highlight the considerations and pitfalls museum professionals address regarding the effectiveness of such platforms for the visitor's learning experience. A common critique of these devices in museums is that apps tend to encourage "anti- social behaviour" (Fisher and Moses, 2013, p.9); they have acted as distractions from the artefacts by minimizing social interaction and failing to keep the visitors' attention in a real space. In this sense, apps focus mainly on sharing information such as images and videos on social media networks (Arvanitis, 2010), while neglecting the advantages that museums possess for offering prompts for thought and discussion. However, other studies have highlighted that images with a dynamic and appropriate design can hold the visitors' attention in the real space (Gammon and Burch, 2008).

For museums to attract diverse audiences and to develop appealing products, a combination of educational and entertainment aspects (Ioannidis *et al.,* 2013) have been seen to fulfil visitors' expectations and to encourage interactivity. Pervasive games and playful interaction delivered to mobile devices are being explored and offer opportunities to encourage the visitors to approach museum's exhibits in a different way and to create a powerful way to interact and learn (Ioannidis *et al.,* 2013; Astic *et al.,* 2011; Sanchez *et al.,* 2011).

Previous research indicates that game-based approaches have the potential to encourage meaningful experiences and support learning (Cesario *et al.,* 2017; Ioannidis *et al.,* 2013; Astic *et al.,* 2011). Various forms of games have been employed in museums in the past for a range of visitors. For example, mystery and treasure-hunting game formats (or scavenger hunts) have maintained their popularity and facilitated inquiry-based activities. Visitors are invited to work in teams to decipher clues to uncover museum artefacts. In this way, they are prompted to become active explorers of the museum content, while their learning becomes more engaged (Kuflik *et al.,* 2014;

Avouris and Yiannoutsou, 2012). It is argued that treasure hunting and problem-solving tasks through a novel technology may facilitate a child's participation and engagement in the museum's exhibits and help them to construct meaning (Economou *et al.,* 2015; Kuflik *et al.*, 2014). Stories told using a game format have the potential to improve the playful aspects of the museum visit and provide a range of entertainment.

Mobile technology with location-based systems allows any information to be conveyed through different multimedia features such as text, picture, and sound. As Yianoutsou and Avouris, (2012) argue, interactive game-based activities offer rich learning experiences and introduce the creation of new relationships (Economou *et al.,* 2015). Through this, visitors assume the role of collaborator; they become deeply immersed in the learning concepts and "feel ownership over the knowledge" (p.669) they gain, which then needs to be integrated into the game. Weitze *et al.,* (2012) suggested the Smiley model for designing engaging games by including the essential game elements, such as a goal, action, rules, and feedback. To enhance children's intrinsic motivation, the model proposes that the use of motivation factors (e.g., curiosity or social relations) is necessary.

This study aims to explore the museums' digital practices for children with autism. However, a review of the implementation of treasure hunt apps in the museum field as an approach to entertaining and engaging the diverse audiences is beyond the scope of this study; a brief overview of work related to this topic can be found in Appendix B. Having considered a general overview of the digital practices museums embrace for their collections, this review has highlighted the potential of treasure hunt-based games to provide an enhanced and engaging museum experience. This review has also raised the issue of what digital media designed in museums to enable access to disabled people may offer particular benefits for visitors with autism. The next section addresses this issue and focuses on studies and initiatives that have considered children with autism as potential visitors who may use a digital device in a cultural institution.

2.4.3 Addressing diverse groups: technology-based approaches and their impact on museum visits for children with autism

The implementation of the Disability Act in 2001 and the Web Accessibility Initiative has created a fertile ground to promote equality of access for disabled people. The NMC Horizon report (2016) went one step further and argued that "technology can aid in enabling more inclusive experiences" (p.26) and, thus, reach a wider audience. Museums can reduce the barriers and provide tools to enhance participation opportunities for people with disabilities. As such, institutions and non-profit organizations can work together to proliferate best practices and meet the needs of diverse audiences. As technology opens up new possibilities for visitors to access museum collections and facilities, museums have adapted technology-driven techniques to accommodate the needs of children with autism. The goal of such techniques is to ensure that the visitors will get the most benefit out of their museum experiences. These additional resources help such children and their families to access and navigate the information beforehand, and to become familiar with the museum experience. Web-based museum resources are the simplest way of encouraging a connection with the collections and facilities (Langa *et al*., 2013) (see http://www.vam.ac.uk/moc/learning/sen/visiting-autistic-child/). Those materials may include a pre-visit visual schedule, directions, museum maps, social stories, and sensory tools, as presented in **Figure 9**.

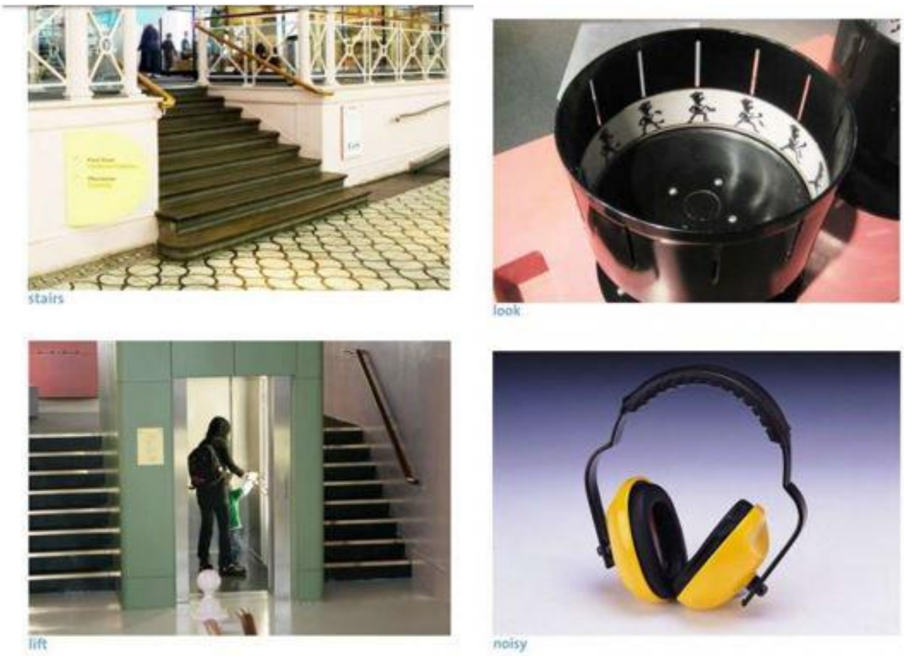

Figure 9 Pre-visit materials booklet from the V&A Museum of Childhood.

One recent attempt to achieve this was undertaken by Swartzenberg (2019), who developed a prototype-app called *Sense-Ease: Strong Museum*. The app focused on children with autism, aged from 4 to 12 years of age, and helped them prepare for a museum visit by offering a sensory-friendly experience. Data were collected through two rounds of user-testing interviews and surveys; the first was with a general audience, and the second was with two families with children with autism. While the findings were preliminary, the study highlighted that the app had immense potential to help reduce the sensory overload children with autism might experience during such a visit, thus making it a less stressful experience. The participants also had suggestions for improvements, such as Bluetooth beacon notifications to provide information about the museum exhibits and sensory information about what to expect in each area, as well as the possibility to choose content based on their age range. However, it seems that the present study was only in the initial stages and due to the number of participants, the findings cannot be generalized to a typical museum experience.

Another example is the *We the Curious* museum in Bristol (UK), which, in 2018, launched a virtual reality (VR) tour as part of World Autism Awareness Week. The virtual tour was a collaborative project involving academics, a special educational school, and technologists. A VR experience was built to help children with autism plan their tour in advance. To help make the visitors' experience enjoyable, the virtual tour included information on exhibits, spaces, and the facilities, while a 'virtual experience' was provided as a means of setting expectations about what the visit would provide, as presented in **Figure 10** (http://www.govirtually.co.uk/3d-model/we-the-curious-virtual-tour/skinned/). The use of the virtual reality (VR) has been assessed involving a pre- and post-test questionnaire (Newbutt, 2018). The study included 11 children with autism who were invited to use the VR experience in a school setting before and after the real visit. The findings revealed that the VR tour helped the children know what to expect before they visited the real-world museum. The participants reported positively on the app helping them be calm and reduce feelings of confusion and stress when visiting in real life. The data suggested that visualizing the space environment in advance improved the participants' conception of where artefacts were placed and contributed to them becoming familiar with the spaces.

Figure 10 Preparation for the visit by Virtual Tour.

Within this context, a museum in Santa Barbara in the United States of America has designed a sensory-friendly app for visitors with autism (MOXI, 2019). The app includes information about the exhibits, features such as a sensory- friendly map, and suggestions on how to prepare for their visit. Meanwhile, a cohort of Chicago museums has developed an app to familiarize the children with the environment. The app was developed based on the different characteristics presented by children with autism.

Each level of the museum provides information about calm areas and indicates where tactile interactions are located (Iyer, 2017). In addition, it provides a selection of verbalization buttons for those with limited verbal abilities, as well as the use of a visual schedule so the visitors can tick off each exhibit they encounter.

In drawing the main conclusions from the review presented, this section has highlighted how a wide range of today's digital platforms has made museums change the way their collections are exhibited to the public and, as such, have offered new ways of effectively engaging visitors with the museum artefacts. Museums have taken initiatives to improve their provisions and accessible services have been integrated into their resources. To ensure access to these services, the current adjustments and provisions need to be transformed and should target the main challenges, such as sensory responsivity, social interaction, communication, and stereotypical behaviours, that have been identified as key factors; as this can influence the involvement of children with autism in recreational activities, such as museums.

Although accessibility and inclusivity have been topics of great interest, studies relevant to the impact of digital experiences and outcomes on children with autism are scarce. The review of work presented, so far, has alighted upon initiatives creating digital services for children with autism. In particular, it has focused on how such services can help children with autism through previewing the museums and by providing information about the exhibits so that can prepare for their visit. Considering the children's abilities, the delivery of digital services is a complex issue and requires careful consideration at the design stage. However, a visitor-initiated understanding offers new approaches and is an important practice in identifying and evaluating what is appropriate and, hence, to effectively embed it in the technology.

The following section addresses the gaps identified in the literature that are relevant to the present study.

2.5 Gaps in the knowledge

This review of studies in different fields (autism and technology, participatory design practices, and museum practices for children with autism) has sought to highlight gaps in the existing knowledge and link these with the present study. The analysis of the literature has highlighted that technology-based programmes can have great potential as effective tools for children with autism. The studies analysed interactive multimedia to explore the impact of touchscreen-based technologies on skill acquisition.

In terms of designing such interfaces for people with autism the field to date has several limitations. The studies, which reported positive effects of touchscreen devices, rarely provided insights into the design process and how the app was developed. Aspects such as these seem to be problematic because this means that "the voices and experiences of those who, by definition, experience the world differently" (Parsons *et al.,* 2019, p.3) are likely to be excluded while further insights to enrich our understanding within the context of designing an interface may be missed. To provide effective products, it is necessary to move beyond narrow research- orientated perspectives and, instead, follow, as Parsons *et al*., (2017) argue, "multi-dimensional and holistic ways of researching and understanding how and where technologies can be used, developed, and evaluated" (p.116). This means that a design experience should be influenced by user-centred practices, while collaboration and consultation among multidisciplinary stakeholders from diverse backgrounds are essential. This interdisciplinary collaboration is likely to contribute to a wide range of views and shape technology in a range of ways. It is one way to address the lack of knowledge and explore further both the children's profiles and the available technology to develop programmes specific to the preferences of the users. To date, there has been little discussion, and these studies have involved indirect proxy users such as teachers or parents. Nevertheless, often research conducted in this field employs short iteration cycles regarding the interface design. Studies tend to include groups of children with autism that are high functioning with verbal communication skills and who can provide articulate feedback to designers/researchers. Thus, the involvement of children with autism and input on the medium spectrum is worth examining. This area remains relatively unexplored, which is an issue the present study will try to address.

Throughout the review, it became evident that the majority of the studies had focused on evaluating the effects of the apps. While details of the activities and how children with autism engaged with a technological programme are limited; links between design and technology features, that may be beneficial regarding their use for children with autism, have rarely been discussed. Authors have stressed the importance of ensuring high quality in the technological design by considering the value of the most effective features that may provide accessible and usable technology (Fletcher-Watson, 2014; Wainer and Ingersoll, 2011, Pennington, 2010). The analysis of the literature review has also highlighted a lack of a holistic approach, one employing a variety of sources and approaching the problem from different perspectives to evaluate a technology-based programme for children with autism. This approach could bring about data consistency and offer a better understanding of the results and limitations. This study will try to address this gap.

The intrinsic role in museums to be socially inclusive and engage populations of individuals with special needs reflects the focus of the present study. It became the inspirational factor to examine the benefits of a museum visit for children with autism using a technological mediating tool. In the studies reviewed, scholars have investigated the role of touchscreen applications in a classroom or laboratory setting; however, limited evidence exists on evaluating an app outside of formal settings. Therefore, there is a need to narrow the gap in the existing knowledge by exploring the effect of a co-designed museum app on the behaviour and engagement of children with autism.

The review has highlighted the current museum initiatives to broaden the accessibility for children with autism while reviewing studies that have centred around the outcome of a direct museum experience. Nonetheless, research on the role of digital platforms for children with autism and how these tools can be embedded into museum practice is rare as are studies examining the effectiveness of a museum visit through parents' perceptions. Thus, there is scope for adopting an inclusive approach and thoroughly investigating the needs and interests of children with autism by gathering their own perspectives and embedding their input in the final design. It is also necessary to consider the children's viewpoints in terms of the museum experience through the lens of a digital tool. Adopting a social model of disability, this study will endeavour to apply a person-centred approach to better understand the needs of children with autism when using digital services in a museum environment. This is an attempt to shed light on an overlooked subject area and to pave the way for making a museum visit an enjoyable experience for children, and one that is aligned with their needs.

2.6 Research Questions

The review of the literature undertaken in the Chapter 2 led to the exploration of the following research questions.

1. How might the involvement of mid-to-high functioning children with autism inform the design process of a museum-game application?
   1a. What are the benefits of the effective involvement of children with autism in the design of a museum-game app and what adaptations need to be considered throughout the whole design process?
2. Does the use of a co-designed game app contribute to bridging the gap between physical and digital spaces for mid- to high -functioning children with autism to encourage independent and social interactions in a museum environment?

2.7 Summary

This chapter provided a review of the literature across different fields. It started by providing a brief overview of current strategies that support the wellbeing of children with autism. It then reviewed studies in the field of computer technology and explored the affordances of touchscreen-based programs for improving certain skills in children with autism. Additionally, studies reviewed in the field of user-centred approach recognised the need of adopting a more inclusive approach. This approach weaves and facilitates the involvement of the children with autism to make their voices being heard. The children’s input and feedback at various stages of the participation is viewed as a valuable step to discover what their needs, and preferences are. The following section reviewed research on museum programs for children with autism and their families in the past years. The museums are seen to work towards creating inclusive activities taking into consideration the skills of children with autism. Following this, the literature review focused on digital services that are being developed and aim to broaden the access to diverse audiences including people with neurodevelopmental disabilities.

The following Chapter 3 discusses the research design along with the data collection and the analytic approach which was followed in this work. Details related to the participants in this study and how the study was conducted at different stages to address the research questions are provided.

Chapter 3

Methodology

Introduction

This research lies at the intersection between assistive technologies for children with autism, co-design and museum accessibility; hence, this chapter outlines and answers the challenges inherent in adopting a holistic approach that appropriately answers the research questions of the present study. This chapter aims to give an outline of the overall research design adopted in this study by presenting the nature of the study and the methodological approach followed. It is organised chronologically to reflect how this research evolved, and it comprises three main sections.

The first section begins with the study's position in the research and discusses the ontological and epistemological aspects underpinning the philosophical rationale for the current study. It then explains the research design and justifies the choice of a qualitative methodology, examines the different views and considers the understanding of how knowledge is constructed. This study adopted an interpretive approach, which allowed the researcher to be positioned within the research, recognizing the ways the research design was facilitated. It then describes the procedure followed for selecting the chosen settings and it discusses in detail the context of the school. Information about all the pupils[2] involved at various stages of the study are provided.

[2] Please note: hereafter, the children with autism who participated in this research will be referred to as 'pupils with autism' or 'pupils' to differentiate them from children with autism in general.

The second section describes the methodological framework employed and examines how the methodology informed the research design. It outlines how the research was conducted by involving children with autism and school staff in the design of the museum app. It presents the data collection and the subsequent data analysis. In the third section, the data collection sources and the reasons why these methods were considered appropriate for the evaluation of the museum visit are reviewed. The section that details the analytical procedure consists of two sub-sections. The first part gives the background of the analytical approach by representing the researcher's position, and the second considers in detail the method of analysis selected for each chosen methodology technique. The ethical considerations are also presented.

3.1 Philosophical stance: Ontological and Epistemological Assumptions

Kuhn (1962, p.viii) defined a research paradigm as "universally recognized achievements that for a time provide model problems and solutions to a community of practitioners''. Elaborated further, the research paradigm constitutes an overarching approach; it is a worldview that defines the nature of the world (O'Reilly and Kiyimba 2015). To conduct research, it is therefore important to include the following three philosophical components (see in **Figure 11**).

Figure 11 The interrelationship of the philosophical underpinnings of research paradigm.

- *Ontology*- What is the nature of reality?
- *Epistemology*- How can knowledge be obtained?
- *Methodology*- What procedures can be used to acquire knowledge?

Ontology and epistemology are aspects that are associated with a person's worldview of the nature of reality. They create a holistic picture of how knowledge is constructed, the methodological approaches used to uncover it, and how the researcher positions himself/herself regarding this knowledge (Cresswell, 2014; Crotty, 2003). Ontology is concerned with the nature of reality, that is, what kind of things exist in the world. In other words, ontology refers to *what is true* about the real world, and so, the researcher needs to decide whether the research is subjective or objective (Gray, 2014).

Epistemology, on the other hand, is "a way of understanding and explaining how we know what we know" (Crotty, 2003, p.3). This philosophical stance concerns the relationship between the researcher and what it is known in the field of study (Guba and Lincoln, 1989). The concept of epistemology also includes the techniques of knowledge production whilst the interaction with the participant is an important aspect of knowledge acquisition (O'Reilly and Kiyimba, 2015). The researcher's epistemological position determines how the knowledge is conceptualized. Furthermore, methodology is related to the distinct methodological procedures that the researcher will follow to explore human behaviours.

Research paradigms have been classified into three main philosophical perspectives: a) objectivist (or positivist), b) constructivist/interpretivist and c) critical postmodernist (Gray, 2014). Those three worldviews hold different stances, and they affect the way the researcher approaches the research. In this case, the researcher positions this work within the methodological framework of the constructivist epistemological paradigm. **Table 1** outlines the constructivist approach as applied in this study. It is classified into the nature of existence (ontology), the nature of knowledge (epistemology), the theoretical perspective, the methodology, and the methods of data collection employed.

Table 1 The research paradigm the study adopted.

Research Philosophy Paradigm	Ontology	Epistemology	Theoretical Perspective	Methodology	Method
Constructivist/ Interpretivist	There is no single objective knowledge	It is underpinned by interpretation and observation through human interactions. It uncovers the underlying meaning behind a social action.	Interpretivism	Grounded theory	Qualitative: Case study - In-depth study of events.

Emphasis was placed on capturing how people construct their own meaning and their knowledge of a particular situation by experiencing new things and then reflecting on those experiences within a real-life setting (Cresswell, 2014). The researcher's stance was not to have a passive role, but rather to be an active observer who has a direct involvement in the activities to identify the meanings of social actions. The RQs presented in the introduction chapter will help the researcher to focus on the reactions of the pupils and the analysis of their activities in formal and informal educational settings using a variety of tools for engagement.

The underlying philosophy of the ontological position of constructivism is that there are multiple realities, and they differ from one person to another. An individual's multiple realities are constructed through interaction with the real world (Gray, 2014). In terms of the interpretive epistemology, constructivism focuses on real world phenomena; the knowledge is elicited through the interaction between the researcher and the participants and is developed in a social situation (Gray, 2014). In this environment, the researcher is able to observe, collect, and interpret the data to derive an in-depth meaning from individuals' views and behaviours. Importantly, therefore, a constructivist approach is based on the examination of social phenomena in natural settings.

From the constructivist point of view, there is no real objective knowledge or truth; but rather, knowledge and truth are constructed by humans in groups via communication and interaction with the real world (Gephart, 1999). Cresswell (2014) highlights that constructivism aims to delve into *how* social realities are constructed in specific contexts and relies on the relationship between the researcher and the participants. Constructivism's emphasis is not on building a new theory; rather, the aim is to evaluate and clarify interpretive theories.

3.1.1 The constructivist paradigm in this study

The main aim of the present study was to explore two issues: 1) how to design a museum-game-based app for pupils with autism, and 2) how a museum-game app is perceived by pupils with autism in a museum setting. Having this as a starting point, the literature was reviewed to gather evidence from wide range of perspectives and sources and eventually the avenues were identified relevant to this study. Through this, the researcher found that the current research is imbued with unequal power relationships in which the representation of the experiences and knowledge of children with autism is limited or ignored. Due to this issue, this study aimed to explore the issues appropriately, as the emphasis was on working **with** rather than focusing **on** children with autism, as the pupils were involved at all stages of the research. The pupils' views were considered, as they are the actual target audience of such technology-based programs, but to date, their involvement has been limited (Parsons and Cobb, 2011). To apply the constructivist concept in the context of this study, the researcher's role was that of an 'explorer', and the aim was to explore and interpret the truth from multiple points of view. The term 'explorer' in this context has some similarities with the Florian and Hegarty's (2006) definitions about how technology can be used, as discussed in the literature review chapter. In both contexts, 'explorer' is about the active construction of knowledge and meaning as the result of social interaction within the real world and upon the foundation of prior knowledge and new events.

As such, the study intended to examine how a group of children with autism experience and interact with a digital tool in a museum environment. In doing this, the use of different methods and interactions among the pupils helped the researcher in drawing attention to the pupils' desires and in capturing an overview of the situation. This study can be described as exploratory and interpretive in nature because it sought to investigate what happens in a real situation, to reveal the *subjects'* views and feelings of these experiences in the real world, and to make sense of the situation that emerged.

Another aspect that needs to be considered is the form of study employed. In this study, the approach taken is based on grounded theory; it was generated from the data and emphasised the issues that were important to the participating pupils. In this way, valuable insights were provided into the pupils' behaviours and social constructs by adopting a flexible approach. The knowledge was constructed by following inductive reasoning and gathering data to generate a theory. This means that the study started not by testing a hypothesis, but instead, the focus was on exploring the theory from a body of collected data and facts and then interpreting the participants' constructs. These constructs were critically analysed and reflected upon to identify the claims, factors, and concerns, and to develop a coherent narrative (Simons, 2009).

3.2 Research Design

A research design refers to how a study is being conducted. It is the logical sequence that combines the research study's components with an endeavour to answer the research questions of the given research problem (Gray, 2014). These include the purpose of the study, the literature review, the strategies used to select the sample, the tools for gathering data and the methods selected to analyse and interpret the empirical data (Thomas, 2016; Gray, 2014). The present research was conducted in several stages. **Figure 12** shows, the steps of the methodology design plan adopted for the study.

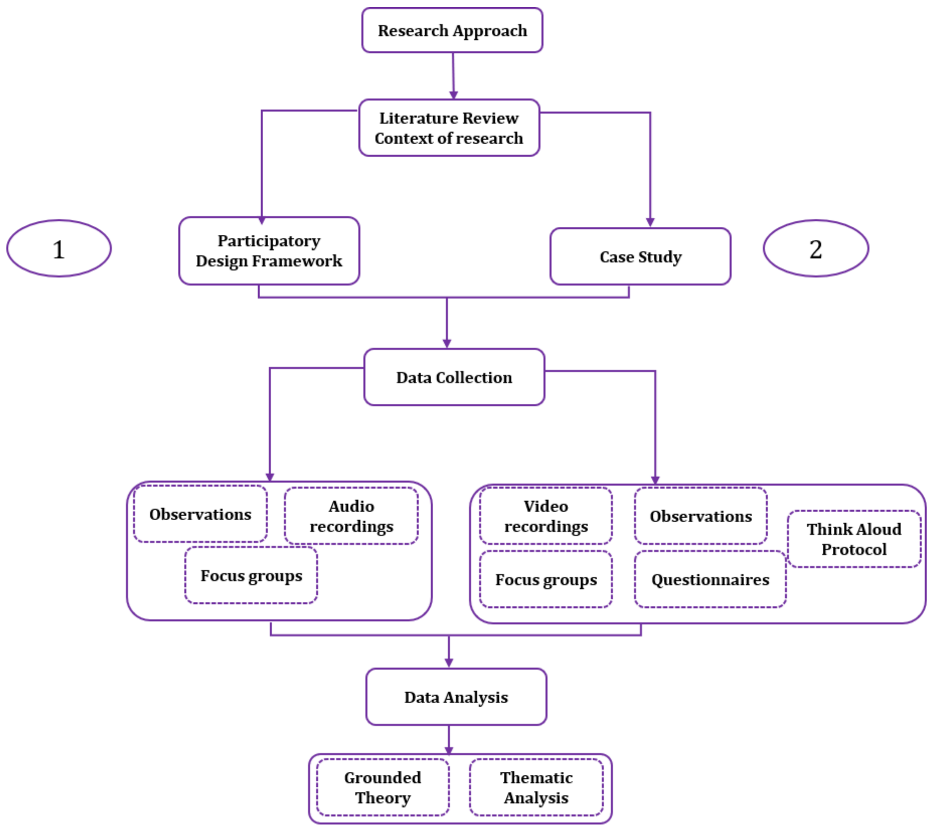

Figure 12 Overall outline of the research methodology undertaken.

Depending on the nature of the study, the researcher can choose different methods of inquiry to answer the main research questions and accomplish the research aims. Due to the focus of this research (i.e., value in recognizing the perspectives and inputs of children with autism as data) and its several questions, this research has employed a qualitative research approach. An extensive literature review of the best practice of design guidelines, and the context and a review of recent studies underpinned the study. This helped the researcher to expose a gap in the knowledge in this field and to find some practical and successful solutions to the identified gaps. The design and development of the app was carried out in accordance with the knowledge generated from the literature review (Appendix A) and the recommendations derived from the participants (pupils with autism and their teachers) (Chapter 4). Next, data collection and analysis were conducted in the museum setting to examine whether the intended aims and objectives had been achieved.

3.2.1 Qualitative Approach

The qualitative research method is an approach that places significant emphasis on gaining a "deep, intense and holistic overview" (Gray, 2014, p.160) of the topic being studied. The underlying approach requires an in-depth observation and explanation of the dynamics of social relations, which enables the researcher to yield information related to real experiences.

Flick (2014) stated:

> Qualitative research is interested in analysing subjective meaning or the social production of issues, events, or practices by collecting non-standardised data and analysing texts and images rather than number and statistics (p.542).

This definition emphasizes how people make meaning of something and that it is closely linked with multiple aspects of reality. As the social world is complicated, the researcher's responsibility is to explore and understand the various systems of meanings. Given the accepted notions of ontology and grounded theory, the qualitative method seemed to be the most appropriate in this study. It is a naturalistic research method, as it seeks to capture data that come from 'real-world settings' (i.e., a classroom and a museum), and it involves direct contact with the participants (Bryman, 2016). In this study, the researcher had face-to-face interaction with the pupils, while observing them with the aim of making sense of the multiple interpretations. The direct contact helped the researcher understand a group of pupils with autism and the social contexts within which they experience new things. Qualitative research has its philosophical grounding within the interpretive paradigm which means the researcher maintains the focus on "learning the meaning" (Cresswell, 2014, p.186) of the participants. As such, it reviews various forms of data and then provides verifiable results. However, as the sample size is often small groups of people, it is difficult to generalize the findings, and the results it generates can take the form of words rather than numbers. Therefore, in this study, the researcher's role was to develop an in-depth overview of the issue by incorporating multiple views and factors regarding the complexity of a museum environment, and afterwards to construct larger knowledge assertions of the topic (Gray, 2014; Cresswell, 2014). Investigation of the participants' views and experiences on aspects of the research helped their voices be heard. To do this, the research participants were encouraged to be more reflective on a particular situation.

Despite the usefulness of a qualitative research approach, Bryman (1988) discussed the limitations of adopting this approach, noting:

> The commitment to explicating the subjects' interpretation of social reality is a (one might even say 'the') *sine qua non* of qualitative research (p.71).

In other words, in a qualitative approach, researchers adopt a stance that explicitly focuses on their participants' interpretations of social reality; however, one concern is how to evaluate the validity of their interpretations. Qualitative research has been criticised as being subjective as its research quality is dependent on the researcher's skills and is influenced by the researcher's personal predispositions and biases. This occurs because researchers are frequently in close contact with the people being studied. The lack of repeatability of a qualitative study is regarded as one the main limitations as it may not give consistent and reliable data (Bryman, 2016).

3.2.2 The Rationale of Case Study and Research Procedure

Case studies have been long established in the psychology, sociology, and education domains of research as a versatile form of qualitative enquiry for presenting a detailed analysis of a social phenomenon (Thomas, 2016; Cresswell, 2014). Simons, (2009) refers to this method as an empirical inquiry that provides new insights, and its main purpose is:

> to generate in-depth understanding of a specific topic (as in a thesis), programme, policy, institution or system to generate knowledge and/or inform policy development, professional practice and civil or community action (p.21).

In case studies, the integration of different opinions and perspectives can develop a rich understanding of the complexity of a single case in a real-life situation. Applying this definition to this research, the terms 'real life' and 'context' have a crucial role. This might be achieved through an in-depth exploration and from multiple perspectives. According to Thomas (2016), case study research encompasses two main principles: a) the subject (e.g., children with autism), and b) an object or an analytical frame, (e.g., using the app in a museum setting) (see **Table 2**).

Table 2 The main two parts of the case study as indicated by Thomas (2016).

Thomas Principal (2016)	Present Study
Subject	Children with autism
Analytical frame or object	A case study analysis of the use of an iPad app in a museum setting

To capture the interrelationship between the phenomenon and its 'real life' context, a case study methodology was selected as the most suitable research methodology for this specific investigation. As the nature of the present research is exploratory, a case study is viewed the best research design frame to answer to 'How?' and 'Why'? questions, so these two additional factors determined the reason why the case study was regarded as the most appropriate approach. Hence, a case study methodology was adopted to create a rich and holistic account of the particular phenomenon of a museum visit for pupils with autism by "using different kinds of data collection and gathering views, perceptions, experiences and/or ideas of diverse individuals relating to the case" (Hamilton, 2011, p.1). The case study methodology was considered appropriate to answer the study's research questions about the experiences of the pupils using a software program as a medium to explore and engage with the museum artefacts. By focusing on interpreting the diverse views, omissions, and contradictions, the aim was to understand the dynamic features of context or situation and investigate and report the complexity of the experiences of pupils with autism in a museum environment.

In fact, a case study whether it uses single or multiple cases, entails in-depth knowledge of a small sample of a situation and can maintain a "chain of evidence" (Yin, 2009, p.3). Due to limited research existing in this field and the nature of the research questions, this study has focused on empirical evidence (knowledge acquired by means of observation and experience) and has employed a single case study design to explore the views of pupils with autism and their experiences using an app; this is a field where, to date, knowledge has been scarce.

One of the advantages of a single case study is that it offers the opportunity for testing and confirming a theory (Yin, 2009). Generally, in social research, three kinds of case study subjects are distinguished: 1) outlier, 2) key, and 3) local. Each type has different purposes and leads to different routes depending on the researcher's interests and limits (Thomas, 2016). The present study's emphasis was on a key case subject, which examined an ideal case in depth. Thomas (2016, p.113) argues that the research is also determined by "the purposes, approach and process" that the researcher should take after deciding on the subject. All of these are connected with each other, but they are categorized separately. Based on Thomas' (2016) categorization of case studies, this study, as shown in **Table 3**, can be described as exploratory (purpose) and interpretative (approach), since it seeks to investigate in depth *what* is happening in a real situation and why and to uncover participants' views and positions regarding those experiences. In terms of the process, a simple case study was conducted with two classes as nested units within the school.

Table 3 Mapping out the design of the case study adopted in this research project, as applied by Thomas (2016).

Subject	**Purpose**	**Approach**	**Process**	
Key case	Exploratory	Interpretive	Single case	Nested

The characteristics of a case study paradigm mean it has a number of limitations. The 'too subjective' criticism seems to have a negative connotation in case study research as it "interferes with, prevents, or inhibits having true, genuine knowledge" (Schwandt, 2001, p.16). Therefore, the study has less scientific value. Guba and Lincoln (1981) referred to this as:

> the unusual problems of ethics. An unethical case writer could so select from among available data that virtually anything he wished could be illustrated (p. 378).

An attempt to eliminate subjectivity is not necessarily the most relevant approach in qualitative inquiry, but rather, authors argue that it is important to know how the researcher's values, preconceived views, and feelings that may influence the research (Simons, 2009; Schwandt, 2001). The goal then is to acknowledge when subjectivity is a positive force, as it can lead to understanding and insights, and when it might be negative, as it can lead to potential bias. This issue of bias is explored in detail in the section discussing ethics. Further limitations involve the issues of reliability and validity, and whether generalization is fully considered either in the natural or social sciences. Given that qualitative research focuses on a specific phenomenon, one issue that arises is the lack of generalizability and how a single case study can produce data that can be transferable to other situations (Yin, 2009). As Hamel (1993) observed:

> The case study has basically been faulted for its lack of representativeness... and its lack of rigor in the collection, construction, and analysis of the empirical materials that give rise to this study. This lack of rigor is linked to the problem of bias... introduced by the subjectivity of the researcher and others involved in the case. (p.23)

The problem with reality in the social science field, Thomas (2016) argued, is that "such expectations are unrealis-able" (p.69) when reflecting on human interrelationships. One approach to considering generalizability for case study research is through analytical generalization. The strength of the case study is that it allows the exploration of real-life situations and validates the participants' views directly in relation to several phenomena. The established theories act as a basis to cross compare the empirical results of the case study. However, in the present study, the endeavour was not to make generalisations but rather "to try to attribute causal relationships" (Gray, 2014, p.266) and to emphasize 'particularity'. To address these limitations, it was decided to extend the methodology to include the teachers' views and the researcher's personal reflections as having the role of the 'explorer' throughout the study. Through this, the researcher described in depth the developed themes were described in depth and were explored from various angles.

3.3 Selection of study sites

The involvement of different key stakeholders was essential to the implementation and success of the present research. To do this, in the first year of the study, initial contacts (via email) were made with potential key stakeholders in the area of Bristol. Links were established with local schools and specific services to children diagnosed with autism and with museums that promote education. These links and relationships allowed the potential participants to have input into the design process and evaluation of the app. In order to conduct the study, it was necessary to recruit a group of pupils with autism whose school and guardians/parents were willing to support the present study and allow the pupils to visit the museum. For the selection of the school, the researcher contacted ten special educational needs schools were contacted in Bristol via email with a request to arrange a meeting about a potential collaboration in the current research. **Figure 13** shows in detail the process and the time frame through which the case study school was selected. Only two schools out of the ten showed an interest in hearing more about the project, so meetings were arranged with both schools to discuss their potential participation in the proposed research. Following this meeting, one school remained interested in the study; the other school was excluded because it failed to meet the inclusion criteria (i.e., a class with children with autism). In this meeting, the representative of the school and the researcher established that the development of a museum app and its use in the museum would be a beneficial experience for the pupils involved.

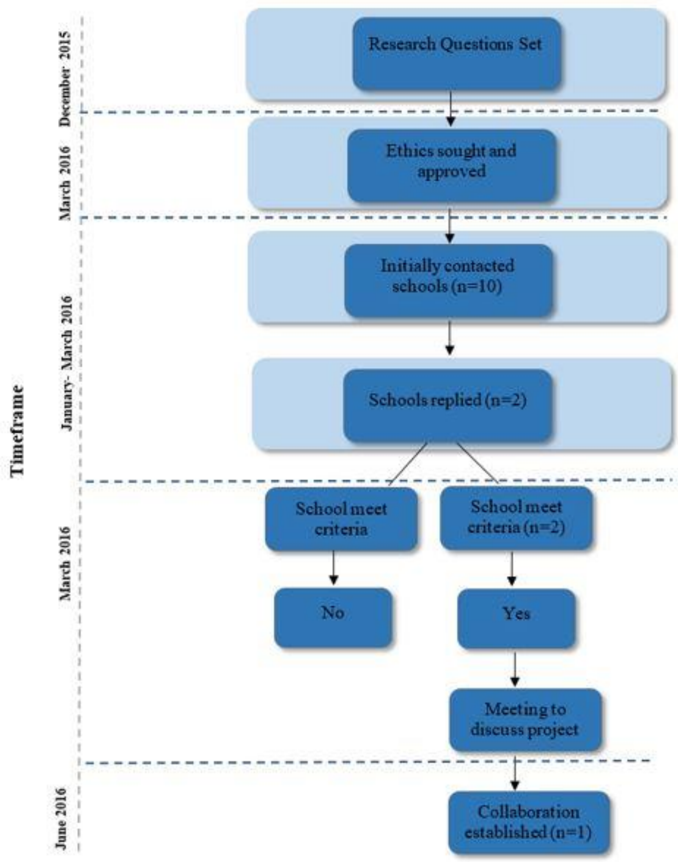

Figure 13 The process of finding the school of the case study.

Prior to the start of the study, the researcher visited the school to discuss the rationale and aims of the study with the teachers and to observe and interact with potential participants. As autism covers a broad range of symptoms and severity (American Psychiatric Association, 2013), pupils diagnosed with high to mid- functioning autism were nominated by teachers following the guidance the researcher provided. The guidance included the requirement for the potential participants to be able to work independently and based on the inclusion criteria initially established for this study. The stakeholders in this study included the participating pupils, special educational needs teachers, the design team, and the researcher with her supervisory team. Inclusion criteria for selecting the pupils to participate in the research were as follows:

- having a formal diagnosis of ASCs
- aged from 10 to 13 years old
- being familiar with electronic devices
- having functional language ability
- being able to participate in the museum visit
- having motor skills to interact with technology programs

Meetings with the Head of Transformation at Bristol City Council and the researcher were organised to make the proper arrangements in terms of selecting the actual site. According to the schoolteachers, the museum professionals, and the principal investigator, the M Shed museum met the criteria for inclusion in the study established in the planning phase, and it was chosen as the research site where the case study would take place. One of the reasons for selecting this museum was because of the museum's architecture. Research highlights that the physical design of buildings plays an integral part in ensuring a museum experience that is "conducive to the learning, enjoyment, and comfort of all visitors, including young children" (Piscitelli, p.42). M Shed museum was seen to provide a welcoming environment, with signposts to help visitors find their way about. The museum also considers a range of modes of learning, such as visual, auditory, tactile, and kinaesthetic, while it provides opportunities for exploration between interactive and static exhibits. **Figures 14-15** are photographs of the museum's internal space of the ground floor. To lay the groundwork for the present study, the researcher established a partnership with the M Shed museum team, which facilitated a continuous collaboration throughout the study.

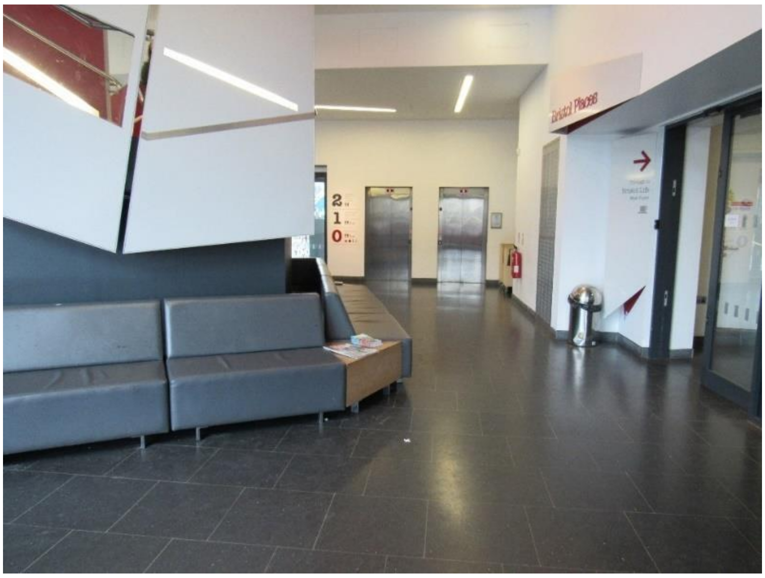

Figure 14 Views of the entrance of 'Bristol Places' gallery on the ground floor of the M Shed museum (Photograph: Dimitra Magkafa, March 2018).

Figure 15 View of 'Bristol Paces' gallery on the ground floor of the M Shed museum (Photograph: Dimitra Magkafa, March, 2018).

3.3.1 Description of the research sites and context

As described above, the study was undertaken in partnership with a local museum and a special educational needs school in the Bristol area. This school was purposefully selected for data collection because of its proximity and its specialization in children with intellectual disabilities. Yin (2009) addresses the importance of proximity, as it helps the researchers to have a "prolonged relationship" (p.93) with the case. The chosen school includes different types of special educational needs; it focuses on behavioural, social, and emotional difficulties; speech and language communication needs, and moderate learning difficulties. It is a well- provisioned school with an interest in collaborating in research projects. **Figures 16-17** depict the layout and the setting of the classroom sessions and reflect the school's OFSTED report (2014, p.1[3]) which states that "in this very well-resourced school, pupils in all key stages make good progress and achieve well". It was clear that the pupils learn well, and this is helped by the encouraging atmosphere of the school.

[3]OFTSED is a non-ministerial department of the UK government and its role is to inspect, regulate and provide reports about the quality of educational institutions and children's social care services in England and Wales.

Figure 16 Classroom layout.

Figure 17 Example of pupils working in the ICT class.

The school caters for children from Bristol's most deprived areas. According to Bristol Council's report (2018), Bristol is "a city of contrasts with deprivation "hot spots" (p.3) including 42 areas in the most deprived 10% in England. Minority ethnic representation is low with one in five pupils attend this school. The school's programmes are varied with particular focus on “spiritual, moral, social and cultural development” (OFSTED, 2014, p.4).

M Shed museum is a local museum that represents Bristol’s history. Its doors opened in 2011, and it is situated in the Bristol’s historic Harbour-side. The museum’s mission focuses on four main principles, namely being: 1) excellent, 2) inclusive, 3) resilient, and 4) valued. Its vision is to “deliver, facilitate and support cultural activity in Bristol” (M Shed, n.d). By presenting and sharing its knowledge about the city’s past, the museum aims to represent a cultural offering in the city. In terms of its content, M Shed represents Bristol’s history over the centuries and houses approximately three thousand artefacts, ranging from prehistoric times to recent advancements in the 21st century. The visitors can uncover stories of Bristol and its people at different times in the city’s history, such as the transatlantic slave trade, war-time experiences in the First and Second World War, as well as stories from people who lived in the city. Its uniqueness lies in the fact that there is a collaboration with local people and communities to create stories about everyday life and people’s experiences.

3.3.2 Participant Information

This section provides data about the Statements of Special Needs, and information about the age and sex of the pupils (based on assessments taken in 2017). In setting out ethical guidelines, the British Educational Research Association (BERA) highlights that educational researchers need to conduct research in an inclusive manner (BERA, 2018). It was considered an important part of the inclusive approach in this study to include pupils who did not meet the criteria that this study had established initially. Thus, while the majority of the pupils have a formal diagnosis of autism following the DSM-IV criteria, other pupils included in the study had diagnoses of Attention Deficit Hyperactivity Disorders (ADHD), Foetal Alcohol Disorder (FAS) and Pathological Demand Avoidance (PDA) in addition to autism. The data below provide insights into the case study group involved in the co-design sessions (stage 1), the user testing, and the museum visit along with their confirmed Statements of Special Needs. This information was provided by the teacher (Oliver) and presents pupils’ skills levels throughout the academic year 2017-2018 (the year this study was conducted). More specifically, **Table 4** presents data on four subjects, namely, reading, writing, speaking and listening, and ICT, and provides a picture of the pupils' achievements across all areas of the curriculum. The National Curriculum is divided into four Key Stages:

Key Stage 1: Ages 5-7

Key Stage 2: Ages 7-11

Key Stage 3: Ages 11-14

Key Stage 4: Ages 14-16

Table 4 The demographic characteristics of the case study group and the Key Stage levels expected 2017-2018.[1]

Participants	Stage 1 Codesign sessions	Stage 2 Evaluation in the museum	Status	Child age (years)	Reading	Writing	Speaking - Listening	ICT
Charlie	√	–	ASCs	12	2A	3	4	3
Aisha	–	√	MLD[2]-ASCs	15	2A	2A	1	1
Hanna	√	–	ASCs	10	2B	2C	3	3
Charlotte	√	√	ASCs	12	2C	2C	1A	1
Tina	√	√	FAD[3]-ASCs	13	2A	2B	2B	2
Chloe	√	√	ASCs-OCD[4]	12	4	3	3	3
Bruce	√	√	ASCs-ADHD[5]	13	2A	2A	5	3
Samira	√	√	ASCs-PDA[6]	12	3	2A	3	3
Rob	√	√	ASCs	13	2A	2B	2B	2
Tom	√		ASCs	13	ADULT	5	5	4
Matt	√		ADHD	13	5	4	5	3
Jason	√		ASCs	13	3	3	3	3
Andrew	√		ADHD	13	4	4	3	1
David	√		ASCs	13	1B	1A	3	2

[1]Those participants with numbered footnotes had an informal diagnosis but are on the spectrum through the local school reported diagnosis.
[2]Moderate Learning Difficulties.
[3]Foetal Alcohol Disorder: Foetal Alcohol Spectrum Disorders are a group of conditions which describe people with alcohol effects. It is a lifelong disability and its effects can include physical and mental problems (CDC, 2019).
[4]OCD: Obsessive Compulsive Behaviour
[5] ADHD: Attention Deficit Hyperactivity Disorder

[5]PDA: Pathological Demand Avoidance

From the table, it can be seen that while many of the participating pupils were below the National Curriculum and Key Stage standard levels for their age, Matt and Tom seemed to have reached and even exceeded the expected level for the group. While the majority of the participants fell under the inclusion criteria, as discussed previously, there were a few who were neither within the age range nor had a formal diagnosis of autism. In consultation with the teachers and the school, the decision was taken to include these pupils due to the issue of equity and fairness. Integrating the principles of equity and inclusion, the intention was to value the presence and the equal participation of all pupils regardless of their personal characteristics and also include a diverse group. This study tried to include all the pupils, as according to the teachers, all of the potential participants exhibited autistic traits but some of them did not have a formal diagnosis. **Table 5** also presents the demographic information for those who participated in the usability testing session.

Table 5 The profile of participants during user-testing.

Participants	Diagnosis	Age	Reading	Writing	Speaking &Listening	ICT
Eleni	MLD	12	1B	1A	P4	1
Franjesca	ADHD/ASCs	8	2B	1B	1C	1
Sergio	ASCs	11	3	1B	1C	3
Iris	ASCs	11	2B	2A	1C	2
Yianni	ASCs/Attachment Disorder	12	2C	2B	1C	P4

3.4 Case Study Procedure

This section describes the research design adopted to conduct the case study. The elements covered in this section include the planning phase, the data used to address the research questions and the objectives of the study.

3.4.1 Planning Stage

In this study, two classes of pupils with autism, from Key Stage 3 (KS3) were assigned to participate in the study. The classes (Blue Class and Green Class) were chosen by the school staff based on the criteria established previously. The children's ages when the study started ranged from 10-13 years; there were 5 female participants and 8 male participants. Members of the school staff (four in total), comprising teachers and teaching assistants, who were familiar with the pupils, were present in the sessions. The pupils had a wide range of cognitive and language difficulties. The research design consisted of several steps which are illustrated in **Figure 18.**

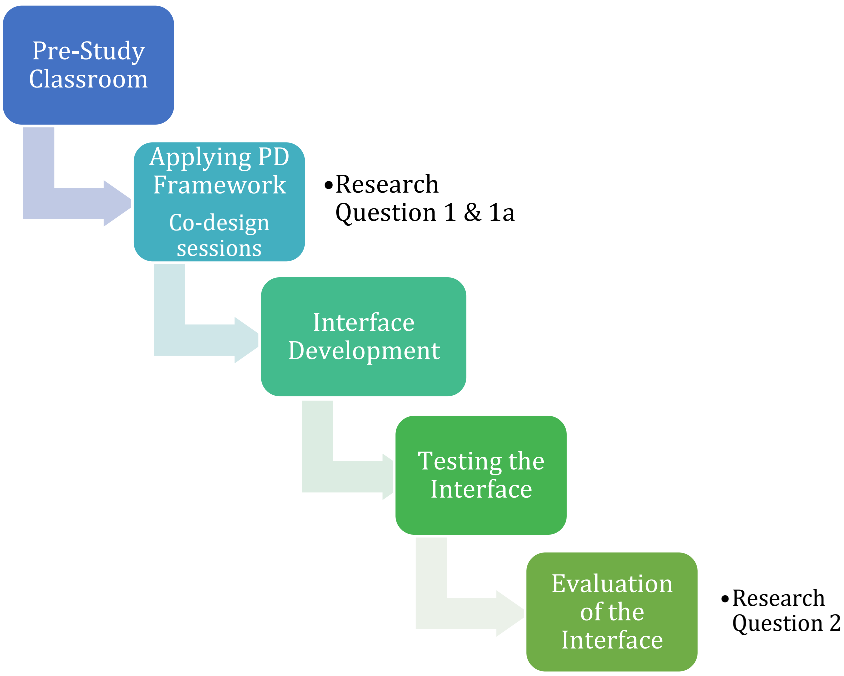

Figure 18 Steps undertaken in the case study.

This stage of the study involved pre-study observations of the classes the researcher was planning to work with. To become acquainted with the research site, the researcher observed a series of ICT classroom activities. The researcher attended the pupils' ICT lessons one day a week and the period of the observations lasted from September 2016 to February 2017. These observations were considered important for several reasons. They allowed initial access to the potential research participants, and the researcher to identify whether the pupils might have the appropriate ICT skills for interacting with input devices. Establishing a rapport with the pupils is a prerequisite for and an essential component of effective intervention practices. As the focus of the research was on conducting research **with** rather than **on** children with autism, the familiarisation process enabled the researcher to establish initial relationships with the potential participants. These prior actions allowed the pupils to familiarise themselves with the researcher, which facilitated their early access to the project. The rapport-building process was also seen as important for reducing pupils' anxiety and for facilitating their communication skills throughout the study process. As the time progressed, the researcher engaged with the pupils in several of the activities the teacher requested them to carry out during the class. By becoming a familiar figure in the class, the researcher was gradually able to hold informal discussions with the pupils about the research project. Through observations, certain information was gathered that was relevant to the behaviours and interactions of each pupil within an ICT classroom context. At the beginning of these sessions, the researcher introduced herself to the pupils and explained to them her role as a researcher doing a project at the university and that their school had been selected to take part in this study. As discussed in Mayall's work, (2008), the researcher's position was as an adult who lacked knowledge about the status of being a child and so needed to collect the information with their help. During the sessions, the researcher became a passive member of the situation by taking notes. The time period of the observation lasted from September 2016 to February 2017. **Table 6** below summarises the researcher's notes on how the pupils responded to the teachers' requests in ICT lessons.

Table 6 Notes of pupils' behaviour during ICT class.

Potential Participants	Notes
Charlie	He works very well on ICT tasks without any prompting (such as locating identical items). He often asks questions (that are sometimes irrelevant to the activity) and seeks attention from the teacher. He was observed to bounce on his chair quite often or run around the classroom.
Aisha	She was not in the classroom when the researcher was doing the observations.
Hanna	She needs prompting to complete a task on the computer. If the teacher provides her with help, she can perform all the steps of the task.
Charlotte	She is very quiet and shy and is hesitant to ask or respond to any questions. If she cannot understand a task, she asks for additional help her. Her writing skills are quite limited, but she is good at using the mouse and completing simple tasks (drawing, connecting lines, or finding images on the internet).
Tina	She is easily distracted when she is working on a task. She is good at using the mouse and moving items from one side to another. She needs constant verbal encouragement to perform any action on the computer and if she feels overwhelmed, she quits and moves around the class.
Chloe	She shows independent skills looking for information on the internet and using Microsoft programs (Word, PowerPoint). She is able to complete all the activities well ahead. She is focused and quiet when she is working on a task. She has never needed any help or encouragement to work on something.
Bruce	He is working well in the requested activities. He likes expressing himself what he is doing to complete the tasks or asking further information about an activity. For example, he is able to identify differences and similarities in images but sometimes he needs extra help to progress to the next task.
Samira	She is very independent in working and completing an ICT task. Sometimes, she speaks out aloud her thoughts and she is very focused with the activities. The task about diversity and her illustration in the PowerPoint slide was well presented (really good at metaphors). She is not needing additional support.
Rob	He is keen on doing tasks on his computer. He shows independent skills in how to use different features of the Microsoft Word and PowerPoint presentation; sometimes even

	he is helping out his peers to complete the requested activities. However, he finds it difficult to concentrate on tasks if they take a long time. He is showing an obsession in drawing vehicles.
Tom	He has the ability to perform various actions in the computer (save, copy, paste, etc). He may need further instructions if he gets stuck with a task but, overall, he is quite independent.
Matt	He is quiet and is able to follow the instructions. He has the ability to use the computer, mouse, keyboard, and navigate the internet and manage the activities very well.
Jason	He works well and he is quick through a task. He is confident with the computer tasks and he is able to understand what he is required to do.
Andrew	He needs additional support to get started a task. He sometimes leaves the class if he gets stuck or refuses to continue.
David	He is always focused and able to work on the requested activities. He is able to deal with the instructions and complete the tasks without any further support. His ICT skills are excellent using the keyboard, the mouse, and various programs such as Excel (putting data into a basic spreadsheet).

3.5 Participatory Design Approach Procedure

The research data in the stage of the museum visit were derived from various forms of instruments to address different aspects of the topic under study. The main sources of evidence included the pupils from three different classes and the teachers and teaching assistants of those classes. These different perspectives were derived according to the different sources of evidence adopted. This stage of the thesis starts to address the following research questions:

1. How might the involvement of mid- to high-functioning children with autism inform the design process of a museum-game application?

1a. What are the benefits of the effective involvement of children with autism in the design of a museum-game app and what adaptations need to be considered throughout the whole design process?

To answer these questions, a review of the literature was conducted to identify any research related to design guidelines that could guide the development of technology programs for children with autism. As the focus was to generate input from the pupils, a PD approach was chosen as an appropriate way to conduct the study. **Figure 19** shows the PD approach as adapted within this study.

The literature review highlighted that the PD approach is a well-established methodology for gaining a deeper understanding of the needs of children with autism and obtaining possible ideas for application in technology design processes (Benton *et al.,* 2014; Frauenberger *et al*., 2013). To achieve this, that is, to enable the pupils to communicate their ideas and opinions, it was necessary for them to undertake an active role in the design process. Nevertheless, due to the difficulties that children with autism encounter with new situations, effective strategies had to be applied to increase their understanding (Turcios *et al.,* 2017) and so increase the likelihood of them engaging successfully with all the activities.

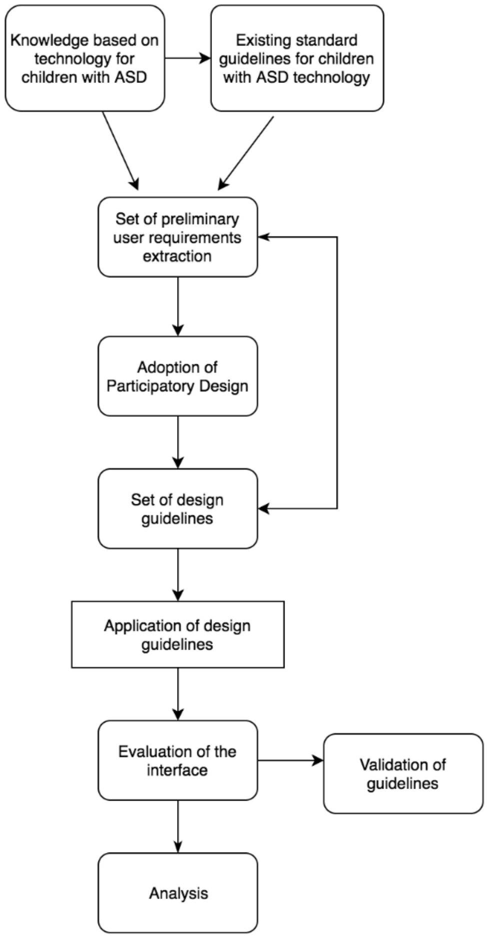

Figure 19 Methodology framework for this study.

Regarding this, the involvement of participants, including not only the pupils but also other stakeholders, such as teachers, was important from the outset of the study. A major advantage of the PD approach is that it gives a voice to end-users and other stakeholders at different stages of the design process to use the product, test the validity of the interface, and experience any software being studied (Muller and Druin, 2003). Given the time constraints of this project, the focus of this method was on eliciting responses from the perspectives of pupils with autism in terms of their interests and preferences in the design and functionality of the app. In this study, the term 'co-design' is used and refers to the active involvement of the participants in the design process; that means, the pupils with autism became a part of the process rather than giving their own feedback at the end. The different techniques and tools relevant to the chosen topic were intended to bridge the gap and to build an environment by eliminating the differences between designers/researchers and participants.

Furthermore, the familiarisation strategy resulted in the researcher being a familiar presence to the pupils during their involvement in the co-design activities.

As stated by Druin (2002), the level of the involvement of children varies, as it depends on the nature of the research. In this case, the pupils had two distinct roles throughout the design process: in the first stage, two groups of pupils were involved by assuming the role of informant and providing input, and in the second stage, an additional group of pupils was assigned the role of tester to inform the validity of the interface. **Figure 20** shows the break-down of the process (discovery stage) undertaken to determine the pupils' needs in terms of the design principles that needed to be embedded into the app. The number of pupils who participated in each co-design session ranged from twelve to fourteen (12-14). The decision to involve two groups of pupils was made in consultation with teachers; these only two classes of the school included pupils with an autism diagnosis; however, if one of them were excluded, the suggestions might have been limited, and this would have subsequently affected the design of the app. Including both classes led to the generation of ideas about the design of the app and made it possible to obtain an understanding of pupils' preferences and ideas.

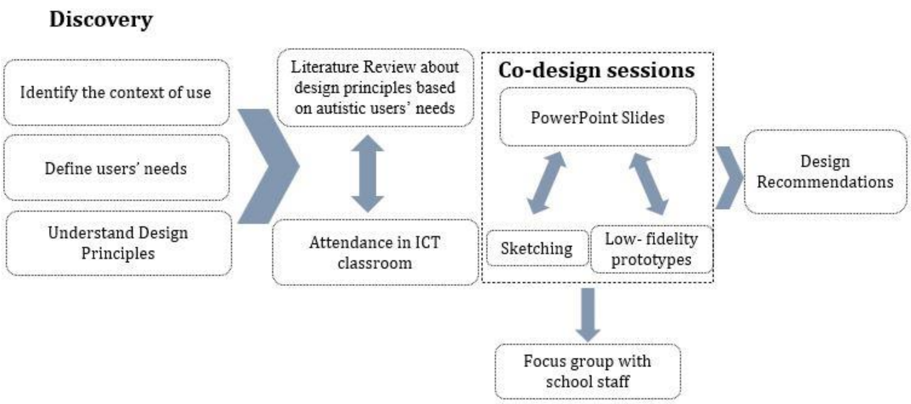

Figure 20 The procedure conducted to identify the pupils' preferences for the design of the interface.

The sessions were undertaken in a naturalistic setting, that is, in the pupils' classroom at school, as a class activity. In total, four co-design sessions were conducted, with each session lasting around 40 to 50 minutes. The sessions were led by the researcher whilst the presence of the staff members who worked with each class was necessary to help support the pupils and to explain the technical terms used.

Before the beginning of the activities, the researcher informed the pupils about the purpose of the co-design sessions and explained their involvement within the design process. The pupils were shown images of the museum and narratives to give them context and structure to the idea generation process as seen in **Figure 21**. The sessions were focused on designing a museum-game app as according to the teachers this would give a fun element to the sessions.

Let's design a fun game-app together for the M-Shed museum!

M-Shed is filled with bits and bobs from Bristol! Let's think what stories we can make together for the app.

Figure 21 Brief of what the pupils were shown in the beginning of the co-design sessions.

3.5.1 Data Collection Methods during the co-design sessions

According to the literature various techniques are available for conducting co-design activities with children (Fails, Guha and Druin, 2013). These techniques are design activities which are utilized at varying points and involve children and adults in the design process. Walsch *et al*., (2013, p.1) define a technique as a "creative endeavour that is meant to communicate design ideas and system requirements to a larger group". In this research, techniques were implemented to address the specific sub-goals of the study. Walsch *et al*., (2013) highlight that when children become involved in the design process, this necessitates "different lens to examine techniques and a framework needs to consider the different motivators" (p.2). Considering this, different techniques were selected based on a) the pupils' abilities, b) time constraints, and c) access to the pupils' classroom. In this stage of the study, data was collected through fieldnotes, audio recordings and focus groups to explore different aspects of the topic of interest as presented. To conduct the co-design sessions, different participatory techniques were chosen to capture the pupils' views regarding the usability of the interface and so determine the level of difficulty. These included: PowerPoint slides, brainstorming (sketching), and low-fidelity prototypes (Magkafa and Newbutt, 2018). **Table 7** presents the research questions of this study, the method of data collection, and what type of data was used in this stage of the study.

Table 7 The research questions of this stage of the study, the participants, the activities used, and the data collection techniques.

Research Questions	*Participants*	*Activities*	*Data Types*
RQ1 How might the involvement of mid- to high-functioning pupils with autism inform the design process of a museum-game app?	1 Pupils with autism	PowerPoint slides Sketching Low-fidelity prototypes	Field notes Audio recordin
RQ1a What are the benefits of the effective involvement of children with autism in the design of a museum-	1 Teachers		Field notes Focus group

game app and what adaptations need to be considered throughout the whole design process?

Field notes

Fieldnotes are viewed as an essential component of rigorous qualitative research, as they enhance the data and provide a rich context for analysis (Cresswell, 2013; Patton, 2002). Authors advocate that field notes help in building thick and rich descriptions of the topic under study and in documenting contextual data (Philippi and Lauderdale, 2018; Thomas, 2016). In this study, field notes were used for two reasons: first to identify how pupils with autism behave and interact when attending ICT classes and secondly, to reflect on the pupils' perceptions about the design of the app.

Focus groups (stage 1)

The researcher chose as a participatory generation technique in order to create an environment in which the pupils would feel empowered through the use of various activities (Thomas, 2016). Prior to each of the co-design sessions, the researcher briefed the pupils about the process and what they were intended to do. Following this, the pupils were encouraged to share their ideas and preferences in terms of the design of the museum-game app. In this study, school staff participated in a focus group with the purpose to generate their views on the success of the co-design sessions. The outcomes of this stage produced a set of design guidelines. The above methods provided the researcher with valuable insights into how the pupils engaged and interacted when they were involved in the technology design process. A focus group with the teachers of both classes was also undertaken. The session lasted for 30 minutes and included a brief introduction to explain the goals the research sought to achieve through these sessions and six questions related to the topic. The questions led to the discussion of some interesting aspects that the school staff pointed out about the structure and implementation of the co-design sessions.

Audio Recordings

As the researcher was the only investigator, throughout the co-design activities, the data were recorded on a digital audio recorder to capture the pupils' preferences and ideas (Thomas, 2016). Then the data were transcribed onto a sheet of paper as field notes based on what the researcher had observed as well as any difficulties the pupils had expressed or experienced. It should be mentioned that there was only permission to record the pupils' behaviours.

The next section considers how the case study in the museum context was conducted and what techniques were used to evaluate how the pupils perceived the museum visit through the use of the museum-game app.

3.6 Data collection of the museum visit

The evaluation of the interface in the M Shed museum was taken place in the third year of the study (March 2018). The combination of data collection methods was chosen to provide a coherent picture of the museum visit. The method of data collection instruments and the data sources along with the research question are presented in **Table 8**. The selected methods yielded insights of particular behaviours and elucidated actions from the perspective of the participants (teachers and pupils).

Table 8 The research question regarding the evaluation of the museum visit, the participants, and the types of data collection.

Research Question 2	*Participants*	*Data Types*
Does the use of a co-designed game app contribute to bridging the gap between physical and digital spaces to prolong and encourage independent and social interactions in a museum environment?	1 Children with autism 2 School staff	1. Observation 2. Questionnaire 3. Focus group 4. Video recordings 5. Think aloud protocol

3.6.1 Sources of Data

As the aim was to explore and discuss the views and experiences of pupils with autism and the perspectives of their teachers on using a museum-game app in a museum visit, qualitative methods were considered to best serve the purpose of the study.

Observation is indicated as one of the most common practices to gain knowledge, and it is undertaken when a case study is conducted in a real- space, offering important insights into the topic (Thomas, 2016; Yin, 2009). A major strength of this technique is that it helps in conducting long-term observations as well as recording, analysing and evaluating particular types of behaviours over a certain length of time (Cresswell, 2014). Yin (2009, p.110) argues that “observations of the technology” used by people are “invaluable” components for obtaining an in-depth understanding of the use and effectiveness of the type of technology being examined and the difficulties that may arise.

Considering this, the researcher’s role as a participant observer was to directly observe and collect data “in the natural setting of the case” (Yin, 2009, p.109). Observation in museums is recognized as an effective and reliable method for the collection of data about visitor behaviour, and it has been widely applicable in museum institutions and research studies (Charitonos, 2015; Moussouri, 1999). In this study, observation was an important part of identifying how pupils reacted and behaved while using an app in a new environment (e.g., a museum). In addition, observation of the pupils helped the researcher gain a better understanding of specific aspects of the visitor experience:

- to see how the pupils used the various elements of the gallery
- to observe whether the pupils were interacting and engaging with the exhibits and the app respectively
- to track the time spent in each spot and the pathways followed

The pupils had been informed about the researcher’s presence in advance to eliminate any distraction or discomfort; the researcher’s task entailed taking notes, talking to the pupils (upon request and agreement) and pinpointing unusual aspects first-hand at the research site. To validate and increase the reliability of the observation data, observation with video recording was selected to capture a social situation and record the pupils' perspectives (see below in image-based section).

The observation data included notes (see Appendix C), video recordings, and pictures taken during the museum visit. In total, four adults accompanied the pupils in the gallery during each visit: the researcher, one teacher, and two research fellows. An observation sheet was prepared for the visit, and this was used by the main researcher and the research fellows to track the pupils' actions. However, it was not possible for the research fellows to fill out the observation sheet, so it was decided that the research fellows should give an oral observation of what happened. After the sessions, the school staff verbally gave some general observations.

Image-based methods can be audio, visual, or video materials, and they offer a range of possibilities for the researcher. In particular, video recordings are widely embedded as a medium-research tool and provide a rich source of data (Thomas, 2016). Using recordings, the researcher can capture and have a better sense of human behaviour in a social context. Video data can also reveal insights into the degree of consistency between participants' self-reported behaviour and their actual behaviour.

Video recordings were conducted during the visit at M Shed museum. Recordings were made with a CANON SX530 camera used by two camera operators (research fellows) while the researcher was present to observe the pupils and take field notes. Meanwhile photographs were taken at the study site (M Shed) following the pupils' route. Photography was employed to supplement the field notes and assist in the analysis of the pupils' behaviour in the situational context. These data included narrative views and acted as observation techniques, which assisted the researcher in determining the pupils' attitudes (Cresswell, 2014). During the visit, the video recording lasted 1 hour and 30 minutes, including all the sessions with the groups.

***Questionnaires*,** which are a written form of asking questions, offer an efficient way of gathering data to triangulate research findings when used in combination with other techniques (Gray, 2014; Flick, 2014). The researcher intended to view the data in such a way as to identify associations and differences among the data as well as to challenge and reflect upon the data using other methods. In this study, five post-questionnaires were designed to be filled in by all the pupils and teachers as listed below:

a) A questionnaire (1) was given to the pupils to identify their experiences visiting the museum. This questionnaire was handed to the pupils after the visit and completed in the pupils' classroom (Appendix D).
b) A questionnaire (2) was structured to identify the effectiveness of the iPad app (Appendix E) and was given to the pupils in their classroom.
c) A questionnaire (3) of teachers' perceptions was distributed to the teachers via email (Appendix F).
d) At the point of testing the questionnaire, a usability-testing questionnaire (4) was given to a test group of pupils who did not later participate in the study to measure the usability of the app (Appendix G).
e) A usability- testing questionnaire (5) was used to find out the teachers' views on the usability of the app (Appendix H).

The questionnaires were modified based on the pupils' specific experiences and abilities. The questionnaires were piloted, and subsequently updated based on the advice from teachers of the individual pupils. This made for an authentic use of the pupils' data and ensured that the experience of the pupils whilst using the app and during the museum visit was reflected as accurately as possible, and in as nuanced a manner as possible.

In total, seven (N=7) out of seven questionnaires were gathered. For each of (1) and (2) questionnaires, the questions included a mixture of formats to capture pupils' experiences and perceptions as feedback of the visit, involving them in discussions and sharing their ideas and attitudes (Cresswell, 2014).

- closed (e.g., 'Do you have any favourite object from the spots you visited?')
- multiple choice (e.g., 'How do you think the children felt being at the museum?')
- rating-scale questions (e.g., I feel happy when visiting museums)
- open-ended questions (e.g., 'If yes, what was the most interesting thing you learned about your city?')

The use of different types of questions helped to improve measurement and ensure that the data gathered will answer the research question; the open-ended questions allowed the participants to freely answer the questions and provide further information about how they perceived the museum visit through a game-app while the closed-ended questions enabled them to easier select from a set of alternatives than to make an unstructured decision. By easing the format of the questions, the purpose was to increase the participants' enthusiasm for completing the questionnaires.

Focus groups (stage 2) are a common qualitative research technique, as they provide insights into participants' views, feelings, and experiences of the phenomenon being studied (Thomas, 2016; Gray, 2014). This method focuses on generating data through group interaction in which the researcher plays the role of facilitator (Thomas, 2016). Those who support the use of focus groups in social science research argue that focus groups provide the opportunity to ask participants to elaborate further upon their views Thomas, 2016). The intention is to capture deeper information from a chosen group of individuals about various subjects and situations. The teachers were invited to discuss a set of topics about the museum visit that were phrased as questions. The focus group also enabled the researcher to validate ideas and concepts about this topic of interest. At this stage, the researcher's role was to lead the conversation by asking questions and being in control of the discussion. The session lasted 45 minutes and the questions led to the discussion of how the pupils had perceived the museum visit through the use of an iPad app.

Think-aloud protocol is a method of eliciting research data. It was first used in cognitive psychology (Ericsson and Simon 1984), but it is also referred to as a widely used method in HCI for the usability testing of interfaces and websites. Think- aloud protocol means that the participants are asked to accomplish a set of tasks and to verbalize their thoughts, put simply, to *think aloud* by expressing their thought processes while working on the tasks. The main advantage of this method is that the outcome is more a reflection of use of the interface than focusing on participants' perceptions (Charters, 2003). An additional advantage is the direct observation of what the participants try to do. Whilst the presence of two participants as a group allows a direct dialogue to be conducted, providing a source of data that is valuable for the research aims and objectives (Charters, 2003). In practice, the think-aloud protocol was chosen to test the app at the museum and outline its overall efficacy as experienced by the pupils. However, the purpose of applying the concurrent think- aloud protocol was not to ask the pupils to think aloud during the task, rather, the pupils were encouraged to talk aloud and share with each other their experiences. This approach helped capture the groups' comments in terms of interaction and collaboration.

Documents have the advantage that they can be viewed at any time during the research and contain important information about the case under study. In addition, documents are useful in corroborating evidence from other sources (Yin, 2009). Similarly, in this study, the ***archival records*** in the form of computer files provided essential information about the condition of the pupils (measurement of IQ, range of difficulties) (Gray, 2014).

3.7 Background to the analysis

Following the collection of data from a variety of sources, the next step was to focus on the analytical frame or 'object', as Thomas (2016) notes. The analytical frame is considered an essential part of the case study and refers to *how* a holistic analysis of the case study will be conducted. As mentioned previously, a case study research methodology was chosen to address the research questions whilst qualitative analysis was applied to elicit multiple perspectives and look at relationships. To understand a complex phenomenon, it is necessary to examine the multiple "realities experienced by the participants themselves- the "insider perspectives" (Suter, 2012, p.344). To plan the data analysis, Silverman's (2015) guidance was followed, suggesting that the process should be continuous, applying a 'right to left' or 'bottom up' approach when analysing text. Such an approach means the researcher is obliged to continually question his/her assumptions, to consider the effect of a range of influences (including the effect of the researcher) on the research participants, and to explore precisely how, and by what methods, conclusions are reached. In reaction to a research strategy, consideration should be given to the role of an investigation in theory formulation and the contribution the research is making (and how). As Saunders, Lewis and Thornhill (2009) note, it is not that there is a hierarchy of research strategies, indicating superiority or inferiority of any attendant strategy but rather, it is important to choose a research strategy that provides the best fit in addressing the research question(s).

In grounded theory analysis, participants are active in the construction of knowledge; the focus is on exploring the meaning of human actions and the researchers aim to ask questions about *what* happens and *how* people interact in a particular situation (Bryant and Charmaz 2019; Bryant, 2017). Grounded theory analysis involves a non-linear process of data collection and analysis and this approach helps researchers to identify relevant concepts. In the words of Saunders, Lewis and Thornhill (2009, p.149), grounded theory research "by its nature it is 'messy'. It requires researchers to develop a tacit knowledge of, or feel for, their data". Rather than being able to apply pre-determined models of analysis, the researcher applying grounded theory needs to uncover the reality they find themselves and the research participants in, and base their analysis on that. The starting point is either an assumption or hypothesis, or the qualitative data themselves. Therefore, based on the situation in hand and the research questions, a grounded theory was adopted as the main method of analysis. Initial steps of the analysis considered the organization and interpretation of the data; these steps were conducted simultaneously with the collection of the data. In this case, the phenomenon was the experiences of a group of pupils with autism using an interactive device in a museum setting with each group acting as a nested unit within the case study. The researcher's intention was to use the collected data as a guide to perform an in-depth analysis and to uncover emergent themes and patterns of the pupils' performance at the research site (Patton, 2002).

The result of the data analysis was expected to demonstrate how a museum visit was perceived through the means of a museum-game app and identify the reasons for the appeal of the visit. The results of the data analysis from different angles provided empirical evidence in response to the research questions and supported the rationale of this research. Some of the data were collected from focus groups and questionnaires (from both stages of the study), where the researcher sought to develop an understanding and interpretation of the pupils' attitudes. The video data and observations informed the researcher's view of how an app affected how the pupils interacted with the exhibits and a museum environment. It also allowed an analysis of the pupils' behaviour as it was experienced during the visit. This type of data enabled the researcher to identify and evaluate certain types of behaviour. Hence, emphasis was given to the pupils' experiences. From the data analysis, it became apparent that the textual and oral data were intertwined with the visual data and all together, they generated a subjective account of the pupils' meanings by representing both convergent and conflicting concepts.

The data gathered for each group's museum visit were classified and stored in separate folders. In particular, it was of immense interest to track how each group's movements were shaped across the exhibition gallery using a portable device. In view of this, the pupils' activity offered an in-depth reflection on the effectiveness of the visit while it allowed the researcher to gather information about the pupils' movements and length of stay (Moussouri and Roussos, 2013). In analysing the pupils' navigation route within the museum, the aim was to pinpoint the activities that pupils appeared to show an active engagement with, thus providing a more complete picture of their experiences in the museum.

3.7.1 Analysis of data collected across the museum and the school

3.7.1.1 Analysis of video data in the museum and the think aloud protocol

Part of the analysis relied on video data captured in situ (e.g., in the museum). The analysis of the video data provided insights into the ways the pupils reacted to using the device and exploring the museum exhibits. In accordance with the research question of the study, a coding scheme was designed to facilitate the analysis procedure. The pupils' behaviours were divided into smaller segments and each encompassed a range of actions and /or behaviours with detailed notes, as can be seen in Appendix I. The procedure of coding followed an in-depth analysis of short segments of video data. Every time a behaviour occurred, it was coded. If two or more actions occurred simultaneously, both of them were coded. The coding scheme focused mostly on the frequency of the pupils' actions and/or behaviours. In addition, emphasis was placed on the verbal communications that occurred. That means that part of the coding involved transcribing the verbal communications that took place between the teacher and the group, or comments the pupils made to each other or to themselves. The analysis of the verbal quotations enabled the researcher to ascertain the patterns of words used and the relationships between them through focusing on specific aspects of meaning (Grbich, 2012). The close examination of the material helped the researcher counteract the issue of examining the text through the lens of her own assumptions (Flick, 2014).

In this study, to ensure the analysis of verbatim quotations is well organised, a Microsoft Excel spreadsheet was used. Following an iterative process going through the text several times enabled the researcher to look for themes and patterns and so assign segments of the quotations to the categories of the coding frame.

3.7.1.2 Analysis of Focus group

The focus groups were employed for the co-design session and the evaluation of the app in the museum. In the first phase, the focus group was one of the main methods for eliciting teachers' opinions regarding the pupils' involvement. The analysis of the evaluation of the museum visit confirmed the empirical evidence from the co-design sessions regarding what features might appeal to pupils with autism when interacting with a museum-game app. Since the teachers were actively involved in both phases, that is, a) the design of the interface, and b) the case study in situ, the primary purpose of the focus group was to clarify any misconceptions and to obtain deeper knowledge and understanding of the teachers' reasoning. This technique allowed the corroboration of concepts and opinions among the different sources used; it also helped build a rounded picture of the impact of the museum-game app on the pupils' experience within the walls of the museum.

To analyse the focus groups, a thematic analysis was carried out. According to Braun, Clarke and Weate (2016), thematic analysis is a descriptive method for "identifying and interpreting patterns of meaning (or 'themes') in qualitative data" (p.84). The focus groups with the teachers (from both phases of the study) were first transcribed, and then a coding process technique was employed to categorize and conceptualize the data into patterns and opinions. The action of coding helped the researcher to ask specific questions about the events, incidents, or thoughts found in statements such as the following (Bernard *et al*., 2016).

What is happening in the text?

Why is it happening?

How is it happening?

Bryman (2016) points out that the coding strategy in qualitative analysis is regarded as an essential step, and it helps the researcher to discover the most frequently used emergent themes, thus giving a meaning to the data gathered. For the analysis of the focus groups, a five-phase process was carried out as suggested by Braun, Clarke, and Weate (2016).

Data familiarisation

An initial process of familiarisation involved listening to the recordings and re-reading the transcribed data several times. The researcher repeated this process several times in order to develop a familiar sense of the meaning of the data and ensure that the context of the pupils' perspectives was being reported. In this way, the researcher was able to take notes that could provide potential insights that would need further exploration.

Data coding

The next step in analysing the transcripts involved the development of codes for segments of data. Some of the codes were descriptive, as they captured some ideas that were related to the research questions, while others were interpretative, as they captured the researcher's interpretations that underpinned the descriptive content. In order to ensure the careful recording of the statements, the coding procedure was performed using the NVivo software.

Searching for themes

This step entailed identifying potential connections among the codes; to see whether certain ideas, concepts, or meanings were repeated and to make the most sense of categorizing the data. This step was important, as codes were required to organise the coded data and to provide a clear picture of the data and of the researcher's interpretations (Braun, Clarke and Weate, 2016).

Reviewing Themes

The review phase enabled the researcher to develop the analysis in relation to the data sets and the coded data. This process ensured a quality control that the themes captured the content of the data and presented the fullest story that meaningfully answered the research questions.

Defining and naming themes

This step determined the 'story' for each theme (Braun, Clarke and Weate, 2016). In other words, this part is concerned with the narrative that tells the reader what is happening and why this is important. As part of this process, quotations were chosen to illustrate the perceptions of the participants (teachers and pupils) relevant to each theme.

3.7.1.3 Questionnaires

Post-visit questionnaires were designed to ascertain whether the museum app had a positive effect on the pupils' attitudes. The questionnaires were designed on the basis of this researcher's professional practice and experience. The questions were discussed with the teachers who participated in this research in order to triangulate the researcher's thoughts with their own experience. The draft of the questions was then discussed again with the teachers in order to ensure the best possible fit.

For the qualitative analysis of the data obtained using post-visit questionnaires, the need for a suitable software programme involves the computation of data captured from participants. The data of the closed-ended questions were coded and entered into the Statistical Package for Social Sciences program (SPSS), version 20 as a suitable programme for this requirement. For the open-ended questions, a thematic analysis was adopted to identify emergent themes from the comments. In representing the data, responses per theme were qualified while verbal quotations were also included to support further some of the themes.

3.7.1.4 Observation in situ

The final method employed for the collection of data was observation in situ. The rationale for using field notes was that it would allow the researcher to evaluate first-hand the pupils' behaviours when navigating the museum by using the device. An observation sheet, as mentioned in the data collection techniques section, was designed to track each pupil's route and to record the time they spent performing each task. The data from the observation sheets were presented through visual graphs comparing each group's performance (see Appendix J).

3.7.2 Validity and reliability of findings

The terms ‘realiability’ and ‘validity’ are two central concepts in social research. Reliability is about the quality of the research which aims to use rigour in the design by striving for empirical groundedness and the minimisation of bias (Franklin *et al.,* 2010). Particularly, qualitative research is concerned with the consistency of the findings and deals with the question of whether the results are replicable (Guest, MacQueen and Namey, 2012; Rafuls and Moon, 1996). In other words, reliability refers to the degree to which a set of meanings obtained from multiple interpreters are congruent in the research process (Franklin *et al.,* 2010; LeCompte and Goetz, 1982). Moisander and Valtonen (2006) suggest that specific strategies need to be employed to ensure reliability in qualitative research. These include a) making the research process transparent and explaining in detail the research strategy and data analysis methods, and b) focusing on ‘theoretical transparency’ and making explicit the theoretical stance and how this produces particular interpretations.

Validity is described as an internal process and refers to "the integrity of the conclusions that are generated from a piece of research" (Bryman, 2001, p.30). It addresses whether the methodological criteria can validate the conclusions made from the data (Kirk and Miller, 1986). Guba, (1981) describes validity as referring to credibility, which involves the truthfulness of the findings in which the researcher is responsible for providing a chain of evidence and a set of narrative accounts that are credible (Hammersley, 1992). Because of the qualitative nature of this research, it was necessary to ensure that the process and outcomes are viewed as credible and reliable by academics, colleagues, and examiners. Therefore, to increase the validity and reliability of the study, the following steps were undertaken that were considered appropriate to the logic of qualitative research.

Prolonged engagement

Prolonged engagement is viewed as one of the best ways to increase the overall validity in qualitative studies (Franklin *et al*., 2010). In this study, the researcher used the prolonged engagement method with the selected school to reduce any distortions that might have been caused by her presence during the co-design sessions and the museum visit. Furthermore, this provided the researcher with the opportunity to test her own perceptions and biases (Guba, 1981). Having taken field notes (as mentioned previously), enabled the researcher to reflect on how the pupils with autism perceived the design of a museum app.

The importance of quotes

The importance of making the data and the analytic process transparent is highlighted in the literature as a way to judge the research findings (Guest *et al*., 2014). Quotations are the foundation upon which qualitative data analysis is based, and it is difficult to be critical as they "lay the emergent themes for all to see" (Guest *et al*., 2014, p.18). Silverman (2001) suggests that reliability can be achieved using "low-inference descriptors" (p.230). To report the data from the focus groups, think-aloud protocol, and audio-video recordings, the researcher recorded the viewpoints and interactions of all the pupils, carefully transcribed the recordings, and then presented long extracts of data, which can be found in both the analysis chapters. Accordingly, the verbatim quotations from the focus groups and video-audio recordings were used as the 'stars' (Chenail, 1995) of the research. This helped the researcher make connections between the pupils' words with the data summary and the subsequent interpretation, thus exemplifying an intended concept. Furthermore, as far as field observations are concerned, extended extracts from the field notes were provided to give the reader an understanding of how the field notes were recorded and in what contexts (Bryman, 1988).

Cross-checking

The validity and reliability of the observation method was also ensured by the involvement of two research fellows who observed the pupils independently during the museum visit. To minimise judgment errors (Franklin and Ballan, 2011), the researcher's observations were cross-checked, which made it possible to present accurately events of which she may not have been aware.

Reliability is an integral component of the video coding process, as it ensures that the phenomena being recorded are accurate representations of the variables and provide a high degree of consistency and transparency (Cornish, Gillespie and Zittoun, 2014). Researchers suggest that an inter-rater reliability is necessary for establishing the overall reliability of a study (Franklin, 2010). This research involved interrater reliability to measure the extent to which the scores are in agreement through a Kappa statistic technique. All video data were rated and assessed by a research fellow according to an agreed set of categories (coding scheme). This technique was applied to verify that the present data adhered to the phenomenon being studied. It also helped with interpretating the data and with coding a subset of the data (e.g., video data). The average inter-observer agreement was 0.76, which indicates a good degree of agreement between the coders. This score, therefore, indicates that the data generated from the coding process are reliable (Coenen *et al.*, 2013).

Criterion

The criterion is concerned with whether the methods used are similar to other studies in the field. The researcher sought to explore the perspectives of two different informants within the same project. Previous studies have explored the views of participants separately. The most common way to identify the effectiveness of a technology-program for children with autism is through the use of observations and video recordings as determined in the studies of Piper *et al*., (2006) and Escobedo *et al*., (2012), paired with focus groups or questionnaires with teachers/parents or guardians to validate their observations. Focus groups (through drawings) as a tool were also employed in Frauenberger, Good and Alcorn's (2012) work to identify the views of children with autism on designing a software program. Deng (2017) and Langa *et al.*, (2013) used field observations to explore how a museum visit is perceived by children with autism and their parents/guardians. Overall, the techniques employed in this study have already been used by other researchers and are considered valid and appropriate tools for the pupils involved in this study.

Negative case analyses

A common criticism when reporting qualitative research is that the data presented are purposefully chosen to support inferences made by the researcher (Guest *et al*., 2014). To avoid this, this study actively looked for data that would contradict common themes in a narrative; this process reflected the complex nature of the human experience and incorporated the overall interpretation of the findings (Seale and Silverman, 1997).

Content validity

Content validity is concerned with the extent to which the items in a questionnaire represent the entire construct the questionnaire is intended to assess (Guest *et al*., 2014). In relation to this study, the questionnaires were brainstormed with input from the researcher's supervisory team who were familiar with the study and were able to list topics and questions relevant to the topic. Careful wording, format and content were also considered as essential steps to avoid misunderstandings. The process of validation was followed by testing the questions with the teachers who judged whether the questionnaire items were appropriately worded according to the pupils' abilities and ages. The teachers assessed whether the questions were clear and easy and whether the pupils would be able to comprehend what each question item was seeking to find out. Through these procedures, the validity of the research instrument was improved. The codes produced by this method were approved by the supervisory team. However, one limitation of the design of the research questionnaire was that its reliability was not tested using other measures, such as piloting.

Purposeful sampling- triangulation

Purposive sampling guides researchers on how to replicate a study with a similar purpose or objective. Franklin *et al*., (2010, p.13) explained "If a researcher can reproduce the finding in a new context or in another case, the hypothesis gains more credibility". To do this, the researcher attempted to replicate the findings as data were collected from the different participants. Triangulation is seen as a hallmark of good research and is a powerful approach to counteract bias and raise the validity and reliability of the research results (Bryman, 2016), thus strengthening a qualitative research design. Triangulation can be used to achieve confirmation of the constructs and to gain a robust picture of the topic (Franklin *et al*., 2010; Miles and Huberman, 1994), this is called having a "three-dimensional view" (Thomas, p.5, 2016). The rationale behind data triangulation is that accumulating diverse sources of evidence can lead to "the development of converging lines of inquiry" (Yin, 2009, p.115) and can minimise the intrinsic bias that stems from single-methods, single-observer, and single-theory studies (Guest *et al.,* 2014). In other words, examining a social phenomenon from several angles and under a variety of circumstances and techniques is likely to help the researcher establish data triangulation. Pursuing such techniques and drilling deeper can lead to accurate results on different occasions.

In this study, methodological triangulation (Patton, 2002) was considered the most appropriate method to corroborate the research findings. The chosen techniques seemed to be an essential prerequisite in the collection, analysis, and interpretation of data for the study. The combination of multiple perspectives (multiple methods, techniques, and informants) provided the opportunity to gain a better understanding of the topic by comparing the findings as a unit for convergence or divergence. Further, the validation of the findings led the researcher to construct a strong justification of the themes that emerged from the research site. As can be seen in more detail from **Figure 22** below, the outcomes from the teachers' questionnaire were compared with the results from the pupil's questionnaire. Combining the data from the questionnaires further triangulated them with the data from the field data reports, video recordings, and think-aloud protocol conducted during the museum visit. By collecting data from multiple angles, a comparison was made, and the facts of the study were verified by more than one method. Furthermore, through cross-checking observations among divergent data sources, differences may be reduced, and interpretation of the data may be generated that coheres with all of the divergent data sources (Franklin *et al*., 2010). In this study, the triangulation of the data increased the internal validity of the results, enhanced the credibility of the research, and reduced research bias (Berg, 2004).

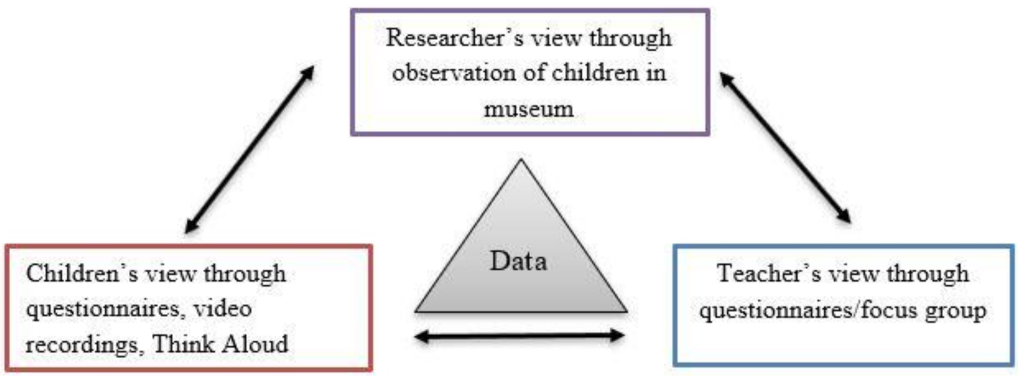

Figure 22 Convergence of multiple sources of evidence of the research design.

3.8 Ethical Principles

Ethical codes and principles have been established in educational research, and these should be adhered to any research dealing with the human population. Ethical issues are used to delineate the collaboration between the participants and the researcher (BERA, 2018). BERA, (2018) states that all educational studies should be carried out within "*an ethic* of respect for: the person; knowledge; democratic values; the quality of educational research; and academic freedom" (p.5). It is compulsory for the researcher to abide by the principles of the protection of human participants in an inclusive manner and to demonstrate an ethic of respect to any of the participants' beliefs and values. In the case that participants are children and young people of different ages, specific ethical principles of consent should be applied. BERA, in compliance with the United Nations Convention on the Rights of the Child draws attention to the appropriate decisions researchers need to make in which these groups can be supported.

Because this topic is sensitive and concerns a recognized 'vulnerable' group, such as those with learning disabilities, ethical considerations complied with the necessary requirements. Based on these principles, the researcher was responsible for taking steps to secure the participants' rights and to minimize and manage any potential risks of physical, psychological, or emotional discomfort that might arise during the research process (Cresswell, 2014; Gray, 2014). Prior to the implementation of the study, the research protocol was approved by the Ethics Committee of the Arts, Cultural Industries and Education department. Given the nature of the project, there was prolonged contact with the participating pupils over the course of the research. Therefore, it became particularly important to build a rapport with the pupils and make them feel comfortable. It was essential, however, for the researcher to obtain consent forms giving permission for the participation of the pupils and other stakeholders involved in this study (BERA, 2018). On account of the above requirements, the ethical issues raised in the present research have been addressed as outlined below.

3.8.1 Ethical Requirements

Informed consent: Prior to the implementation of the study, consent forms, information letters, and brochures were distributed to the pupils, and to their parents or legal guardians. These documents differed in content according to the reader (child, teacher or parent), and they provided a detailed overview of the project, its purpose and the process that would be followed (see Appendix K). Additionally, the information letters explained why the participants had been selected, how their anonymity would be preserved and the likely outcomes of the research. Written assent for the pupils' involvement was obtained from each group separately. In the letters, there was clear information that the pupils could decide verbally or in a written format whether or to take part in the research project. Contact details of the researcher were included and those of her supervisory team in all documents.

Confidentiality and anonymity: Anonymity and confidentiality are issues all researchers need to consider carefully when they involve any kind of vulnerable group in research (BERA, 2018). The parents/guardians of the pupils had been assured (via attached consent forms, Appendix K) that the collected data would be treated confidentially, and the pupils' responses would be used for the purpose of the study only. The pupils' details remained anonymous by the removal of their names or other personal information whereby they could be identified. The parents/guardians were informed that anonymity would be preserved throughout the dissemination of the work in articles, journals or conferences and that the principle of anonymity would be preserved through the use of pseudonyms at all times. If the parents/guardians were uncertain about any aspect of the project, they were able to contact either the researcher or her supervisor (via email). Finally, the data will be available to the Viva Committee, who will examine the researcher when the work has been submitted.

Data security and protection: Security measures have been taken to ensure the protection of the data in compliance with Data Protection Act (1998) and the General Data Protection Regulation (GDPR) from May 2018. During the research process the collected data were kept securely on UWE servers and remained password protected. Access could be obtained using the researcher's personal laptop or the university's computers via the external access system.

Voluntary participation: At the beginning of the research, information letters and consent forms were given to the parent/guardians of the pupils. The parents/guardians were informed that the pupils' role in this project would be voluntary and that they could withdraw from the study at any time during the process. The pupils had the option to withdraw from the process either by speaking to the researcher or to their teachers. The teachers monitored the pupils and confirmed that they were willing to continue with the procedure phase. During the implementation of the project when the pupils were using the iPad, they had the option to withdraw from the phase by pressing on the menu the button 'undo'. If the pupils did not want to answer any question or to be video/audio taped, they had had the right to opt out without giving any reason. Also, if they chose not to be included in video or audio capture, this would not affect their learning or progression in class.

3.9 Summary

This chapter started by contextualizing the research paradigm and presenting each philosophical position separately. It emphasized the congruence of ontology, epistemology, methodology, and methods in a research framework and explained how all these positions are important elements for the production of knowledge. It argued that the qualitative research procedure is non-linear in nature and that all positions are linked to each other and to the research questions being addressed. From a theoretical perspective, the study was influenced by conveying pupils' perceptions in a real context. Thus, a qualitative approach was undertaken, as it was the only feasible method that could be used. It has been shown that given the nature of the study, a single case study with a small sample would be appropriate for obtaining a better understanding of the topic of interest. In doing so, the research questions and gaps in current knowledge were addressed.

This chapter presented in detail the procedures followed to recruit the selected research sites. A description of the context of the research sites was also presented. This chapter provided in detail information about the case study participants (the pupils with autism) involved throughout the study including their official diagnostic status and Key Stage levels. To investigate the pupils' views, it was important to collaborate and engage with the pupils in a classroom setting over the time period of the project. This provided the researcher with better knowledge of pupils' behaviour when using technologies in a classroom context and how they might perform in the given activities and tasks. This chapter further described the rationale of the methodological framework undertaken in order to conduct the co-design sessions. The interface was designed with the contribution of the teachers, pupils, and researchers in the field of autism. For the design of the app, the methodology was inspired by the PD approach in which the pupils became actively involved at various stages. The enquiry strategies selected for the evaluation of the museum app were discussed. The approach undertaken to analyse the data collected was also described. It focused on the process of how each source was analysed using different techniques. As the aim of the study was to achieve triangulation, it was necessary to provide consistent and accurate interpretations. The reliability and validity of the data were also considered necessary and were addressed in this chapter. A description of the ethical procedures that needed to be considered for the successful implementation of the project were discussed.

The next chapter provides in detail the co-design sessions undertaken with two groups of pupils with autism in the classroom. The input of the pupils during the sessions are presented. Along with this, the key themes that emerged from the focus group with the teachers are analysed and discussed thematically. Finally, a framework of what this part of the study found regarding the pupils' involvement in co-design activities is provided.

Chapter 4

Analysis of applying co-design practice with children with autism

Introduction

This chapter describes the steps undertaken to involve two groups of children with autism to participate in the early stages of the technology design process. As noted in the introduction chapter, one of the main objectives of this study was to design and develop a museum-game based application for pupils with autism. The study was theoretically informed by a user-participatory approach, and it addressed the preferences of two case study groups. This chapter presents the role of the pupils who participated in this study and the activities undertaken as part of the design process in collaboration with the researcher and the school staff. Data were obtained to address the following questions as outlined in **Table 9** below.

Table 9 presents the research questions of the thesis, the data collection procedures undertaken, the analysis strategy, and the chapter in which these questions are answered.

Research Questions	**Data Types**	**Analytical Approach**	**Chapter**
1 How might the involvement of mid-to-high functioning children with autism inform the design process of a museum-game application? 1a. What are the benefits of the effective involvement of children with autism in the design of a museum-game app and what adaptations need to be considered throughout the whole design process?	1. Focus groups 2. Field notes 3. Audio recordings	Qualitative	4

The data presented in this chapter contribute to addressing research questions (RQ1& 1a), which focus on the pupils' contribution to co-designing a museum app, and the chapter explores the design ideas generated through the different PD activities within this study. Therefore, to examine the pupils' input and role within the technology design process, it was important to obtain the teachers' perspectives.

To gain an understanding of the pupils' preferences regarding the design of a museum app audio recordings were used with the two classes. Throughout these sessions, field notes were also taken to identify the pupils' needs and perceptions and reflect on the whole process (see field notes on Appendix L). Focus groups with the class teachers followed to explore the teachers' perceptions of the sessions and the pupils' input. The data were coded and thematically analysed. The field notes were supplemented by the focus groups. This approach permitted cross-validation and facilitated the exploration of the pupils' experiences and input in the design process. These sources were used to corroborate and support the evidence, thus achieving triangulation. The analysis followed a qualitative approach guided by the grounded theory.

Each step of the design process is presented and described in the following sections. This chapter begins by analysing each of the co-design sessions conducted and then presenting the ideas generated by the two groups of pupils. The co-design approach resulted in a summary of the main points derived from this process regarding various features of the interface. The teachers' perspectives as gathered from the focus group were transcribed and coded, and key themes emerged. The outcome from the pupils' input (through field notes) along with the teachers' perspectives are presented, and the main points are discussed. The analysis of the co-design resulted in the development of a framework that can have a direct impact on the experience of a PD process.

The following section provides an overview of the setting and of the pupils involved. The data gathered through different co-design tasks are described. The next section draws conclusions and discusses the knowledge obtained through the co-design procedure. The last section provides a summary of this part of the study.

4.1 Study Design: Participants

The study incorporated two separate groups (Blue Class and Green Class) involving thirteen pupils with autism and other conditions. The pupils were aged between 10 and 13 years (mean age= 11.9 years, standard deviation= 1.14). Their cognitive and spoken language difficulties varied from significant language and communication issues to well-developed functional speech. None of the pupils involved had a physical disability.

Table 10 presents the demographic characteristics of the pupils involved in the study. The sessions were led by the principal researcher, and the school staff members were present in each group to give support whenever necessary. Alongside the activities being carried out with the pupils, a focus group session was conducted with the teachers. Their experiences and involvement in those activities were considered important to assess the pupils' participation. The focus group with the school staff took place within the school environment at the end of the day and lasted 30- 40 minutes. The teachers involved at this stage were as follows:

- Oliver (Teacher 1)
- Amelia (Teacher 2)
- Emma (Teacher 3)

Table 10 Demographic information of the participating pupils.

	Participants	Age	Gender	Status	Speaking
Group 1 (Blue Class)	Charlie	10	Male	ASCs	4
	Aisha	10	Female	ASCs	3
	Charlotte	11	Female	ASCs	1A
	Tina	12	Female	FAD-ASCs	2B
	Chloe	11	Female	ASCs-OCD	3
	Bruce	12	Male	ASCs-ADHD	5
	Samira	11	Female	ASCs-PDA	3
Group 2 (Green Class)	Rob	13	Male	ASCs	2B
	Tom	13	Male	ASCs	5
	Matt	13	Male	ADHD	5
	Jason	13	Male	ASCs	3
	Andrew	13	Male	ADHD	3
	David	13	Male	ASCs	3

4.1.1 Co-design procedure

The participatory design approach was chosen with the aim to develop a child-centred and valid interface that would align with the pupils' preferences and strengths. Through this, evaluation of the existing practices and information about technology use was obtained which helped improving our understanding of the pupils' needs. As discussed in the methodology chapter, the co-design sessions were carried out in the pupils' classrooms as a class activity. The researchers' involvement in the pupils' classrooms occurred over a long period of time thus making it possible to build a rapport with the pupils and the teachers; this familiarisation stage also helped the pupils feel comfortable interacting with the researcher on their own and engaging with the design activities.

The initial idea was to design a game-based museum app, and after a consultation with the class teachers, it was agreed that a game-based app would be a good way to engage pupils in the museum. Thus, the format of the sessions and features was based around a game app. The aforementioned sessions focused on four main design elements: 1) navigational tools, 2) customisation, 3) accessibility, and 4) aesthetics. Concentrating on these aspects made it possible to gain an insight into the pupils' interests, obtain their input (i.e. they essentially co-designed the app), and reflect on those concepts. The outcome of each session was used as a starting point for the following session until the first prototype had been built and assessed and could be used to devise subsequent sessions. **Figure 23** illustrates the process taken towards organising the activities and engaging the pupils in the design process to address RQ1 and RQ1a.

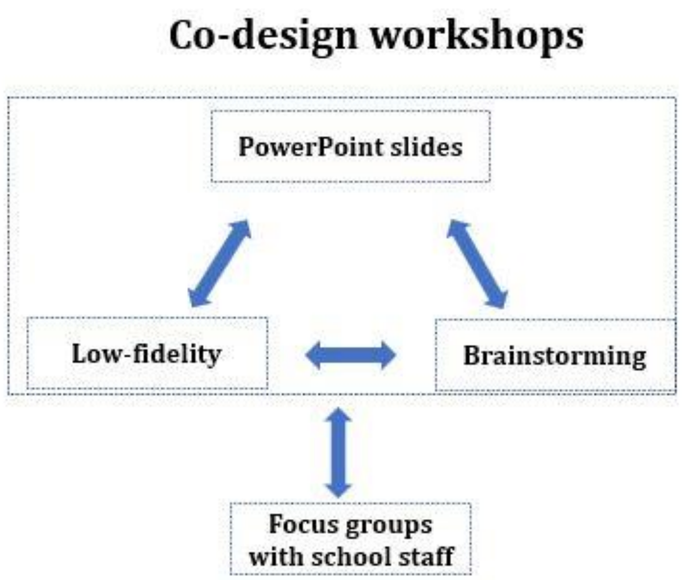

Figure 23 The process of conducting the co-design sessions.

In total, four co-design sessions were conducted, and a combination of hands-on activities were included to stimulate the pupils; each session lasted 40 to 50 minutes. At the outset of the first session, the pupils were introduced to the concept of the activity and its aim, i.e., that they would collaborate with the researcher and the teachers to design a game-based museum app to be used by children when visiting the museum. The structure of the sessions was outlined and the pupils' role in this context was explained in detail. As a result of such explanations, the pupils were able to better understand what they were being asked to do. The pupils were informed that the app would be tested at the M Shed museum and some pictures of the museum were provided. Additionally, the teachers reminded the pupils that they had visited this museum the previous year. Finally, it was explained to them that they were free to decide which features would be best suited to the museum app (irrespective of whether or not such suggestions could be implemented or were too complex), as the aim of the sessions was to brainstorm their ideas.

In the first two sessions, the pupils were asked to choose the features of the app based on their responses to several questions that were presented via PowerPoint slides. In each question, the pupils were asked to express their opinions by placing a post-it note (Like-Dislike) on the corresponding answer. The third session involved a brainstorming activity; blank paper-based templates in the shape of a tablet along with some art materials (e.g., coloured pencils, glue, and paper-based images) were provided with which the pupils could draw their own ideas for the museum-game app. Following the sketching activity, the pupils were given a low-fidelity prototype (paper-based format), and their task was to synthesize their ideas and add features and activities they thought the game app should include. This gave them the opportunity to develop further their ideas that could fit in a museum app. All of the co-design sessions are described in detail in the next section, e.g., how they were conducted, what was learnt from them, and what were the outcomes.

The pupils' input was obtained by eliciting their feedback through their words and behaviour and through them producing their own ideas by brainstorming and sketching. The role of the pupils over the course of the sessions evolved to encompass them being more than merely informants (Druin, 2002) and to include them giving direction and providing ideas. To prevent the pupils from being distracted and nervous, the teachers acted as facilitators and contributed to the reasoning of the ideas generated. The facilitator's role was to guide the pupils through the activities and regain their interest when the pupils were confused or losing concentration.

Throughout the co-design sessions, the teachers who took part in the study played an important role on consulting the activities. Before each session, the researcher discussed, with the teachers, the briefing of the activities and their suitability for the children. The discussions were also used to provide the materials which would be employed and to clarify the teachers' roles of ensuring that the sessions flowed smoothly. Following each co-design session, further meetings were held between the involved teachers and the researcher to reflect on the outcomes and to work on further improvements.

Following the co-design sessions, a focus group was held with the involved class teachers to explore further their perspectives. The discussion centred on the pupils' first involvement in the design of an app and reflected on the overall outcomes. It also provided insights into the aspects that would be valuable in promoting the pupils' positively engagement.

4.1.1.1 Discovery: Co-design activities with children with autism for the development of a museum-game app

PowerPoint slides

The first two sessions were structured as follows. To start off the activity, numerous questions were presented via PowerPoint slides, with the specific aim being to capture what types of features the pupils were fond of. This activity was used to introduce the pupils to the topic. Sticky notes were provided, and the pupils were asked to think about what they could include and how they would prefer to see different elements of the interface, such as feedback, types of rewards, position of menu action buttons, welcoming page, collaboration between the pairs, and/or preference in terms of the colour background. Subsequently, the pupils were invited to write their names on the sticky notes, along with their likes or dislikes, and to place them in one of the possible answers on the whiteboard (**Figure 24- Figure 25**).

During the first two sessions, the pupils were active and continuously answered the questions, but without giving further feedback. For example, the aspect of collaboration, the customisation of the colour background was agreed upon by the pupils. In response to a question regarding how the information content would be represented, such as the layout of the questions, Andrew and Jason said: "*We want the simplest way*" (see Appendix L).

During these sessions, the pupils were mostly answering questions without commenting on the questions or giving further feedback. For example, the aspect of collaboration was agreed by the pupils in the first session. In a question about how the information content would be represented such as the layout of the questions, Andrew and Jason said: "*We want the simplest way*" (see Appendix L).

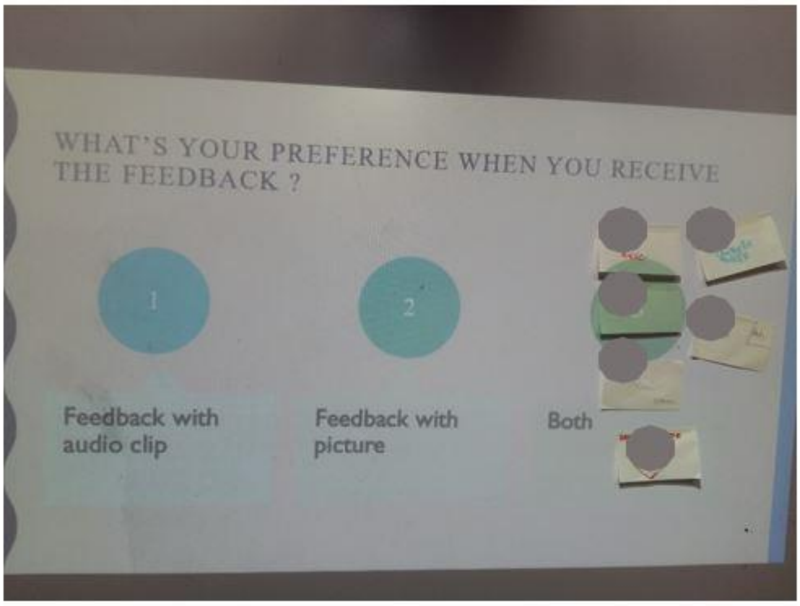

Figure 24 Pupils' feedback provided by Blue Class.

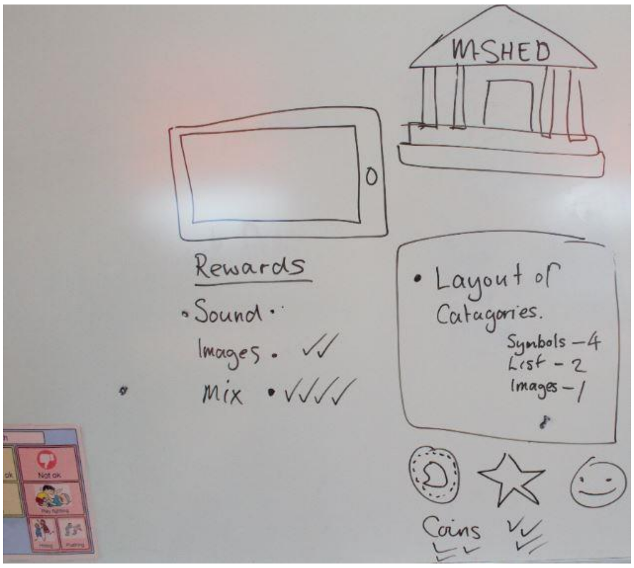

Figure 25 Pupils' feedback provided by Green Class.

Brainstorming-Sketching

The brainstorming activity was the third session. This session was creativity-focused; each pupil's task was to draw their own ideas of how their app would look in a paper-based format. Visual supports were provided via Power Point slides with examples of how a mock- up is devised, and this provided the pupils with a general idea of what the interface would look like. This session was structured by giving the pupils step-by-step guidelines on how to make their sketches. The pupils were free to write or draw their ideas and include their own interpretation regarding what they wanted to include. Blank A3 sheets, cut-out images, and art supplies were provided to facilitate the pupils' idea-generation process. These supports helped the pupils understand better what they were requested to do and avoided them becoming confused when faced with a completely blank piece of paper with no text or guidance (Guha, Druin and Fails, 2013). Using art-based materials, the pupils could stick paper-based action buttons and write or draw content that could be added to the interface (**Figure 26**).

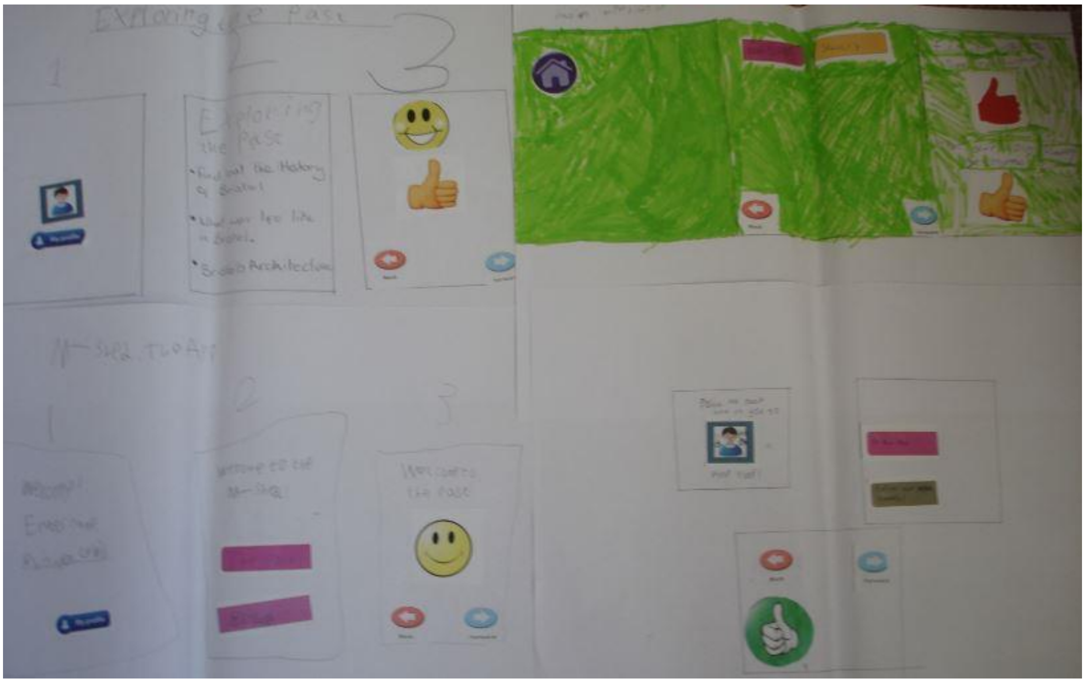

Figure 26 A compilation of pupils' outputs from session 3.

At the beginning of this session, the pupils in Blue Class were well behaved and listened to the researcher's instructions. Following the introduction and a summary of the previous sessions, the pupils were required to work on their own. In Appendix L (date, 21/03), it can be seen that Bruce seemed to feel confused about the questions and the task he had been asked to complete. He was repeatedly saying: "*I don't understand what this is*", "*I do not understand what I need to draw now*", "*I do not know how to design it*". As Bruce appeared to be confused, the teacher intervened; through verbal prompts and guidance the teacher managed to re-engage him and he then continued working on the activity until its completion. Bruce's statements indicated his disorientation when trying to focus on the current activity. It seems that the available resources and the explanations provided during this activity could not help him to process the information and to start generating his own ideas. He was puzzled by the idea of an empty template and an unfamiliar task, and so he looked for direction from the teacher.

During the brainstorming session, there was a difference in the pupils' ability to communicate and to develop their own interface ideas. The field notes recorded the following observations (Appendix L, date 21/03), "Tina seemed to struggle with the requested task and asked for help in each step of the activity. She became easily distracted and started moving around the class speaking to her friend and laughing loudly". "They [Aisha and Charlotte] were willing to do the activity and were smiling every time they completed a step. However, they got stuck at various points of the task and they were looking at [the researcher] and asked for help several times. No progress in thinking out of the box".

Some of the pupils, such as Charlie, Samira, and Chloe, were able to work well and independently through the task. They seemed focused and confident regarding the nature of the activity, and they completed it on time. According to the field notes (date 21/03), "Samira was able to deal with the instructions and completed the task quickly. She was focused and loud talking about the app (no clear speech sometimes). She proposed as rewards to have a coin starting with the letter M". "Charlie was, at times, loud and hyperactive getting up and down from his chair. He worked well and managed to extend the original story of the app. Charlie named his app 'Pokemon Go'".

The data indicated that some of the pupils found it difficult to concentrate on the activity. For example, Tina needed additional explanations and prompting from the teacher for each step of the task. Every time she completed something, she stood up and walked around the class (smiling) several times and had to be asked to sit back down in her chair. In addition, she had little interaction with Chloe, who was sitting next to her. Aisha and Charlotte seemed to be happy and cooperative in doing the activity, however, they were less able to work on their own and they looked for the researcher's attention and reinforcement to progress to the next part of the task. Although they were able to make progress, they could not generate their own ideas due to their difficulties with spelling. Samira was observed to display independent skills; she was particularly excited and was often talking to herself about her drawings. Although her speech was not clear, she commented that the rewards of the game could be a coin with the letter M, as this is the initial letter of the museum (M Shed).

Throughout the session, Charlie was vocal and hyperactive, moving around in his chair and moving around the class. He had to be asked several times to go back to sit in his chair and complete his task. He was confident in presenting his ideas. He commented out loud suggesting a different name for the app, and when the teacher prompted him to change it because it did not fit with the app, he replied: *"Pokémon has been used for a couple of years, so its old".*

In Green Class, the first part of the session, the researcher provided further details of what the pupils needed to do in this session. The pupils were initially involved in making prototypes; however, based on the field notes (Appendix L, date 21/03), Andrew decided to withdraw from the activity. The field notes also recorded the following observation: "Tom and Jason were sitting at the same desk, and they exchanged some ideas about the sketch. They were curious about the task and asked me: *"Why do we need these sketches for the app?"*. "Jason required assistance at various times, and he seemed not sure what to write in the boxes", "David seemed cooperative and worked well. He worked independently; no assistance required. Some repetitive behaviour was observed when he drew the boxes with green colour". Similar to David, Rob worked in a very focused fashion and progressed through the task to completion.

Moreover, he was keen to learn more about the context of the app and the content of the museum (**Figure 27**).

> Rob: "*What's M-Shed about*?"
>
> Researcher: "*M Shed is about Bristol's past. It tells stories about what happened in the city, what has been found". It tells the story about a dinosaur. It has buses, bikes; it talks about the Second World War".*
>
> Rob: "*Ok so because the museums have many objects, we can have a lot of options for the user*".

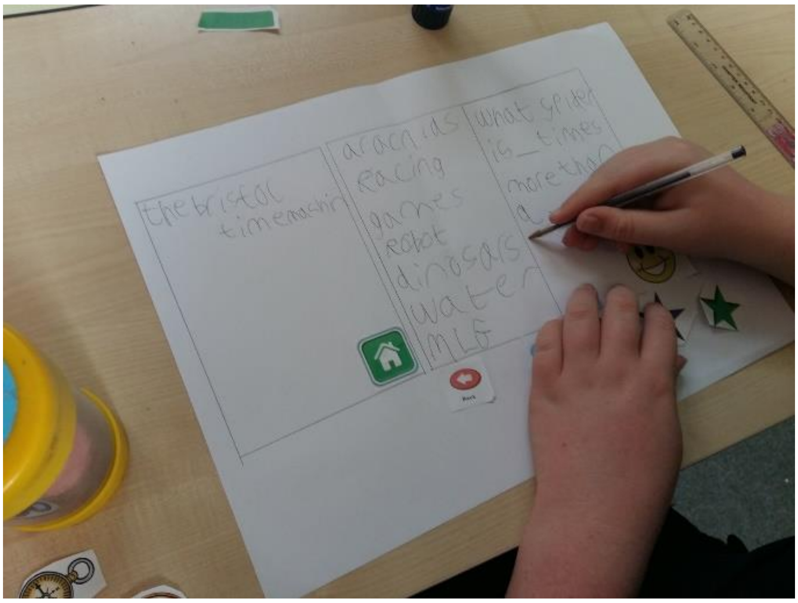

Figure 27 Rob creates content for the interface.

This session demonstrated that the majority of the pupils listened well and seemed to be quiet and focused throughout the session apart from Andrew who withdrew from the activity. Regarding the activity, some of the pupils (e.g., Jason and Tom) required some help in brainstorming their ideas and they needed prompting to progress. They were observed to be confused about how this session could benefit designers. Overall, David and Rob worked very well. They displayed signs of independence and confidence regarding what the activity was about. David completed the task quickly, but he showed some repetitive behaviours while drawing his sketches. Finally, Rob was clearly able to follow the instructions and did not need any support. He seemed to be interested in the museum's content and its collections. His attitude showed an active engagement and motivation to provide input for the technology program.

Low-fidelity prototypes

In the fourth session, the activity was structured by presenting the synthesized the ideas of the pupils about the museum-based app through low-fidelity prototypes. Hard copies of those prototypes were given to those who wanted to work independently. The pupils were shown the low-fidelity prototype of the interface and asked to write or express their preferences about the functionality of the museum app. They were invited to provide their answers either verbally or through sticky notes by placing one of the answers on the whiteboard. Generally, the pupils were active and seemed to be engaging with the task by giving their own input. The pupils' active role and engagement was shown by them suggesting alternative ideas. One example was that both classes preferred to customize the colours of the interface ("Can we have different colours?"). Charlie also mentioned that the navigational components of the interface could be placed at the bottom. (Charlie: "*I prefer on the corner at the bottom, so the users will easily pressing them*").

In Blue Class, the majority of the pupils followed the method of giving their opinions by sticking them on the whiteboard. As can be seen in the field notes, "Aisha and Charlotte were not able to progress with their task and needed more direction" (date, 03/04) and "Chloe was focused on the activity and able to reply to all the questions. She did not provide any further ideas". Bruce appeared to lack confidence and required encouragement and re-assurance regarding whether what he was doing was right or not ("*Mmm Is it ok? Not sure…if its correct*"). Some of the pupils (4) preferred the layout of the museum themes to be presented as a list, while the others did not provide any answer. Following the completion of the session, Charlie was eager to provide further ideas and to add new elements to make the interface more interactive and customizable (as seen in **Figure 28**). He commented:

> Charlie: *You have different characters and a search bar, and the user can select one of those (guy, lady or child). On the corner, you can have a little thing with the face of the character. So, you can select which one you want male or female. I'd go for female.*
>
> Researcher: *If the app provides one character?*
>
> Charlie: *So, you can have some other options for the players to select which one they want?*
>
> Researcher: *Like what? For example, different items of clothing to dress up the character?*
>
> Charlie: *Yes, why not? Or different eye colours. Now they need to scan the barcode which is around the museum and then a quiz will pop up.*

Charlie: *For the next level, you keep doing that over and over again scanning barcodes and at the end to find the treasure.*

Charlie: *On top at the corner, there will be a tiny button, click on that and say "Find the hidden treasure".*

Figure 28 Charlie presents his ideas about the design of the museum-game interface.

In Green Class, the session appeared to be engaging and all the pupils replied to the questions by ticking on the whiteboard what they wanted to see in the app. Regarding this, Rob showed an interest in talking further about the design of the app and referred to the inclusion of new features that could make the app more engaging.

1) about short-and long-term goals "*The users need to get two items in order to open the first box and then four to open the golden one.*"
2) added an idea about a multiplayer mode of the game: "*This part of the game can be a multiplayer game, so more people could play together.*"
3) expressed his opinion about a non-linear route "*The players can choose which spots to visit.*"
4) He suggested the integration of various exhibits' options. *"The players can select one of the categories written on the 2nd square."*
5) Finally, he asked: "*Can we use colouring options for the character*?."

At the end of the session, Rob was still eager to talk about the app, and he expressed the desire to present his ideas in a PowerPoint presentation (three slides) as seen in **Figure 29**. His presentation showed that he had a strong interest in unlocking clues and gaining rewards.

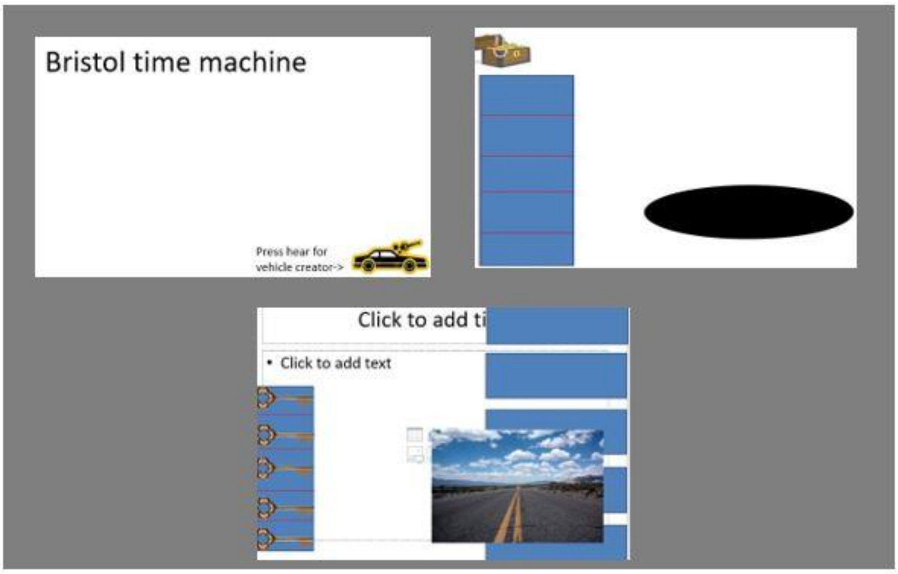

Figure 29 Rob's ideas (slides 1-3) for the museum-game interface.

This session revealed that the approach followed using traditional methods was valuable in terms of exploring pupils' reasoning behind their ideas. The results indicated that the pupils expressed different levels of enthusiasm. Not all the pupils were demonstrated the ability to think outside the box and extend the design of the app. Charlie and Rob enjoyed taking part in the session and felt confident expressing their preferences. Indicative of this is that they seemed to be verbal and to be focused on the task as directly generating input for the design of the interface. The dialogues presented previously captured the ideas of the use of an avatar with various players, the ability to modify the interface settings (customization) displaying physical human characteristics, to follow clues that will lead through the museum's exhibition, the preference for introducing various activities for the pupils to explore the museum through a location awareness system, the incorporation of number of challenges to reach the treasure, a multi-player mode game, and finally, the pupil's ability to navigate freely through the gallery (non-linear route). This reasoning with the various input modalities, shows the pupils' thoughts regarding an adaptable interface that can provide features the pupils would prefer to use. The use of customizable features for the character of the game is also similar to the pupils' comments in the brainstorming session.

4.1.2 Analysis of the outputs and focus group with the teachers

The previous section focused on identifying the pupils' contribution and input in the technology design process. This section presents the researcher's and the teachers' points of view regarding the co-design approach and the pupils' input in the technology design process. The findings from the sessions' outcomes are analysed and discussed based on the key themes that emerged.

Engagement and input of children with autism based on their abilities

The aim of the first two sessions was to familiarize the pupils with the context of the study so that in later sessions, they would be able to focus on the activities in more depth and concentrate on specific features. According to the field notes, all the pupils became enthusiastic and played an active role in replying to the questions with some ease and expressing their opinions and thoughts.

In the brainstorming session, the pupils used the paper-based template to draw freely and to include information relevant to the content. The brainstorming and low-fidelity sessions produced a number of drawings and texts on sticky notes that needed careful consideration to retrieve information and inform the design of the app. The proposed designs extracted from the sessions demonstrated the pupils' initial interest and enjoyment in contributing to the design process. Teacher 3 commented that *"for the higher ability ones [children], it was really an enjoyable experience while the others needed an additional support to complete the tasks. It is a very tricky class to work with these levels".* Teacher 2 reported *"Samira was pleased as well"*. The difference in the tasks' involvement was subject to each child's cognitive abilities and personal interests. It was noticed that some pupils (Samira, Charlie, Davis, Chloe, and Rob) engaged independently with the task, working for a long time in a meaningful way while others needed re-assurance and reinforcement (Bruce, Aisha, Tina, and Charlotte). This is also consistent with the field notes.

Teacher 3 further suggested that it would be better if "*you break off the higher level group with the lower ones rather than doing this as a class because we have differences in the class.* For example, Charlotte "*wouldn't be able [to understand]. She adapted as an activity to do. It was quite a good activity for her, but she couldn't get the real meaning".* As Teacher 1 added *"This massive differentiation is tricky in our class as well and then for you too"* in general. Indeed, sometimes, even for the teachers, it is challenging to know whether the techniques and resources used are appropriate for all the class; as Teacher 1 commented "*Can I teach them the same thing*?".

Teacher 2 further added with regard to the researcher *"Your attendance did help a lot and did work quite well"* by allowing the pupils to be familiar with the whole concept and "*to make and build relationships*". She also noted that *"Another important thing is that they listened to you"*; all the pupils in Green Class were shown to be engaged. This aspect was quite positive considering that *"this class is quite difficult to get to listen to anybody, and sometimes they are a bit chatty*". However, on this occasion Teacher 2 commented *"They listened really well…they took part in the sessions. That was positive though"*, thus showing an active and positive involvement in the sessions.

These findings reveal that the pupils with higher abilities seemed to perform better and exhibit independent skills; they were able to understand the concept of the activities and contribute to the design of the interface. Therefore, for those who needed additional support and reinforcement, the level of behaviour was perceived positively as they seemed to behave well and listen well throughout the sessions. Indicative of this was that only one pupil dropped out of the brainstorming session.

Continuous adaptability to support the needs of children with autism

The analysis of the sessions' outputs is crucial, and thorough consideration should be given to the decisions which need to be taken before, during, and after each session; this makes it possible to be prepared for what has to be done and what the expectations should be. During the design of the sessions, the main focus was on how suitable the activities had been for the pupils, as well as the ability of the activities to actively engage the pupils and produce useful results for the design.

In this process, the careful planning of the sessions with a clear purpose, and the defining of roles, as well as consultation with the teachers after the end of each session, resulted in an effective way of delivering the sessions. Teachers who knew the pupils well provided useful information on the appropriateness of the activities used for the co-design session in advance or useful tips on how to gain the pupils' attention and manage expectations. The purpose of offering such information was to minimise the risk of unexpected situations and thus facilitate the smooth progress of the session.

It was observed that the pupils preferred different ways of expressing their opinions either verbally or through sticky notes depending on their abilities and skills. For this purpose, the researcher's role was to ensure, first, that the pupils were free to express themselves and, second, to provide them with multiple materials and resources to help them represent their opinions in their preferred way.

The teachers recognised that the varied types of activities in the co-design sessions were deemed successful by the pupils. These activities made it possible to adapt to circumstances and contributed to a progressive engagement of the pupils throughout the co-design sessions. The variety of activities and materials employed proved to be valuable, in many ways, for the pupils and the researcher respectively. The analysis indicated that the first two sessions provided contextual information and knowledge regarding the main features for the design related to the context of the study. It was also progressive engagement, as confirmed by the school staff. Teacher 2 commented that the chosen activities "*were well-designed and helped the children express themselves individually*".

It was agreed that the activity from the first two sessions was not useful in terms of further elicitng their own ideas, although the teachers expressed their enthusiasm about the brainstorming sessions. However the chosen activities later encouraged the pupils to express their creativity. The pupils' outputs made it possible to collect specific design ideas and knowledge on the topic by producing a series of recommendations and some original stories relevant to the pupils' interests and abilities that could be directly integrated in the design of the app. In this stage, the researcher was advised to continue using more creative activities in order to capture the pupils' reasoning in more detail. Teacher 1 added *"It worked quite well, it got better as they went on. You got the feel of the level of the children; you adjusted the language…". The later sessions became better because you started using the visual aids, speech language levels".* It was also observed that the pupils' comfort increased as the routine and the sessions became familiar. Teacher 1 further stated *"You probably would have to do it again in the same way. The fact that you started off with something and then you adapted [it] when you knew how they responded"* seemed to work well for all the children and a progressive engagement was observed. Particularly, Teacher 1 referred in the focus group to how transitions of any kind, such as new activities, can pose challenges for children with autism.

> "*You never quite know how they gonna respond and how they gonna take something on board until you put all the instructions and process like we do*".
>
> [Focus group Data Extract]

To elaborate further his statement, Teacher 1 pointed out that there are activities that the teachers think will probably work but they do not. Due to the differentiation, he pointed out *"there is an element of trial and error in this but as long as you build up and you notice what it is getting noticed and you have a realistic target"* that teachers/researchers need to achieve. According to this, the teachers had a positive view on whether the chosen activities and tasks fitted well based on the pupils' skills. The teachers referred to the pupils' interactions with the researcher and the possibility of them staying focused; this attitude was reported as both positive and surprising. The factors that contributed to the successful delivery of the activities include: the use of visual aids and the flexibility to adapt the process to the pupils' abilities, and speech language levels, which were adjusted during the sessions.

The researcher's presence and behaviour and the structure of the sessions made sure that all the pupils were engaged. However, to make the sessions easier for the pupils, Teacher 3 suggested in the focus group: "*Maybe you could have shown something similar to that. Because I don't think so the lower level ones would able to understand the concept".*

These statements also confirm the observations which found that on some occasions the pupils needed further direction and guidance and seemed to feel frustrated about what they had to do. The use of examples would provide a smooth introduction to what the pupils were expected to do and would help them understand the concept clearly.

Embedding a level of ownership and empowerment

The input provided by some pupils is in fact a noteworthy finding as responding to conversation or initiating interaction can be difficult for children with autism. However, the pupils felt comfortable and this in turn facilitated an interaction with the adults. This was also confirmed by the teachers who claimed that the most positive aspect of the activities was that once the pupils understood the concept of the project, *"They did feel a level of pride that we are making something and somebody else is going to use it"* (Teacher 1). The collaborative aspect of the project, with human peers and the pupils' involvement during the early stages of the design process, seemed to help them achieve "*some satisfaction on a personal level*" (Teacher 1). This also reinforced the pride of ownership, that is, the idea that "*you helped make this; your ideas and what you said made an app*" (Teacher 1). This approach encouraged the pupils' contribution, and the fact that they were acknowledged for that contribution motivated and engaged them by giving them some kind of responsibility throughout the process. Teacher 1 further reported that the pupils' behaviour was positive, saying that the pupils *"did enjoy the process, they probably felt some value in the process*", as they appeared to enjoy what was going on. The higher ability pupils seemed to be able to take the view that "*this is an enjoyable thing to do, and it sounds a good thing to do, but the thing is that you built this up incrementally*".

Teacher 2 continued by saying that *"because of this transition, the children cannot be secure in that knowledge from the beginning of the sessions"*, and what their role was in this process. The conversations presented in the previous section have provided an understanding of how the pupils conceptualize an interface. Regarding this, Teacher 1 pointed out that participants such as Rob expressed "*quite strong opinions and ideas on what he wanted to do and where he wanted it [the app] to go*". In addition, Teacher 3 reported that for Charlie *"It was really an enjoyable experience".*

From the audio recordings, there was evidence that, for instance, Charlie and Rob felt empowered and enthusiastic in providing input and feedback in the technological design. They were able to extend the concept of the game and to generate a number of high-quality design ideas either verbally or textually to be incorporated into the museum app. An indicative example was that after the end of the activity, both were still seen to be interested and involved by either drawing on their sheets or presenting their ideas. This was a good practice in getting them to express their ideas. Problems with flexibility in the pupils' thinking is an issue as mentioned by the teachers. Teacher 1 commented *"With this learning type you have something like this, e.g., if it should be like this, so I don't want anything else".* Because children with this learning type may think in a rigid way, they might find it hard to consider alternatives. As Teacher 1 went on to say, one way to deal with this situation is to *"compromise with students like that"* and to make them believe that this project (in this case the interface) is a result of *"building something together. It is something that we always try to do".*

In sum, the reason behind the sessions that for designing a technology program acted as a contributing factor for the pupils' initial excitement and engagement in the process. The outputs from the interface design activity revealed that the majority of the drawings seemed to be simple and had been affected by either the demonstrated example ideas or the facilitator's prompts but showed that not all the pupils were involved in generating original ideas. The drawing activities and verbal recommendations resulted a more customizable environment. Therefore, the direct and indirect feedback obtained during the sessions required careful consideration and interpretation as some of them were either not applicable or not understandable. It is evident that some pupils appeared to have a more active role in the decision making than had others, but this is an issue that teachers always encounter with classroom activities due to the broad spectrum of abilities. As the pupils had a say in the decision making, they were able to voice their opinions during the design process. However, some of the pupils' rigid preferences with specific items prevented them from being able to consider alternative ideas. An indicative example is Rob's ideas, which indicated his particular interest in cars.

The key outcomes derived from the experience of the co-design activities are synthesised below. Based on the main categories which this study aimed to focus on and obtain information about, the pupils' ideas and preferences generated a list of design guidelines which informed the present study. Most of the design recommendations confirmed the current best practices, although some novel ideas were reported by the pupils during the co-design sessions. These include the following: a) locating the buttons (at the bottom), b) customising the colour and the avatar's interface; and c) integrating game features, d) providing a non-linear route and e) offering various activities through a location awareness system. **Table 11** is divided into ten category headings (left-hand column). The second left-hand column synthesizes the current best practices regarding how technology-based platforms can follow a child-centred approach for children with autism. Then, the table continues by providing a summarized overview of what this study found (central column) and finally the right-hand column confirms the existing theory or adds new features that can be considered important for future scholars.

Table 11 A synthesis of the key points found from previous work and feedback gained in the present study.

Review of best practices	Key points from previous work in the field	Feedback from PD in present study	Additional features
Consistency-Structure	- Brief tutorial of the activity - Gradual introduction of new elements (audio and/or visual features) - Clear form of guidance of the activities - Breaking the activities into smaller tasks - Structured situation	Nothing disruptive	
Predictability	- Set consistent expectations and cues to help users predict the outcome	Nothing disruptive	

Content and visual comprehension	- Simple content - Content along visual features - Short text and break up content with numbered lists and sub-headings - Use of symbols or icons	-Simple information -Format of questions via text and sound	Confirming
Customization	- Enable the users to make changes that match their specific needs by changing sound, size and/or colour of the font	Customization through different characters, or functions of the character, foreground and background and layout (input controls)	Confirming
Interactivity	- Simple interface with a few elements for the current task - Use of large and clear buttons with icons and /or text - Visible functions - Big buttons and icons in a click option - Large screen layout and ability to zoom in and out	Nothing disrupting	
Navigation tools	- Simplified navigation - Use of location awareness system - Consistent navigation page buttons (eg., exit, back, and help buttons) - Place the buttons on the same place (on top) - Direct manipulation of the interface	-Menu action (at bottom) -location awareness system for the museum activities	Novel and confirming the rest
Feedback	- Provide immediate feedback for every point of their actions - Use of rewards with visual feedback - Prompts via audio, textual, and/or visual - Presence of onscreen characters for guidance	- Feedback through images and audio - Type of feedback: faces, coins - Rewards through sounds and images - Use of an avatar for guidance	Confirming
Design Colour Layout	- Balance between the background and foreground - Keep a consistent layout - Good contrasts	Customize colours of the avatar's interface	Novel

Game elements	- Narrative storyline with medium and long-term goals - Collaboration as a team - Ability of cooperative gestures	- Short and long-term goals - Multiplayer features - Instructions	Confirming and novel as the existing literature in terms of game features focused on TD children's preferences
Multimedia features	- Multimedia modes with simple layout - Use of sensory rewards through sounds and vibration - Integration of animation, and/or sounds - Audio and visual formats to convey information and/or the content - Possibility to maximize and minimize the pictures	- Integration of visual features such as animations, images and/or videos - Use of visual supports	Confirming

4.2 Discussion on the findings of the PD approach

This section reflects on the findings from the audio recordings, field notes, and focus groups that explored the pupils' contribution in the design of a museum-game app and the teachers' views on the co-design experience. The co-design activities and feedback described above had a direct impact not only on the design of the app, but also on the researcher's understanding of designing for and with children with autism. While PD efforts often focus on specific elements of a software programme, it is therefore important to reflect generally on the process and identify what aspects were seen as valuable in applying a user-centred framework for children with autism. This section presents a framework derived from the feedback obtained as a reflective practice in the co-design approach. The framework is presented in the form of a diagram, and it articulates visually what this part of the study found. The framework includes the main aspects in delivering and managing co-design sessions with children with autism.

4.2.1 A framework for co-design sessions with children with autism

As can be seen from the diagram in **Figure 30** this study started by identifying the best practice in technology design for children with autism. Then, co-design activities were arranged with two groups of pupils with autism in the presence of their teachers to involve them at the early stages of the design process. The analysis of the data presented in this chapter led to the identification of five factors that can influence the experience of co-design sessions for such children.

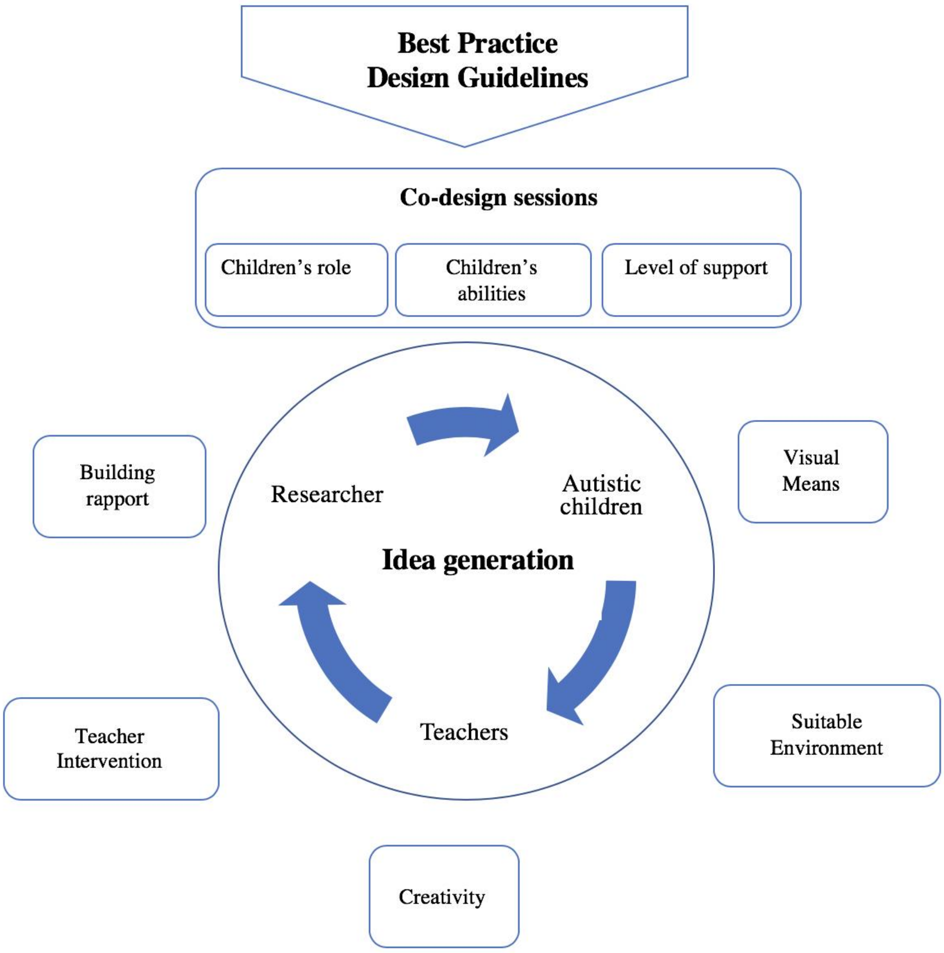

Figure 30 Framework capturing the process and articulating the influential factors for co-designing with two groups of pupils with autism.

These factors seemed to be important and to contribute to an effective organization of the sessions. The variables in the middle part of the framework were influenced by the overall design scope (stage of technology design process) and by identifying limitations such as the pupils' role, pupils' abilities and the level of support they required. Issues around the appropriate use of language and an understanding of the pupils' abilities were identified at the beginning of the sessions.

The teachers' perceptions indicated that one reason why the sessions had a positive impact was the flexibility of the sessions, as they took account of the current situation, such as being able to adapt to the language level of the pupils and to perform tasks tailored to the pupils' own abilities and skills. It became clear that the use of one technique alone would not have been adequate to obtain enough information from the pupils' perspectives. The different ways of informing the design and gathering feedback showed the researcher's flexibility to build on the skills and understandings of the pupils with autism. One way to do this was by providing tasks and activities that encouraged creativity.

The PD framework was used successfully to encourage the pupils to interact and be involved during the co-design sessions. The present study provides empirical evidence that the PD approach proved to be suitable for incorporating the pupils' input into the design process. As reported, social and communication difficulties can make situations challenging and problematic for children with autism (Dawson *et al.,* 2004). These issues can also cause practical problems for their contribution to and involvement in new activities outside those of the school curriculum. To date, previous research has highlighted that a positive outcome is that the children were able to express their needs and preferences while they enjoyed the freedom of offering feedback (Bossavit and Parsons, 2016; Spiel, Makhaeva and Frauenberger, 2016; Benton *et al.,* 2012).

This current study goes beyond previous studies and provides insights into the technological design that may have potential implications for the design. These implications can be considered as the foundation for developing interfaces for the museum context. The idea of producing a low-fidelity prototype museum app seemed to give the pupils feelings of excitement and empowerment.

Giving a voice to the pupils by encouraging them to create their own interpretations worked well, and the detailed reference in some specific features of the app was a positive outcome. It is evident that the combination of different techniques, activities, and materials acted as a medium to elicit deep ideas and focus on features and content that illuminated the pupils' reasoning. Through this, the pupils expressed their preferences for a customised interface, with the navigation components at the bottom of the screen. The use of an avatar could set the goal of the visit while the short stories could direct the pupils to various areas of the gallery via a non-linear route and a location awareness system. They also recommended hands-on experience, several challenges (short and long term) to reach the treasure and cooperative work during the museum visit.

Interestingly, as a reflection of their interest, the participating pupils engaged in the sessions by either asking related questions, completing the tasks, or sharing their thoughts about specific features that could be included in the interface. This view was also supported by the teachers, who all agreed that the pupils showed a high level of involvement in all the activities that had been set out. The teachers expressed their positive surprise regarding the pupils' behaviour throughout the workshops. Despite the pupils' difficulty with unfamiliar routines, they seemed to respond well and were able to make their own choices independently. The analysis of the teachers' feedback and the researcher's observations identified consistent themes on how to support active children's with autism involvement which are discussed below. The identification of themes on similar aspects resulted in uncovering the factors that positively influenced the co-design sessions.

Autistic traits

It has been claimed that problems with changes in routines is one of the hallmark characteristics of children with autism. That means that transition situations are often difficult (Campbell, Milbourne and Kennedy, 2012) for such children and can become even harder when their participation is requested in new concepts. In this study, the familiarity with the environment worked well with the pupils involved to help them feel comfortable. This is consistent with the finding of Bossavit and Parsons, (2016). Meanwhile, Benton and Johnson (2012) stated that the implementation of the participatory activities in the pupils' classroom is of primary concern to lessen the impulses relevant to their special interests and to reduce any anxieties about the unfamiliar nature of the sessions. Similarly, Bossavit and Parsons (2016) addressed the issue of reducing distractions, such as that offered by items of greater interest within the classroom during the sessions. To avoid this, the structure of the activities within the group's main classroom as a class activity and the lack of electronic devices, such as desk-top computers helped reinforce the pupils' performance and scaffold their engagement.

An important aspect of the research is that children with autism are commonly known to demonstrate rigid thinking and to have a narrow range of interests (Baron-Cohen, 2009). As a result, these characteristics are more likely to result in the pupils disengaging from an activity. These difficulties can pose significant challenges for designers and/or researchers. Moreover, the most difficult challenge is how best to keep the pupils' attention and maximize their potential to enhance their performance throughout the design activities. When designing for this group, the selection of methods may not have the expected results. One way to overcome these difficulties is through the researcher's flexibility and suitability "to adapt to the current situation and context" (Malinverni *et al.,* 2014, p.92). In other words, researchers need to assess the value of the activities during the process and re-structure them in way that supports the pupils' special needs, thus facilitating their involvement. Related to this, in this study, the teachers' perceptions indicated that one reason why the sessions had a positive impact was the researcher's approach to be flexible to adapt to the current situation, such as being able to adapt to the language level of the participants and to perform tasks that are tailored to their own abilities and skills. Besides, the first two sessions were identified as an effective way to inform the design and gather feedback in relation to the guiding principles. In the second session, some of the pupils expressed their frustration and lack of interest. This resulted in the researcher changing the nature of the sessions and providing tasks that were considered creative.

Presence of adults

Following a co-design approach, the pupils were placed at the centre of this research giving them the freedom to express their ideas and opinions. The delivery of the co-design sessions in accordance with the teachers' views revealed how important the adult support was before and during the sessions. Teachers who knew the pupils' skills provided recommendations on the appropriateness of the activities planned for the co-design sessions beforehand. Given the diversity of the pupils' needs, during the co-design sessions some pupils required further support and prompting from the facilitators to understand the activities involved. The facilitators' role on this occasion was to prompt the pupils and think of ideas for specific parts of the interface. The fact that some of the pupils could not complete or comprehend the concept of brainstorming and could not fill all the paper-based template with drawing or content, indicated that they might have found this activity vague and unclear. Additionally, another possible explanation might be that the pupils could have had limited creative drawing skills, and this restricted them from informing the design of the app. For example, during the idea generation session, Bruce, Hanna, and Charlotte were not able to understand what to do or how to do it while Rob and Charlie seemed to be willing to develop further the concept of the game. At this point, the role of the researcher was to make the process easier for those pupils who had difficulties in understanding the concept and to encourage the others to develop their ideas in more depth by asking them for further details. This confirms previous findings in the literature, which support the idea of the provision of adult support. In particular, Benton and Johnson (2015) highlighted that the role of adult participant is "multifaceted and the associated responsibilities, functions and actions to perform are wide ranging" (p.33). Thus, the presence of adults has a supportive, facilitative nature (Parsons *et al*., 2011) that ensures the children's well-being and provides support when required.

Building rapport

Previous research has cited that the power imbalance between adults and children is viewed as problematic regarding how adults can become accepted by groups of children, and this difference can have a negative impact on establishing a fruitful relationship (Guha *et al*., 2013). However, the establishment of a rapport with children is seen to have a particular significance in participatory research. According to Guha *et al.,* (2013) one way to address this power imbalance is to give the children the right to participate on their own terms. This relationship between the researcher and child participants can confer engagement and positive outcomes. In this study, the pupils' familiarity with the researcher prior to the onset of the sessions was considered an important factor to scaffold the pupils' active involvement and engagement throughout the sessions. The steps undertaken in the planning stage of the study, as introduced in the methodology chapter laid the foundation for this close collaboration. The rapport stage aimed to build positive relationships and mutual respect, which are considered important variables in the design process.

According to the literature, the idea that child participants opinions matter as much as the ideas of other stakeholders is the foundation for the decision-making process (McNally *et al.,* 2016) while Frauenberger *et al.*, (2012) pointed out that the children with autism "need to equally benefit" (p.368). Frauenberger, Good, and Alcorn (2012) and Davis *et al.,* (2010) contended that building a rapport requires time and empathy to enable the pupils to become comfortable with the researcher. In this study, the idea that the pupils' opinions were important was a key factor in achieving a balance. This strategy, as confirmed by the teachers, had an overall positive impact on the pupils' behaviour. The long-term attendance of the researcher in their ICT classroom before the study led to both groups of pupils feeling comfortable and being familiar with the project. In addition, it contributed to increasing the pupils' self-confidence during the sessions and when generating their own ideas. All these actions before and during the sessions along with the familiarity with the researcher's presence indicated to the pupils that their ideas were valued and could be used in a broader context. An important finding that emerged from this study is that this endeavour gave the pupils a legitimate voice in the design and scaffolded a decision-making power, as they expected that the agreed upon ideas would be included in the final design; this idea made them feel happy and valued. By being encouraged to generate their own ideas and perceptions, the pupils felt the sense of empowerment and ownership in co-creating their own technology. According to the teachers' comments, the fact that the pupils were aware of their empowering 'role' and their power in giving shape to an interface from scratch proved to be a successful practice and, indeed, resulted in improved behaviour. This study has provided additional evidence that the development of good rapport as well as that their ideas have a value can result in children with autism making a contribution to research; in this case, it resulted in them producing a set of design recommendations. As reported, some of the pupils proposed novel ideas that could be embedded into the interface.

Visual means

In order to deliver successful activities and gain input it was vital to assess the pupils' abilities and skills. Based on these, the adjustment of the language levels was seen to have a positive impact on the delivery of the sessions. In addition, results of the co-design session suggest that an important aspect that improved the likelihood of the pupils staying engaged and being actively involved in the design activities was the use of visual aids. As children with autism learn effectively using visual supports, the incorporation of visual aids may have encouraged the pupils' communication and consequently their participation. In this research, based upon the study's findings, the use of visual supports (Benton *et al.,* 2012) proved to be valuable for sparking the pupils' interest and their subsequent involvement. Visual supports such as guidelines were provided on how the pupils could sketch out their own ideas out, and these proved to be useful during the process. Based on the teachers' comments, the visual aids were viewed as appropriate and necessary to allow the pupils to carry out the tasks successfully and ensure the workshops were at a level closer to their abilities. These findings provide support for the effectiveness of using visual aids in activities with children with autism, as such aids help to hold their interest and initiate interactions. However, in cases of repetitive behaviours as a result of the pupils' annoyance with the nature of the questions, the intervention by adults was seen as necessary.

It is important to note that it was not possible to hold the co-design sessions on a weekly basis. Thus, the setup of visual recaps at the beginning of each session not only helped the groups of pupils by providing structure and follow up from the previous sessions, but it also avoided frustration. In order to keep the pupils' motivated, it was therefore important to ensure that the level of the pupils' strengths and skills were addressed in the design activities. However, it was observed that some of the pupils had a few difficulties in understanding the nature of the task and needed further guidance and reinforcement to start brainstorming. This finding supports other studies that applied a user-centred framework in order to develop technology programs for children with autism and stressed the importance of how the visual supports can enable such the children to stay focused on and engaged with their tasks (Benton and Johnson, 2015; Millen, Cobb and Patel, 2011).

Suitable Environments

It was observed in the present study that the pupils' level of participation benefitted from them being in a familiar environment. The co-design activities in the pupils' classrooms and the absence of electronic devices reduced the impulses children with autism have to focus on their particular interests and be distracted and helped the pupils to focus on the tasks. Thus, reinforcing an initial engagement with an unfamiliar situation. It is interesting to note that the participatory activities in the pupils' classrooms were found to improve the pupils' level of comfort gradually from one session to another. This also accords with the suggestions by Davis *et al.,'s* (2010) who stressed the importance of conducting the activities in the children's own environment.

Creativity

A finding that arose from this study was the concept of creativity. Creativity is defined as a core resource in participatory processes and occurs when proper techniques and environments enable the participants to engage effectively and explore new situations (Sanders and Stappers 2008). However, researchers in the context of PD address the issues of what creativity is meant to be and how creativity should be defined. Sanders and Stappers (2008) argued that all people are creative, but the creativity increases in accordance with the level of expertise, interest, and passion. Therefore, the results are encouraging, as with an appropriate balance between positive support and freedom, some of the pupils were able to provide valuable input and to act as contributors to the design of the app. In this study and during the co-design sessions, a number of variables enabled the pupils to reduce their anxiety and so realise their creative potential. These variables included the idea of drawing, the surrounding environment (i.e., children's classroom) alongside features such as free space (into the third and fourth sessions) and appropriate prompts (adult guidance and questions related to the context), which were seen to provide opportunities to encourage the pupils to develop their own ideas.

The literature supports the idea that the technique of drawing is an effective and appropriate way for children to fully express their thoughts and their creativity (Guha *et al.,* 2004). As reported, in this study, the pupils performed several actions, such as using art-based supplies for brainstorming, drawing a model of their ideal app, and revealing their imagination by writing down their thoughts and ideas. This process of engagement can be characterized as creative acts based on the pupils' own interests.

Consistent with the literature, this research found that when accessible tools are provided, such as basic art supplies and when hands-on art activities (Druin, 2002) are performed, the pupils were motivated to develop their creative potential. Through these activities, the pupils felt secure and confident to initiate interaction and conversation or to draw content. The pupils were able to generate their thoughts within the options offered by the paper-based template. Using the self-expression template as part of the design process, the pupils were provided with the necessary context and structure to direct their ideas. An interesting aspect of this process was that all the pupils were able to write or draw on the piece of paper. However, a limitation of this approach was that the templates were small, and this might have prevented some of the pupils from writing detailed descriptions or adding a detailed drawing. In addition, the feedback (direct or indirect) obtained through this approach revealed that some of the pupils' ideas were either not applicable or not understandable. However, as a result of these sessions, valuable insights were gained into the pupils' interests about potential museum themes and the topics that attracted them as well as design features.

4.3 Summary

This chapter was centred on the participatory research approach, which was conducted prior to the development of the app to gain some initial insights into the interface's features. In this chapter, the comments and feedback derived from two groups of pupils with autism and their teachers were reported and analysed. The direct involvement of pupils with autism in the technology design in order to explore their preferences was the main focus of this part of the study. To do this, empirical data through field notes, audio recordings, and focus groups were gathered and reported. The analysis has highlighted the contribution the pupils with autism made to the technology design by offering some design ideas that could result in a museum app that would be both engaging and interactive. The analysis also revealed some key aspects that appeared to overlap among the data. These aspects represent the factors that influenced the experience of the co-design sessions. A discussion on each aspect was also presented.

Based on the pupils' input and on the ideas found in the literature, the following chapter addresses the design and development process of a museum-game app and articulates the input of the pupils with autism in a complete interface.

Chapter 5

Lifecycle of the interface

Introduction

In Chapter 4, the analysis of the data collected from the co-design sessions identified some of the features of the interface that can be useful and appealing to the pupils with autism. This chapter offers a contribution to the development of a museum-game app and explains the rationale underlying its structure as shown in **Figure 31**. Chapter 5 initially describes the process in which the prototypes were developed (paper and digital). It aims to discuss the various ideas and choices embedded in the decision-making process according to input from both the teachers and the pupils and the work by the design team as well as the guidelines derived from the literature review. Detailed information about the layout of the museum is given. Evaluation of the interface was conducted, and a questionnaire was employed to validate the software program's functionality and easy-of-use.

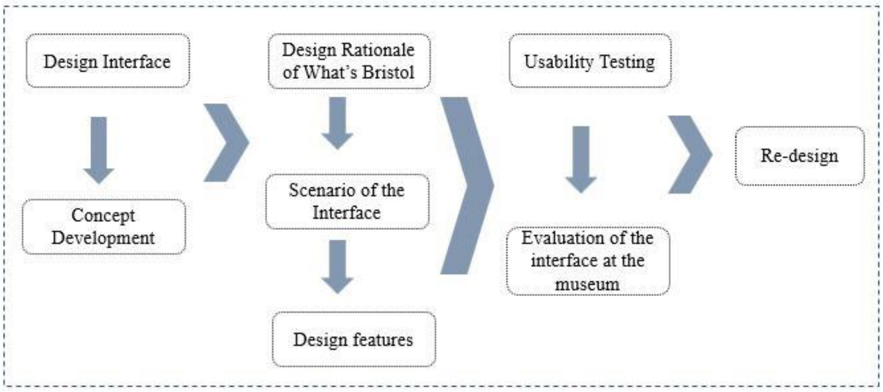

Figure 31 Overview of how the chapter is structured.

5.1 Iterative Process: Lifecycle of the app

Within Human Interaction Design (HCI), the concept of the iterative approach is recognised as an essential step in the life cycle of any digital platform. Iterative design is described as "a purposeful design process which tries to overcome the inherent problems of incomplete requirements specification by cycling through several designs" (Dix, 2004, p.241). In addition, iterative design is aimed at the development of a refined interface in small stages based on feedback gained through evaluation techniques such as observations and questionnaires (Rogers Sharp and Preece, 2011). These stages are repeatedly examined by experts such as the design team, and researchers. In this study, these stages were consequently examined by the pupils with autism and teachers who were participating in the design process. Throughout the cycle, these activities are intended to inform one another and to ensure that the presented prototype can meet the needs of the users. To conceptualise and design a novel app, an iterative design process was employed as seen in **Figure 32**. Throughout these stages, the importance of iteration as well as the involvement and ideas of the pupils' with autism, which were valued by their teachers and the researcher resulted in the development of an accessible museum-game app.

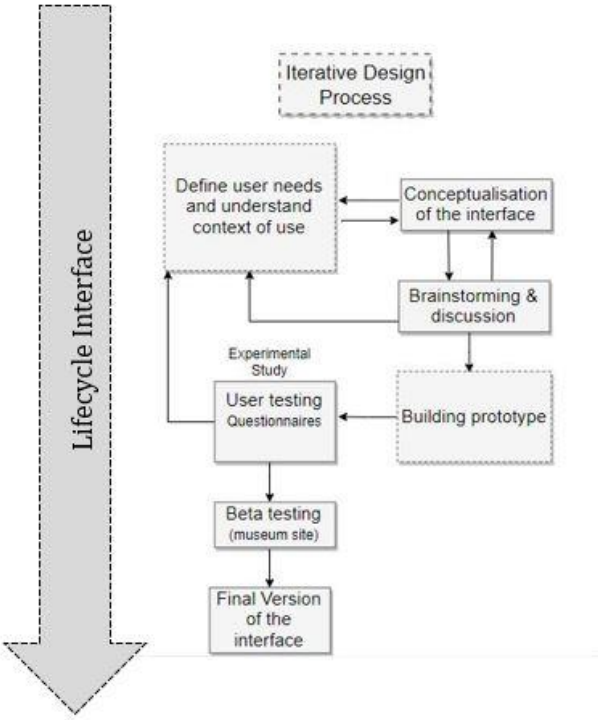

Figure 32 The stages undertaken during the interface development.

The process comprised six steps as follows:

1. Gaining insights into the characteristics of the children with autism and the context of use through knowledge of technology design principles for this group. These insights were obtained through a review of the literature and through focus groups with the intended participants, namely the pupils and their teachers, and were subsequently fitted into the development of the prototype.
2. Design of the interface and analysis of the features included in the interface.
3. Conceptualization of the interface and specification of the requirements of the pupils with autism in terms of how the pupils interacted with the interface.
4. Visualization in which different ideas were collected and presented through paper mock-ups and low-fidelity prototypes (brainstorming). This part considers in detail the development and feedback of the brainstorming prototypes.
5. Evaluation of the interface prototype against the pupils' requirements in which feedback about the interface was obtained through usability testing with those pupils who matched the target profiles and with team members. This stage was

employed to identify functionality issues based on the requirements established in step 1 and to give the pupils a real look-and-feel of the interface.

6. Re-designing and updating of the existing interface.

5.2 Brief functionality of the museum-game app

In terms of the functionality of the app, the core idea was to create an exploratory (Antle *et al.,* 2013) museum game-based app that supports the exploration of the museum content. A scavenger hunt game was chosen, as it is a highly applied form of game to capture children's interest in a playful manner (Avouris and Yannoutsou, 2012). This type of game attracts the players by providing a quick introduction and setting up the mission for them. Similar to what Kuflik (2014) and Heumer *et al.,* (2007) propose, the structure of the game was designed to have easy-to-follow navigation and simple content. The existing written information within the museum was not designed for children with autism, and so the present game app did not aim to deliver factual information by providing details regarding the exhibits gleaned from the information available in the museum. Instead, the aim was to make a museum visit enjoyable and fun by integrating audio and visual, as well as location-based features, in addition to some form of feedback to enable the pupils to gain an understanding of the museum content.

To increase accessibility, the device enabled the pupils to navigate the digital items by providing vocal guidance and relevant information on the screen of the device. The tasks were also differentiated to ensure that the app would support a range of abilities of the pupils and thereby enable the pupils to engage at different levels. Based on the nature of the scavenger hunt games, that is, to search for objects and to go in the right direction, it was necessary to know where the pupils were located. This was achieved by placing iBeacons in the targeted objects. The iBeacons were developed by the design team for the purposes of the present study and were installed throughout the targeted exhibits.

5.2.1 The rationale of the application development

Because children with autism may experience significant difficulties with understanding abstract concepts and processing new or complex information (Frith, 2003) one of the main requirements of this study was to develop a museum-game app with simple context and content. According to this, the rationale for designing the interface took into account, as a guiding principle, the pupils' needs and characteristics as described in Chapter 2 and the information provided in the Appendix A. The approach taken for the development of the interface recognized the need for a user-centred framework and for evaluation of each stage. The exploratory nature of the study included a series of sessions with the pupils as presented in Chapter 4 and an iterative process that contributed to informing the design of the app. Regarding the type of the platform, an iPad touchscreen device (model MD785B/A) was used to install the app.

5.3 Design of the interface: *What's Bristol?*

5.3.1 The setting: M Shed, Bristol

As stated in Chapter 3, M Shed museum was selected as the location to conduct the present research. M-Shed offers a number of autism-friendly services for children with this condition, so as to create autism accessibility and make visiting the museum a stress-free experience. Such services include: a) a pre-visit visual guide to help children familiarise themselves with the museum and the exhibits ahead of their visit (**Figure 33**), b) staff trained in autism awareness, c) telephone advice when the museum is quieter, and d) a Little Bag of Calm, which contains ear defenders, visual prompts, and fiddle toys.

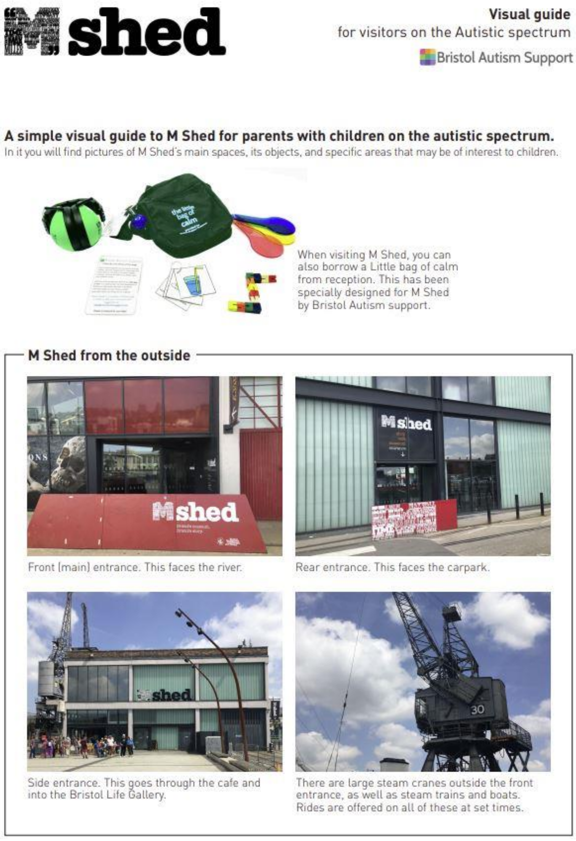

Figure 33 Visual guide for visitors with autism (Source: M Shed museum website.

In terms of its architecture, M Shed museum encompasses three main galleries with a wide range of artefacts, which are classified as follows: 1) Bristol Places, 2) Bristol People, and 3) Bristol Life. The collections of these galleries are distributed across two floors. In consultation with the teachers and the museum staff, it was decided to include the collection and exhibits of only one gallery: 'Bristol Places'.

During the co-design sessions, meetings (in total three, the period March to June 2017) were scheduled with the museum staff. It must be made clear that the museum staff did not provide feedback on any stage of the design of the app, and instead their primary role in this study was to provide recommendations regarding potential exhibits and to further discuss the logistics of the visit.

As reported by the teachers, the pupils had visited the M Shed museum in the past, although that visit was primarily focused on giving the pupils a quick preview of all the museum’s galleries on both floors. The present study aimed to provide important insights into enabling the pupils to remain in one of the museum’s galleries; the focus was to encourage them to engage meaningfully with the artefacts of the museum by acquiring information and completing the requested tasks digitally, all of which were relevant to the targeted objects.

In terms of the scenario, the purpose was to create a storyline of Bristol city including elements that are considered important for the city. As the museum’s focus is on presenting how the city has changed over the centuries, the choice of the artefacts embedded in the app was made by introducing the idea of chronology, that is, the artefacts in the app objects were selected as they represent the city, its discoveries, and its achievements through time. In this way, the pupils were able to have a greater awareness of the past and of how, in the past, people’s everyday lives and objects were different **Figure 34**- **Figure 35** show the ‘Bristol Places’ gallery.

Figure 34 Internal space of 'Bristol Places, as taken by Dimitra Magkafa at M Shed museum (2018).

Figure 35 The floating objects at 'Bristol Places gallery as taken by Dimitra Magkafa at M Shed museum (2018).

5.3.2 Concept development: Brainstorming prototypes

In the stage of concept generation, several sources were consulted to contribute to the development of the prototype. Information derived from the literature, co-design sessions with two groups of pupils with autism, and informal discussions with professionals, such as teachers and researchers in this field, was considered in building the scenario and the framework of the app. For the development of the interface, the research team collaborated with third year undergraduate students (enrolled in a BA Creative Media Design course), based at the same university in Bristol. **Figure 36** shows the procedure and indicates who was involved at various stages for the delivery of the interface. The priority was to focus on the concept and idea development and decide which activities would be implemented in the interface.

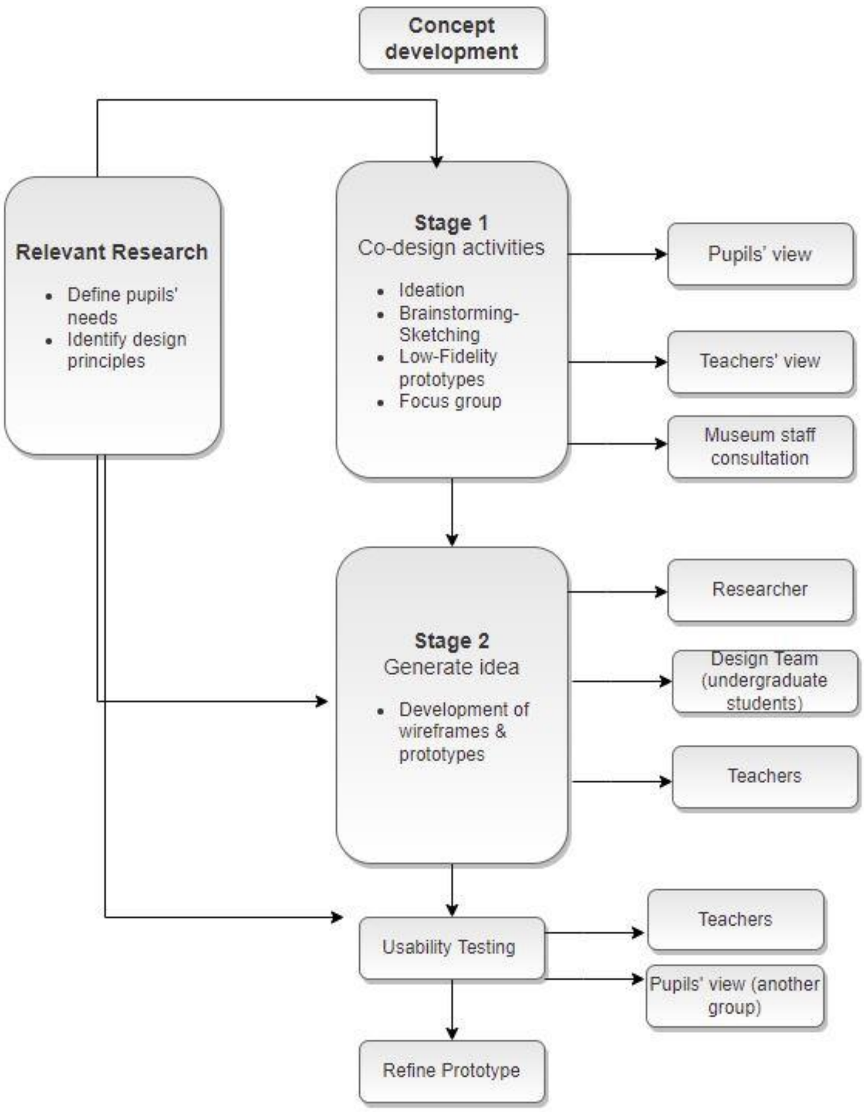

Figure 36 Flowchart of the process and the involvement of various stakeholders.

The idea of a scavenger hunt game and its story was developed by the researcher in consultation with the teachers involved. As the pupils took an active role and worked with the researcher, different ideas and insights emerged regarding the scenario of the app that would be appealing to the pupils (stage 1, end February to April 2017). Following the co-design sessions, the group of undergraduate students was involved in the design process and started working with the researcher to develop the app (stage 2, end September 2017 to January 2018). In this stage, the design team and the researcher reviewed the proposed ideas to determine which were likely to move forward.

The decision was taken to develop, as a concept, the scenario of an alien visiting Bristol. According to a recent study, a mission from Mars is one of the most well-known techniques with which to create interesting and appealing content for a product (Dindler *et al.*, 2005). Based on this as a context, the design team and the researcher met several times to map the wireframes and features of the app according to the requirements from relevant literature, the opinions of the pupils, and what was possible given the time constraints. During the design stage of the app, different ideas were generated by the design team and the researcher; meanwhile weekly meetings were arranged between the researcher, the design team and the teachers, to discuss whether the ideas could meet the pupils' needs and also to provide feedback (verbally) on the plot, the content, and the requested activities included in the app.

From the initial paper mock-up stage, the following issues were identified in the design concept:

- lack of help buttons
- poor design layout of the map with the targeted themes that the pupils needed to click on
- missing colours in usage and variation

Following the conceptualisation stage, the design team brainstormed prototype ideas under the direction and review of the teachers to identify the pupils' requirements and needs. These two stages were repeated to identify the pupils' requirements and needs. The iteration stage, as established previously, was important as new ideas were generated or established ideas were refined. Responding to the evaluation of the initial mock up prototype and after formulating its content, wireframes of an improved version (e.g., paper-based and digital prototypes) were developed by the design team and the researcher to produce a mock-up of the interface of the app, examples of which can be seen in **Figure 37**- **Figure 38**. These prototypes are an indication of how the interface would look like and what its functionalities. This process consisted of discussing ideas and identifying the key principles to be addressed in the interface as well as the tasks to be performed by the pupils.

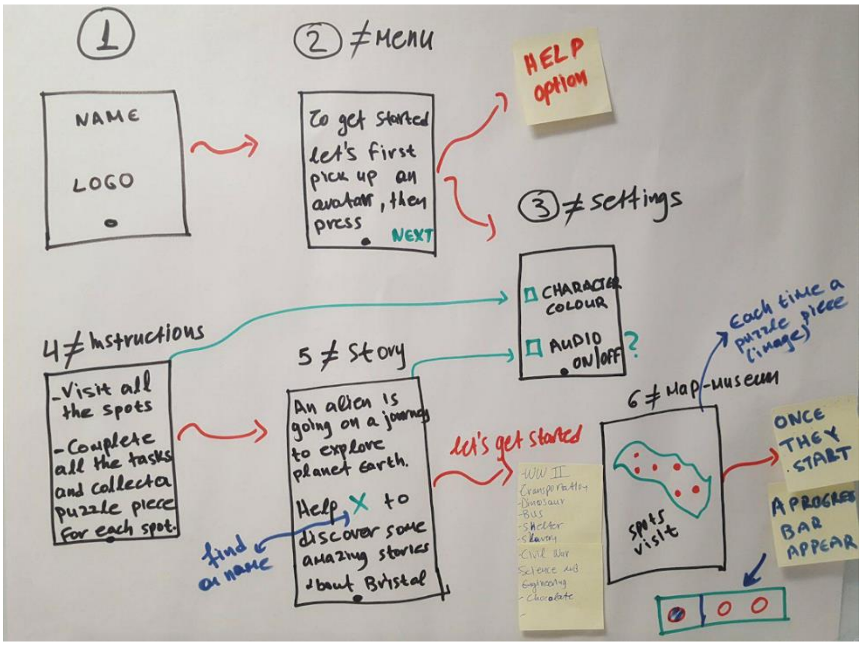

Figure 37 Paper based prototype of the interface.

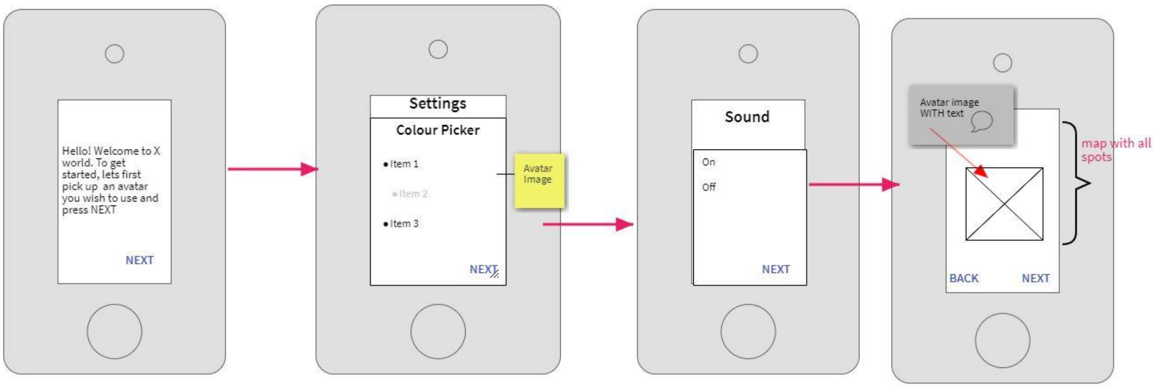

Figure 38 Initial digital prototype of the interface.

Furthermore, the flowchart of the app was an essential part of the design process, as it helped the researcher and the design team to map out the sequence of steps that the pupils were required to perform. **Figure 39** details the journey of an individual pupil and the actions (activities) that need to be completed.

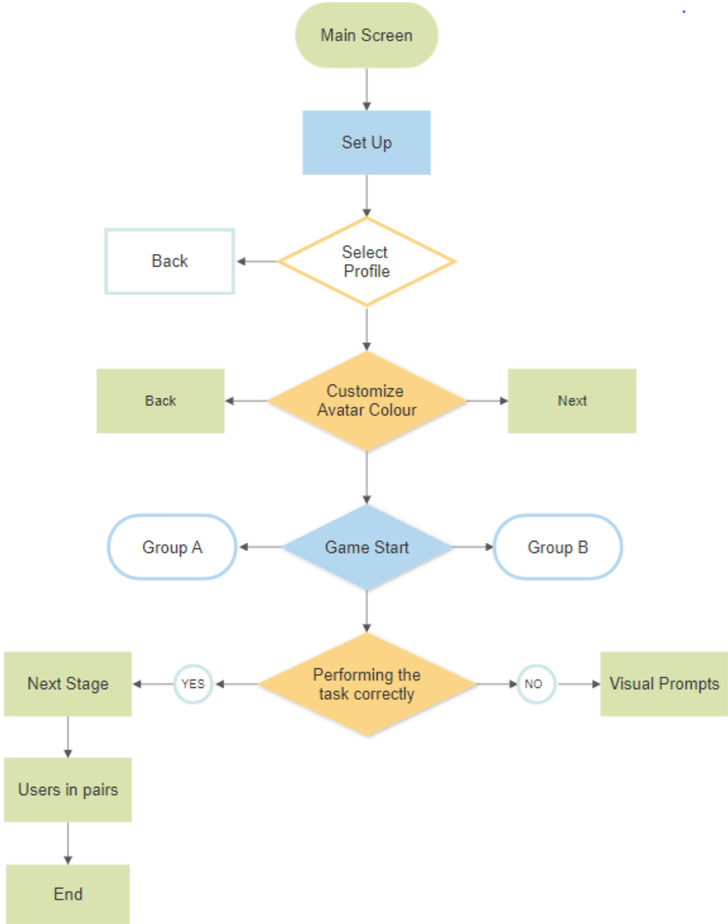

Figure 39 Flowchart of the user interface design layout.

Initially, to use the app, each of the pupils (in total two) is equipped with an iPad device. The pupils are shown the main page of the app and are provided with the story plot and are given detailed instructions (through bullet points) on what they need to accomplish during the museum visit including short- and long-term goals (as will be discussed in more detail later). Next, the pupils are asked to select a colour for Wallis (avatar); the main character of the game. In all these actions, a '*Back*' button is provided. The next page shows a map of the museum with all the artefacts the pupils are requested to visit and collect information about (working in the single 'individual' mode). Once the pupils have provided a correct answer, they are entitled to proceed to the next task. In the case of incorrect responses, visual and audio prompts are given to help them find the correct answer. After collecting all the items, they are prompted to work in the 'pairs' mode so they can exchange information about the exhibits they have explored. Finally, they are prompted to complete the final challenge of the game. During the activities, a 'Help' button appears on the screen in the top right corner. **Table 12** illustrates the timeline of the development of the app and shows the progression of the app according to input from the technologists', the teachers' and the ideas from the pupils. The first column presents all the ideas that emerged during the design process from different stakeholder groups. The second and third columns show the source of the suggestions and when these suggestions were identified. The fourth column indicates the priority level of the idea (may-should-definitely), and the last column includes all the features that were embedded in the final version of the app.

Table 12 Table of change' includes all the ideas proposed by different stakeholders from the initial design of the What's Bristol? app to its implementation, when each idea was produced, the priority level, and the ability to be embedded into the final design.

Suggested feature/idea/change	Source of idea	Session it was generated	Priority Level	Ability to include it to the final version
Integrating augmented reality	Design team	Initial meetings with the researcher	May	Not included as there was not time to integrate a such complicated feature
Simple stories about the exhibits	Researcher	Initial meetings with the teachers and design team	Definitely will include	Included
Treasure-hunt type of game	Researcher-Teachers	Initial meetings with the teachers	Definitely will include	Included
Short route (maximum 20')	Teachers	Initial meetings with the researcher	Definitely will include	Included
Integration of help buttons	Teachers-researcher	During the mock up version	Definitely will include	Definitely will include
Simplified language in some tasks	Teachers	During the mock-up version of the app	Definitely will include	Included

Orientation map	Researcher	During the mock-up version of the app	Definitely will include	Included
Use of instructions to introduce the pupils into the game	Researcher	During the design of the app	Definitely include	Included
Expansion of the app including more artefacts from the ground floor and the 1st floor (e.g., II World War & the Slave Trade exhibition)	Researcher-Design team	During the design of the app	May	Not included. It could have been complicated for the pupils to navigate around two floors.
Selection of colour layout	Design team	During the design of the app	Should	Included
Yellow background	Teachers	During the design of the app	Definitely will include	Included
Design of the figures/artefacts	Technologists	During the design of the app	Definitely will include	Included
Integration of single and pair mode	Researcher/Design team	During the design of the app	Should	Included
More structured activities	Teachers	During the design of the app	Should	Included
Pair-work	Pupils	Co-design (1st)	Should	Included
Simplified language	Pupils	Co-design session (1st)	Definitely will include	Included
Format of questions via text & sound	Researcher-Pupils	Co-design session (1st)	Definitely will include	Included
Reward with sound & images (e.g., coins)	Researcher/Technologists	Co-design (2nd)	Definitely will include	The rewards included sound & image, but

				the image represented part of an artefact (bridge) which would help the pupils find the last exhibit
Feedback with sound & images	Researcher/Pupils	Co-design (2^{nd})	Definitely will include	Included
Representation of the proposed artefacts in a list format	Pupils	Co-design session (2^{nd})	May	Not included. The proposed artefacts were represented graphically on the map.
Navigational components at the bottom	Pupils/Researcher	Co-design (3^{rd})	Definitely will include	Included
Customised changes based on the pupils' preferences (e.g., changing size, clothes or other features of the avatar)	Pupils	Co-design session (3^{rd})	Should	The customisation included only changes of the avatars' colour. as there was no time to make additional work on that feature.
Variety of activities	Pupils	Co-design session (3^{rd})	Definitely will include	Included
Multiplayer mode	Pupils	Co-design session (4^{th})	May	This feature could not be included, as the app was designed for single-player & pair-mode so that the researcher would be able

				to record the pupils.
Location of awareness system	Pupils	Co-design session (4th)	Definitely will include	Included
Integration of game features (e.g., short/long term goals)	Pupils	Co-design session (4th)	Definitely will include	Included
Various exhibits	Pupils	Co-design session (4th)	Definitely will include	Included
Non-linear route	Pupils	Co-design session (4th)	Should	Included but it was designed in such a way that it created a structured route
Add more colour variations for the avatar	Pupils	Usability testing session	May	Due to time restrictions, this suggestion was not included.
Re-adjustment of the size of the navigational buttons	Pupils	Usability testing session	Definitely will include	Included

5.3.3 Design rationale of *What's Bristol*?

5.3.3.1 Scenario of the scavenger hunt interface

As reported in Chapter 4, two groups of pupils with autism contributed to the initial design of the app through several activities. In their role as design informants, the pupils were involved in providing feedback about the features of the app. The goal of any interface is to ensure that the users will be able to have easy access to and understanding of the concept of the app. Therefore, it was important to develop a system whereby the elements would allow the pupils to navigate the platform easily. The analysis of the co-design sessions provided useful feedback and interesting ideas about the design of the interface. The pupils consistently highlighted that the interface needed to provide a level of customization with simple language and the incorporation of some game features. Based on the literature, such features seem to encourage children with autism to undertake an initial engagement with the interface while the use of game components can act as a motivator to keep playing the game (Whyte, Smyth, and Scherf, 2015; Millen and Cobb*,* 2012; Zichermann and Cunningham 2011).

The *What's Bristol?* app presented a story as follows: The story features an alien named Wallis who has been given a mission, that is, to explore Earth, and its first destination is Bristol. Because of the game's mission, Wallis asks for the pupils' help to uncover what it is hidden in Bristol's past. Two different museum paths are delivered. Wallis guides the pupils using the app to explore different areas of the collection of the museum. The main purpose of *What's Bristol*? is to bridge the gap between physical and digital space and immerse the pupils in an unexplored world, specifically, that of the museums. In doing so, the game app relies for its strength on creating an engaging narrative which is well suited to the physical environment, and it presents stories about the museum's artefacts as found in the collection. To uncover the museum's stories, the pupils need to engage with the artefacts proposed by the app.

To proceed to the next stage, the pupils are required to perform a mix of constructive activities for varying levels of cognitive ability in each of the targeted exhibits. The chosen activities include a) multiple choice questions, b) point-and-click, c) drag-and-drop, d) a crossword, and e) puzzles. These activities are intended to make the visit more engaging by allowing the pupils to perform actions by physically moving objects on the screen and to order or combine different elements while uncovering an intriguing story. The chosen activities were considered developmentally appropriate not only for the diverse needs of the pupils but also they were also designed to keep the pupils engaged in hands-on and minds-on enjoyable concepts (Piscitelli, Everett and Weier, 2003). The concept of kinaesthetic thinking in which mind and body are connected during the process can have several advantages for children with autism, who have difficulties filtering sensory input. Accordingly, the app allowed the pupils the opportunity for experimentation through the use of different modalities, such as sight, touch, and sound, which encouraged the pupils to remain engaged during the visit.

5.3.3.2 Game Description

At the start of the experience, the pupils are introduced to the game's instructions and the goal of the game; each pupil needs to move around the gallery with their handheld devices seeking the artefacts shown on the map as depicted in the grey colour. Each of the museum artefacts integrated in the game is related to each of the locations given on the map (see in detail Appendix M). The system allows the pupils to select their own route by following the artefacts of interest to them while being guided by the targeted themes on the screen. A non-linear route was one of the recommendations proposed by one of the pupils in the co-design sessions (Rob: "*The players can choose which spots to visit*"). However, the exploration route was designed to be structured but non-linear; the app aimed to prevent the pupils from being overwhelmed by the large number of artefacts and the amount of information, which could possibly result in them getting lost (Rubino et *al.,* 2013). Thus, a selection of areas that they were required to visit provided comfort in an unfamiliar setting while giving the pupils the opportunity to explore.

What's Bristol? app can be considered a game that enables collaboration in pairs while it gives the pupils the freedom to work on their own to reach the in-pairs level. The story content consists of three levels. In the first level, the pupils are requested to work individually and answer all the questions. To do this, each of the pupils is invited to find and interact with certain artefacts around the gallery. Once in the proximity area of the iBeacon, the digital picture of the selected artefacts displayed on the screen providing them with information about the exhibit. For every successfully completed task, the pupil is rewarded with a piece of a puzzle on the screen. Once the pupils have visited all the locations and collected all the puzzle pieces (four in total), they are prompted to meet with their partner to share information about the different themes explored and then to put all the pieces of the puzzle together (second level). Then, the image of the puzzle (Suspension Bridge) leads both pupils to find the last hidden clue: the Suspension Bridge. This part is the third level of the game where the pupils need to solve the final challenge in order to complete the game (as depicted in **Figure 40**).

Figure 40 Screenshot of the app presenting when the pupils need to find the final exhibit.

The game content was designed to facilitate an active exploration of the museum exhibits with hints provided by the device. In this process, the goal of visitor-screen-exhibit-interaction mode was achieved as the device was assigned the role of the medium. The digital images of the exhibits served merely as a hint to the real exhibits, and the pupils needed to search for clues. Being active explorers, the pupils were requested to look for the exhibits, observe them closely to obtain the clues, and reveal their stories. Pupils could complete the mission as long as all the requested activities were solved.

5.3.3.3 Selection of museum exhibits

The constrained timeframe of the development of the interface (within three months) meant that the space where the pupils would search for objects had to be limited. Based on the teachers' suggestions, the game would last for around twenty minutes. Although the intention was to encompass more themes from the first floor, these constraints meant the app included exhibits of the ground floor only. A number of objects were chosen to interpret and transfer the historical context of the city. In an effort to design an appealing game-type app, the researcher in consultation with the museum's staff selected areas relevant to the local history. The selection was guided by the following criteria: a) to use exhibits located in the 'Bristol Places' gallery and spread around this floor because the pupils may have found moving around two floors stressful and frustrating, b) to include the most attractive and engaging exhibits for children based on the museum's data and evaluation, and c) to select exhibits representative of the city to help the pupils gain a brief overview of what events took place in the city and how it was transformed over the centuries.

5.4 The design features included in the *What's Bristol*? app and its core features

5.4.1 Understanding interaction design and the rationale of guidelines

Universal design or design for all has been defined by Stephanidis *et al.*, (1999) as a concept that "recognizes, values, and accommodates the broadest possible range of human abilities, skills, requirements, and preferences in the design of all computer-based products and environments" (p.3). This approach promotes an inclusive design process that incorporates accessibility measures and individualised environments. Dix (2004) argues that the user interface plays a central role in determining whether a product is successful. Interaction design is concerned with the practical aspect of how to best design user experiences. Information about the intended users is a key step in helping designers to examine how people use such programs as a tool to support a task. Human cognition is a complex and challenging issue, and there is a need to understand further the capabilities and limitations of the intended users when producing interactive products (Dix, 2004). To be able to produce an accessible interface, design principles and guidelines provide a helpful orientation for the designer's thinking and the design process respectively. To understand this better, it is necessary to explain further and identify what *principles* and *guidelines* mean in the field of human computer interaction.

Design *principles* are defined as abstract design rules focusing on the human element in the interaction with any technology program, and they aim to give designers direction about various aspects of their design (Rogers, Sharp and Preece, 2011). Meanwhile, *guidelines* are prescriptive technology-oriented recommendations on what users need to see and how to improve designs based on the users' needs (Dix, 2004). In fact, both *principles* and *guidelines* serve as input in producing requirements for use and for ensuring that the proposed products are accessible and fit for purpose. This, in turn, helps designers/ research teams to build a clear picture of how to act in the best interest of the users and to concentrate on appropriate design directions.

The principle of UCD is central to HCI and enables the designers to produce products and integrate specific features that can fit their targeted users' needs. For example, children's needs and preferences differ from those of adults (ETSI, 2005); there are distinctive differences between the cognitive level and abilities of adults and children respectively about what they want to see and use in a digital product (Rogers, Sharp and Preece, 2011). This leads to designers applying guidelines tailored to children's skills and cognitive development which focus on keeping children motivated and engaged throughout the user experience. In the case of children with autism, this involves a more careful examination of usage profiles, as there is a range of differences. These include impairments in the process of information, perception, reading skills, and problem solving (ETSI, 2005). These differences stress the importance of finding relevant concepts and applying specific requirements that can accommodate the expectations of children with autism (Davis *et al.,* 2010). Given such diversity, all those challenges can have an impact on how and whether children with autism can use an interface effectively.

To design the *What's Bristol* app, the overarching aim was to produce an interface environment that could match the cognitive development of the intended users, that is, pupils with autism. It was therefore important to address the needs of the pupils so that the interface would be reactive to their input style. The portable touchscreen device was designed to help pupils with autism experience the exhibits of a local museum. The app was built by embedding various features combined with game design features to create an interface that was not only suitable for pupils with autism but that was also engaging for them to interact with.

The design process of the interface involved a careful consideration of the existing literature that suited the needs of the pupils and the best practices associated with using technology to improve the access to children with autism. It also required consultation with the pupils who were the intended users. All of these strategies aimed to create a good user experience and enhance the interface's efficiency by providing an interdependence between the pupils and the various features of the app. As highlighted in previous studies, a rule of interface design for this particular group of learners is to reduce complexity and to give a simple and clear exploration of the interface (Weiss *et al*., 2011; Brown *et al.,* 2011). Following these principles, *What's Bristol?* was designed to be suitable for the pupils participating in the study to explore further various points of the city. In developing *What's Bristol*, the design focused on eight features: a) customization, b) consistency, c) feedback and rewards d) navigation tools, e) visual layout, f) design colour layout, g) multimedia features, and h) game features. These features were identified as being important in the exploratory study. A synthesis of the features that were finally integrated in the platform can be seen in Appendix N.

Customization

Customization is a key element which allows users of an interface to express themselves and which connects them further to their character thus adding value to their experiences (Zichermannand Cunningham, 2011; Millen *et al.,* 2011). In this study, this notion was referred to by the pupils in the co-design sessions, while in the user-testing evaluation, the pupils suggested a variety of colours for the main character of the game.

> Charlie: "*You have different characters and a search bar, and the user can select one of those (guy, lady or child). On the corner, you can have a little thing with the face of the character.*"

Although the pupils expressed a desire to be able to customize the colour of the background, it might have had negative consequences. However, the pupils were offered an opportunity to personalize the character of the game and to change its colour. As seen in **Figure 41**, the interface provides four colour options which the pupils need to choose one of the options to proceed to the next step.

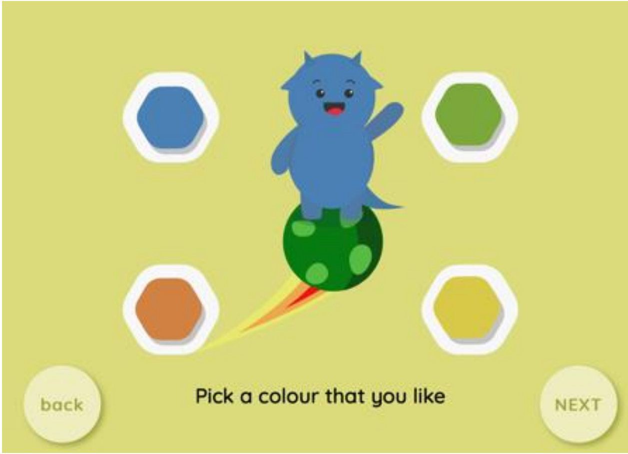

Figure 41 Screenshot of the customised options the pupils are offered.

Consistency

Consistency of the user environment is one of the key principles that an interface needs to achieve to prevent users with autism being made anxious by unexpected situations (Davis *et al*., 2010). This implies that over time, certain stimuli, such as a character's verbalisations or visual actions, should be similar to the current users' actions in a predictable way in all scenes. As shown in **Figure 42** and **Figure 43**, the present interface was designed to be visually consistent by providing the same command buttons (e.g., colours, sizes, shapes), typefaces (such as *Help*, *Next*, *Back*), layout, and icons in each screen. In addition, the behaviour of the character (audio) remains the same throughout.

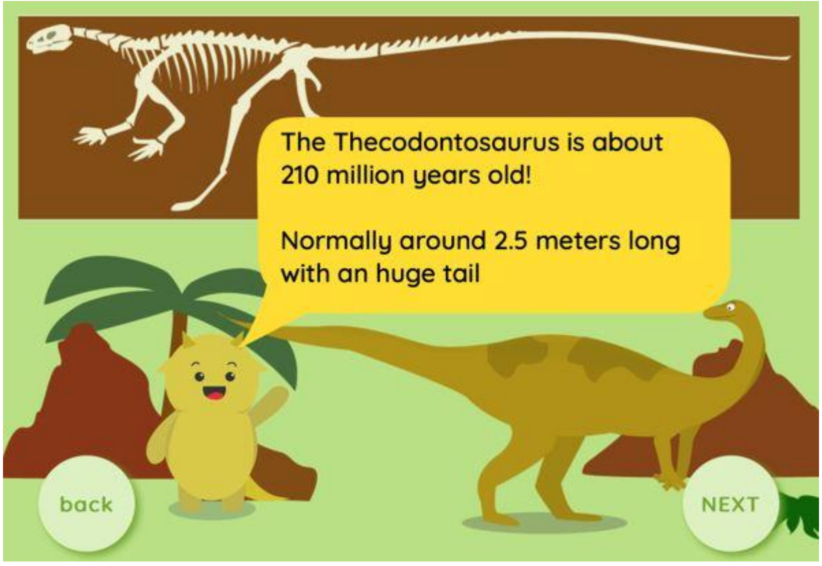

Figure 42 Screenshot of the consistency of the interface through the same command buttons.

Figure 43 Screenshot of the consistency of the interface through the same layout, typefaces.

Feedback and Rewards

In the game apps, the feedback as a feature is reported as being of immense importance to help track the user's actions and control the progress of the game (Hayes *et al.*, 2010; Davis *et al.,* 2010). In this study, the app was designed so that the pupils would receive immediate feedback when they completed each of the four first tasks; a short text "*Well done! You have completed the task and earned a puzzle piece*" is displayed in the middle of the screen, and an audio track is played simultaneously with a voice recording (**Figure 44**) congratulating the pupil when they have successfully completed the in-game tasks.

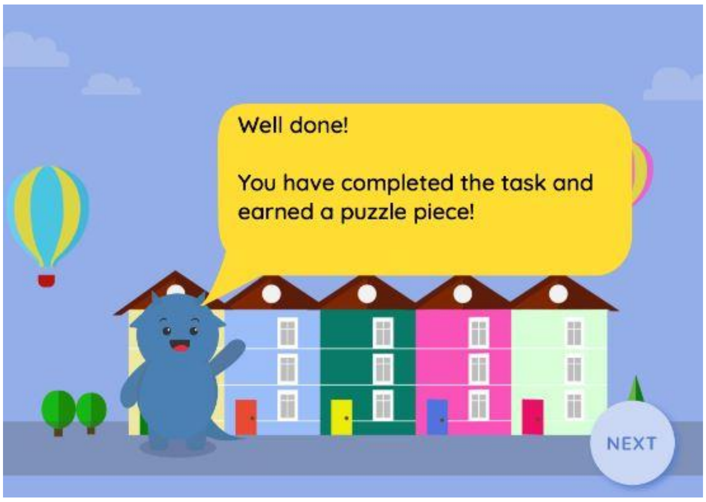

Figure 44 Screenshot of correct feedback.

In addition, the use of feedback (e.g., feedback with audio clip and picture) was a feature that the pupils highlighted during the co-design sessions. If the pupils do not achieve the goal, a *help* message appears and gives more information regarding what they should do (**Figure 45**).

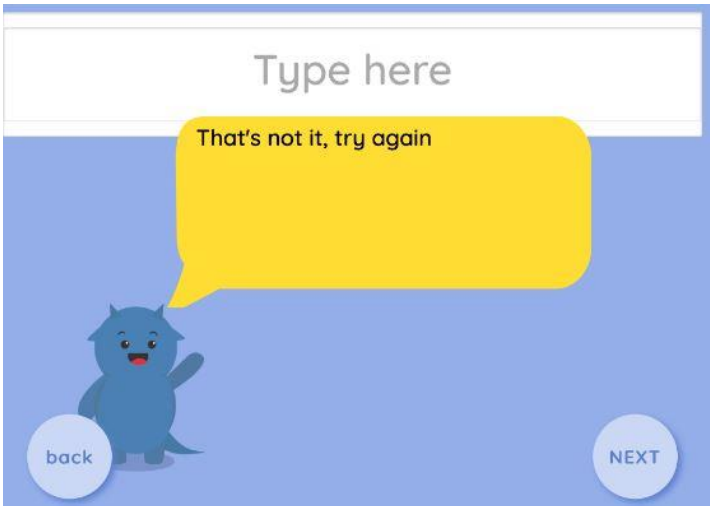

Figure 45 Screenshot of incorrect feedback.

In the co-design sessions, the pupils unanimously approved the use of sound and images as a reward for their achievements and performance. At this stage of the game, the pupils collect pieces of a puzzle, which helps them to measure their success. Each piece is displayed on the screen after completion of the final task of each exhibit (**Figure 46**). The reward is indicated as a points system and acts as an additional driver of motivation to prompt the pupils to collect as many pieces as possible and to then proceed to the next level.

Figure 46 Screenshot of the reward given in a correct answer.

Navigation

When designing an interface, it is considered important to simplify the navigation system efficiently by providing consistent navigation buttons in the same place. In the *What's Bristol?* app, the interface includes three navigational components in the form of buttons with *next* and *back* on each page whilst a *help* button appears every time the pupil cannot respond correctly. The buttons were designed to be sufficiently large to enable the pupils to direct the flow of the game (Darejeh and Singh, 2013) and to navigate back and forth across the interface in order to find their route. Moreover, the navigation buttons were positioned in the bottom corners of the screen as proposed by the pupils and in the case of incorrect responses, the *help* button is displayed on the top right side of the page (**Figure 47**- **Figure 48**).

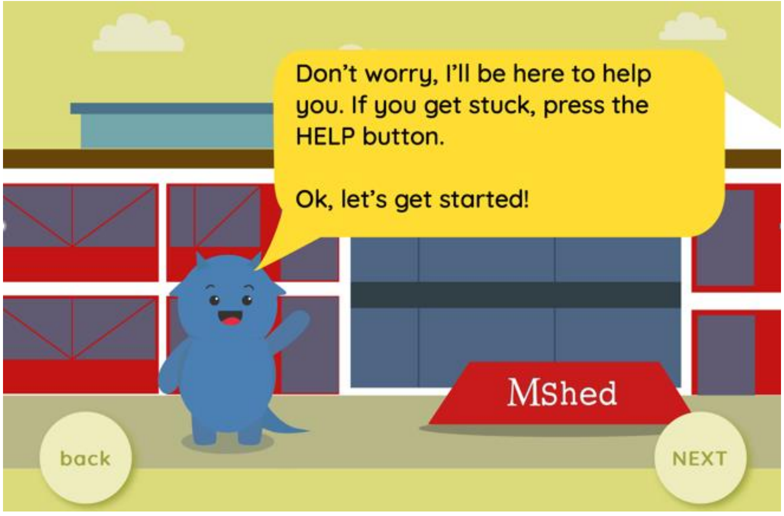

Figure 47 Screenshot of the navigational components of the interface ('Back' and 'Next').

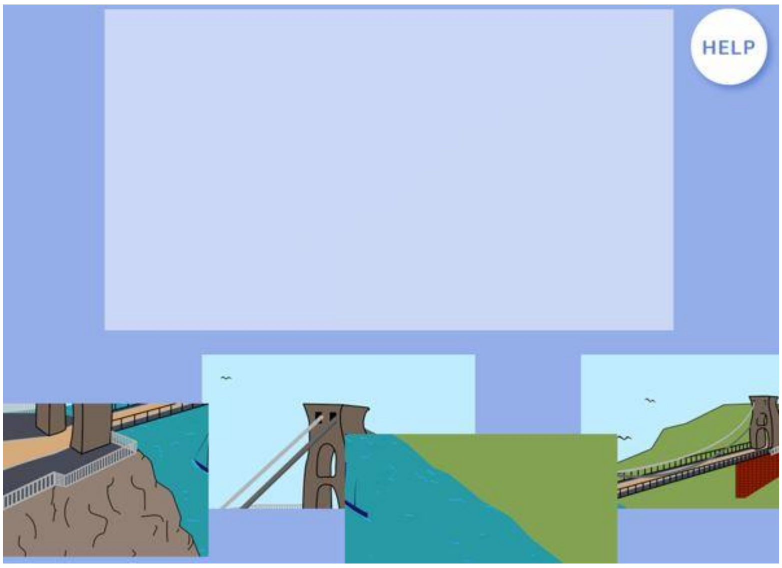

Figure 48 Screenshot of the navigational component of the interface ('Help').

Visual layout

Graphical visuals were applied to the interface by designing digital representations of the museum objects. During the co-design sessions the pupils expressed the idea that the themes of the museum be presented as a list. The preferred spatial layout precisely represented the original layout of the museum's floor in connection with the displayed themes. Given that pupils would be in a new place, such as a museum with a large quantity of exhibits, a visual simplification of the layout was intended to guide them and to help them easily recognize the positions of the target objects they had been requested to explore further. To start the visit according to the designed interface, the pupils had to choose an icon that represents a theme. **Figure 49** and **Figure 50** illustrate the museum's layout in a paper-based format and show how the page appears with the related content of the museum exhibit digitally.

Figure 49 Museum's layout in paper-based format.

Figure 50 Screenshot of how the focused exhibits are presented.

Design Colour Layout

Consistency between the screens plays a crucial factor in enabling users of an app to adjust easily in the interface (Sitdhisanguan *et al.,* 2012; Davis *et al*., 2010), a feature which is of particular importance for users with autism. Therefore, to avoid any disorientation, the background and foreground of the interface differed. More specifically, the navigational buttons (*next* and *back*) were displayed in colours that were clearly different from the background (intense background, light foreground). As illustrated in **Figure 51**, the text boxes of the interface were designed in a yellow background for those pupils who experience reading difficulties. The literature indicates that text presentation can influence the reading performance of people with reading difficulties. That is, warm colours, such as yellow, peach, or orange, over black, are recommended to enhance the ability of users to read on screen (Gregor and Newell, 2008).

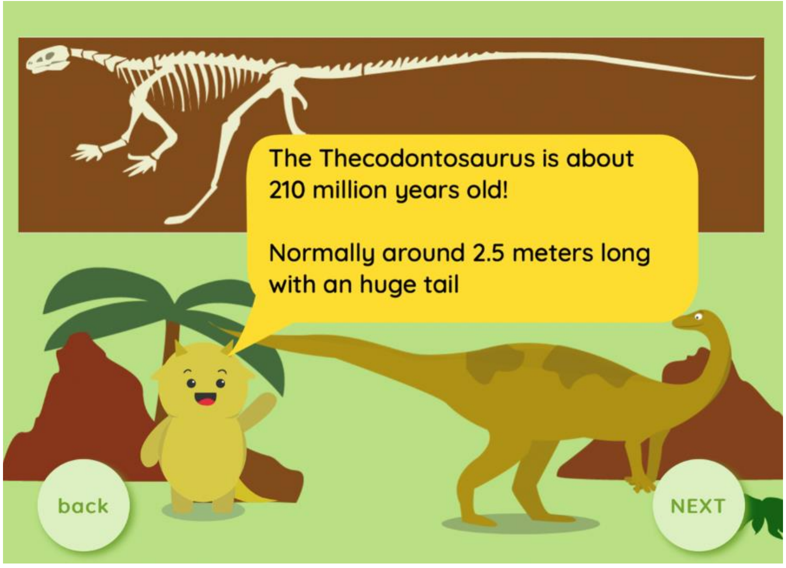

Figure 51 Screenshot of the colour contrast between the foreground, background, and yellow text box.

Multimedia Features

The research suggests that the use of multiple representation and concise text passages with the format of lists is of immense significance to convey information to the users of an app. Hence, due to the pupils having varied levels of literacy and skills, it was considered appropriate for the design of the app in this study (Darejeh and Singh, 2013; Putnam and Chong 2008; Friedman and Bryen, 2007). It was noted that the pupils commented that a simplified content would be helpful for them to reduce any confusion (Andrew: "*We want the simplest way*"). Furthermore, the incorporation of multimedia features through images, videos, and animations was also reported during the co-design sessions by the participants. To achieve this, information content was embedded through a visual medium. Short texts accompanied by digital images in close proximity conveyed information and helped the pupils' concentrate on the task. The content was also displayed in the format of lists to enable the pupils to have a better reading flow (**Figure 52**) and an audio track with character's voice was used as an additional tool to transfer information relevant to the content and help those with reading difficulties.

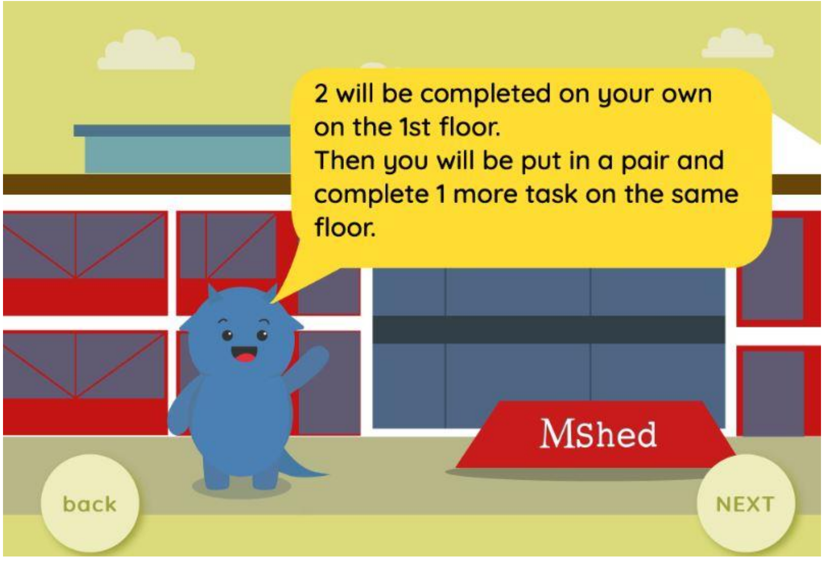

Figure 52 Screenshot of the instructions of the interface as lists.

Games features

For this study, as it was agreed that the nature of the app would be game-based, the interface adopted several game features. Game features are perceived as a combination of different tools to guide how the users interact with the world of the game and improve the motivational appeal (Zichermann and Cunningham 2011). Moreover, the inclusion of game features was mentioned by one of the pupils in the co-design sessions. As such, to inspire the pupils to accomplish their goals and to have a worthwhile experience, the *What's Bristol*? app incorporated several game features. However, some of the features overlapped with the design features; these have already been discussed above.

> Rob: "*The users need to get two items in order to open the first box and then four to open the golden one*"

> Regarding the collaboration between the players:

> Rob "*This part of the game can be a multiplayer game, so more people could play together*".

Narrative story

A story plays an important role in the game's success and helps the users to feel an emotional attachment to the characters and to act upon the story context. The concrete scenario (setting up its adventurous nature) can attract users who are less motivated (Whyte *et al.*, 2015; Sung *et al.*, 2011). Hence, in this study, the integration of a storyline aimed to make the pupils more willing to explore the exhibits. The first screen features the storyline of the game with the aim of capturing the pupils' interest. A cartoon character Wallis introduces itself and establishes the goal of his visit: "to explore Earth with the player's help" (as **Figure 53**).

Figure 53 Screenshot of the storyline.

Short and long-term goals

Challenges and goals "give players direction for what to do within the world of the gamified experience" (Zichermann and Cunningham, 2011, p.64). In this app, the pupils are asked to complete a set of actions. The main goal is to collect puzzle pieces so that a picture of an important landmark of the city will appear. While playing the game, the pupil needs to complete several short-term activities to move forward (e.g., to explore unknown museum objects by finding information from different objects or dragging and dropping pieces of exhibits to complete a picture). The completion of the short-term activities is necessary to achieve the long-term activities (e.g., to work together for the last mission). The idea of setting goals was to make sure that the pupils would be motivated to accomplish something. The combination of actions helped the pupils develop an understanding of how they can progress in solving the puzzle, as shown in **Figure 54** (next page).

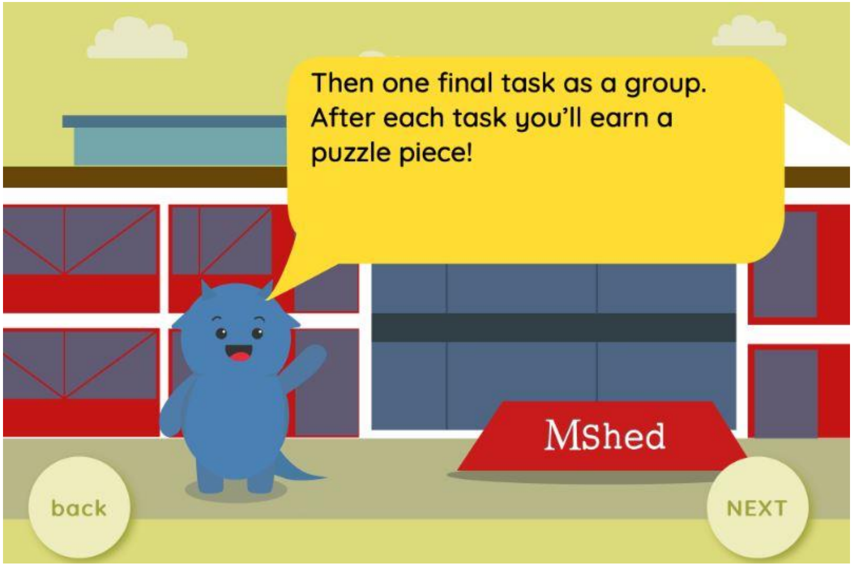

Figure 54 Screenshot of part of the game's goals.

Instructions

In the *What's Bristol* app, instructions are given to establish the actions the pupils should adhere to and follow during the play. This feature was included to help the pupils understand how to proceed to the next action (**Figure 55**).

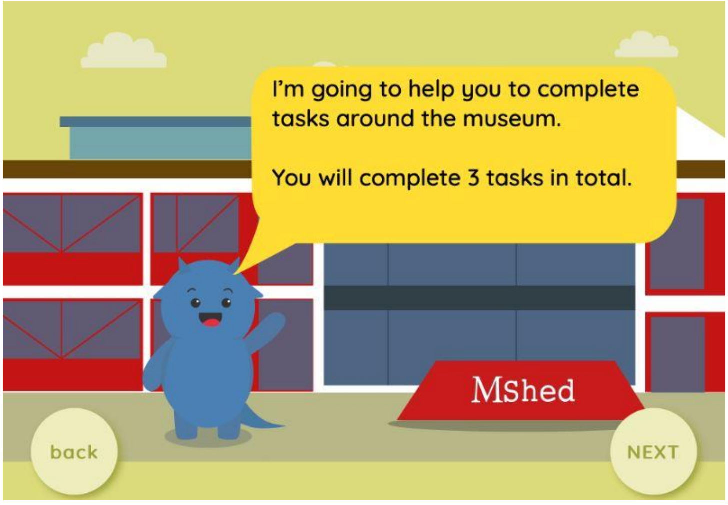

Figure 55 Screenshot of the instructions set in the beginning of the game.

Collaboration

Zichermann and Cunningham, (2011) point out that it is worthwhile designing a single-player game "that can evolve into cooperative play as the player gains mastery and more players join the game" (p.65). This app was designed on two levels: it starts with a single-player mode, where the pupils need to work on their own and explore various locations in the museum, and then it progresses to a two-player mode, where the pupils need to collaborate to exchange information and help each other to solve the final challenge. Thus, the structure of the game is in a single mode; however, some parts were designed to encourage cooperative play between the pupils. The idea behind this was to promote cooperation and examine whether the pupils were able to exchange the new information they had learned (**Figure 56**).

Figure 56 Screenshot of the pair work.

5.5 Usability testing

Improving user interfaces has become a critical step in HCI (Rogers, Sharp and Preece, 2011). An outcome of usability evaluation in practice is to build a user-friendly interface so that the users can manipulate the device in an effective way (Crowther, Keller and Waddoups, 2004). From a designer's perspective, an evaluation makes it possible to improve the interface functionalities and to identify and solve any defects before the interface is put to use (Nielsen, 1994). Through this, designers can elicit any insights into users' needs whereby the interface has to be refined. In an effort to include user testing in the design process, the interface in this study underwent evaluation through user testing with another group of pupils participating in the study. To do this, an initial interface was tested to gain a first-hand insight of the pupils' response. It was also conducted to assess the level of the accessibility (WCAG, 1999), learnability, and usability (Nielsen, 1994) of the interface and to make the appropriate changes required to improve its functionality if necessary.

5.5.1 Procedure

After developing the first version of the app, a usability testing session was conducted (December 2018) with another group of pupils with autism from the same school. The usability test required the new group to test and evaluate the prototype test interface. The aim of the evaluation was not to measure the pupils' behaviour but, rather, to provide empirical data in terms of the app's functionality and content, thus creating a final version that would be understandable and accessible enough to meet the pupils' needs.

The recruitment of the pupils was done by the teachers and based on the criteria set in the beginning of the study. It should be mentioned that some of the pupils did not meet the inclusion criteria; however, as discussed in the methodology chapter, for purposes of fairness and equity, the decision was made to include all of the pupils from the classroom in testing the interface. While the final design concept covered several objects from the 'Bristol Places' gallery, for the user testing stage, only a short part of the plot was developed to be assessed; this included the context of the game (storyline, goals, and instructions), the dinosaur activity, and the bridge puzzle.

The session was held in the pupils' classroom, thus providing a valid contextual inquiry. Contextual inquiry in this study refers to when the process of capturing data and the related activities take place in the context of the pupils' school. This was because the pupils felt more comfortable to express themselves in a familiar setting, such as the classroom (Druin *et al*., 1999). First, the pupils were introduced to the testing session, and its purpose was clearly explained. Following this, each pupil was provided with an iPad device with the app installed and was asked to interact with the interface. A member of the design team and the researcher observed the pupils and acted as facilitators by prompting them verbally whenever necessary to move on to the next task. In addition, one school staff member (teacher) was present. The goal of the evaluation was to examine the information content and navigation of the interface. The session finished by having the pupils fill out a usability-testing questionnaire (Appendix G).

5.5.1.1 Participants

The user-testing class (henceforth, the Yellow Class) consisted of six children (n=6), and the pupils were appointed to the role of tester (Druin, 2002). The pupils' ages ranged between 8 and 12 years (mean: 10.6 years, standard deviation (SD): 1.5); four were males and two were females. Most of the pupils had a formal diagnosis of ASCs or other learning difficulties (details of the pupils' demographic information is presented in section 3.1.2). It should be mentioned that one of the pupils withdrew from the testing before the beginning of the session.

5.5.2 Findings: Questionnaire

Data were collected through a post-test questionnaire. This technique of enquiry sought to reveal the pupils' eagerness to interact with the device and to detect any functionality errors. In addition, a questionnaire was given to the teacher of the class to be filled out (Appendix H). The pupils' questionnaire was based on visual representations (e.g., happy and sad faces) and covered mostly issues of accessibility and usability. These included: navigation, information content, and the integration of media formats, such as the combination of text and sound. (e.g., Was the size of the letters easy to read? ☺ ☹ If you want to say more, write your thoughts here, Was the language easy to understand?).

Of the six children, four (n=4) completed and returned the questionnaire whilst one participant (Sergio) refused to complete it. The feedback from the pupils' testers' group and from the teacher showed that the refinement of the initial prototype was considered necessary by making some adjustments. Overall, all the pupils were found to be able to interact with the interface, without facing certain difficulties; they all found (n=4) the language understandable and the mission of the game clear. Based on the pupils' experience, the tasks were found to be easy (n=4, Iris commented *"very easy"*) and the size of the buttons *"very big"* to click on (n=3). One issue that emerged was that the size of the letters was detected to be *"a bit hard"* for Yianni, as he was not able to read the text clearly. Moreover, they all liked the colour choices, but Franjesca and Yianni further expressed the idea of more colours for example: *"Need more colour* *variety for the Alien" or "Put some colour in the Alien's eyes".* Finally, the pupils responded positively when they were asked whether the option of text and sound was helpful.

5.6 Reflection

The study described in this chapter discussed the process of developing a scavenger hunt game-type application, named *What's Bristol?*. A participatory design approach presented in Chapter 4 was employed, and different stakeholders were involved, such as teachers, pupils with autism, and a design team. All these steps helped to inform the design changes of the interface in the process of moving from making paper-based prototypes to developing an initial prototype. The development of the interface followed an iterative rather than a linear process, as it involved moving back and forth until the optimal version was achieved. The iterative process entailed six different stages, and each stage was discussed in detail.

Initial prototypes were paper based, and then a short version of the platform was assessed by teachers, a group of pupils with autism (user testers), and the design team. On the basis of this initial assessment, the user testing evaluation through a questionnaire was analysed. The results of the user testing showed that the integrated design features helped the pupils to access the interface successfully. It was found that the platform was easy to access, and all the pupils were able to navigate through and understand the mission of the game. The analysis indicated that the information content was sufficiently simple. Further, the pupils provided suggestions in terms of the features of the avatar, i.e. users being able to make changes to the avatar within the game (e.g. change the character's eye colour) while others reported that the design of the buttons was too small. Following testing of the initial prototype, the app underwent changes based on the feedback provided by the testing group (e.g. size of the buttons). It must be mentioned that, due to the tight timeframe, suggestions around the figure of the avatar could not be made.

5.7 Re-design the platform

Following the feedback from the pupils' and the teacher's, the interface was re-designed by the team with the brainstorming and ideate stage to inform one another. The goal of this stage was the iteration and the concept refinement until an optimal version could be achieved. Another testing session with the design team was conducted in the museum environment to make sure that the devices were synchronized with the iBeacons. **Figure 57** illustrates the testing of the interface in the actual site by the design team.

Figure 57 Testing What's Bristol? app at M Shed museum, photograph taken by a member of the deign team.

5.8 Summary

This chapter discussed the stages of the design and development of a museum-based app for a group of pupils with autism. The rationale of the interface was described, and details were given of how the design of the interface was informed in accordance with the pupils' needs and preferences. The lifecycle of the app was explained from the beginning (design) to its end (implementation) and finally, details were given of its assessment. The present study recognized the importance of the iterative process of the interface as well as the varying degrees of stakeholders' involvement. The iterative process through the teachers' input and testing by the pupils (user testing) helped the team identify and solve potential functionality issues with the interface. Further, the features of the interface that were embedded into the platform to build an easy to access interface were analysed in detail. The design principles and guidelines found in the literature and the recommendations gathered in Chapter 4 were considered in the context and framework of the *What's Bristol?* app.

Chapter 6

Data analysis of children with autism's museum experience

Introduction

This chapter focuses on the visit to M Shed museum to report and analyse how children with autism, in this study, pupils participating in the research, experience a museum. This chapter reflects upon and discusses the interplay between the use of a portable device and the pupils' behaviour. It provides an overview of what can be afforded through a touchscreen-based app used by children with autism when navigating a museum environment. In line with the main purpose of the thesis, the chapter examines the potential benefits of promoting active engagement through the use of a mediating tool that contributes to such children's experience of museums.

The aim of the museum activity was to explore the pupils' behaviour, actions, and progress while they interacted with a portable device, looked for clues, and responded to requests from the app. To capture the pupils' interest in the gallery, a mission (through the app) was set up with activities that they were asked to undertake. The modes of action involved in this study were navigating the routes in the museum, touching the screen, observing the exhibits relevant to the digital theme of the visit, participating in the museum activity, and, for the section that involved working in pairs, sharing their interpretations within their partner.

The evidence examined in this chapter draws on several sources including questionnaires, notes from observations, a focus group, a think-aloud protocol, and video recordings. The analysis draws on the post-visit data gathered for each group and discusses and triangulates the findings.

This chapter begins by first providing a brief overview of the steps undertaken that led to the museum visit. This procedure prepared the pupils to become familiar with the environment where the study would be conducted. The chapter also includes the perspective of M Shed museum and provides details of the pupils who took part in the museum visit. Then, the data are described and analysed to investigate the pupils' museum visit from different perspectives with an explicit emphasis on the use of the app during the visit.

6.1 Planning phase

6.1.1 Pre-visit orientation

For children with autism, school excursions can be an overwhelming experience and can trigger immense distress (Hume, 2019; Screibman, Whalen, and Stahmer, 2000). Since children with autism show a preference for predictability and consistency (Mesibov, 2005), the scenario of a school excursion, namely, a change in routine, can make them display a variety of behaviours and an attitude of withdrawal.

In this study, the school excursion was a field trip to a museum, and it was important to ensure that the pupils would have appropriate preparation far in advance. To achieve this, the teacher first explained to the class the purpose of the visit- to use a game app that was co-designed with their own input by exploring the museum gallery. The pupils were informed, that upon arriving at the museum, one group (of two pupils) would proceed to the main gallery and each of the pupils would be given an iPad device with the app installed. The pupils were told that they would need to hold the device, click on the screen of the app to read/listen to the content, and then walk around the gallery to locate the exhibits shown on the app. They were also informed that they would need to solve all of the clues in order for them to complete the game. Additionally, the teachers also presented photos of exhibits that the pupils needed to visit, such as the bus and the dinosaur.

The pupils were told that they would be observed by two research fellows who would video record their movements and verbalisations around the gallery. It should also be mentioned that pupils were not introduced to the actual app and its feature beforehand; however, several steps were taken to help them become familiar with the overall experience. Despite the benefits of familiarisation for this particular group, an intentional decision was made to not preview the game-app with the pupils prior to the visit. This was due to the fact that the researcher wanted to retain the novelty of the app and reduce the risk of the pupils being bored of the apps' content and activities. The aim was to capture the pupils' reactions and behaviours as they used the app for the first time in a live setting, and to evaluate how this experience was perceived by them.

A brief introduction to the visit was planned by the researcher (see **Figure 58**). The researcher visited the classroom to remind the pupils about the upcoming field trip and to establish their expectations of it. A social story leaflet (Garand, 1993), was created by the researcher to allow the pupils to develop a better understanding of the purpose of this visit. The content of the social story leaflet, which was adapted to the pupils' needs, provided information about the museum and contained a sequence of activities (by planning and organizing each step separately). The social story included short scripts of each step accompanied by supplementary pictures to give the pupils a brief idea about the whole trip (see **Figure 58**). Information included topics such as the bus ride, the presence of the teachers and their role during the visit, the gallery's layout, and how the pupils would use the app.

Figure 58 The researcher introducing to the participating pupils the aim of the fieldtrip and what they are meant to do.

6.1.2 Collaboration with the museum staff

In the planning stage of the design of the app, several meetings (in total three) took place between the researcher and two members of staff at M Shed museum. The agenda of the meetings included discussing the scope of the study, the relationship between the researcher and staff members, and planning the visit.

During the development stage of the app, the museum staff were consulted about the exhibits of the museum and discussions were held to identify potential themes that would be interesting and appealing for the pupils. Based on the evaluations of the museum, the staff provided useful advice about specific exhibits that they thought would be the most suitable and engaging for transferring the proposed plot and motivating the pupils to navigate the gallery. The museum staff and the researcher agreed on developing a route that would introduce the pupils to the museum and provide opportunities for them to explore and interact with the exhibits in the museum space. Through discussion between the researcher and the museum staff, practical constraints were identified, and several exhibits were prioritized, which were then included in the final version of the app (e.g., the bus, the map, the shelter, and the dinosaur). This collaboration resulted in the museum professionals and the researcher having an insight into the decision-making process and reaching an agreement on whether the software could meet the needs of the pupils with autism. The final part of the meetings also involved discussions on the risk assessment procedures that should be followed before and during the study.

6.1.3 Research Procedure: Setting and Participants

The museum visit was initially scheduled to be conducted on 5 March 2018 at M Shed museum. However, due to the school's commitments, the scheduled date was altered, and the visit took place on 18 March 2018 when the museum was closed to the public. The activities were limited to the 'Bristol Places' gallery on the ground floor of M Shed museum.

The researcher met with the museum staff prior to the initial scheduled date (12th February 2018) to discuss preparations for the visit. The museum staff was informed the total number of pupils that would visit the museum, how many pupils would be in the gallery exploring the exhibits and approximately the duration of the visit. The museum staff also showed the researcher the room where the rest of the pupils, along with the teacher, could wait before visiting the gallery. The room provided several toys and art-making materials to keep the pupils busy whilst they were waiting for their turn to visit the gallery.

Additionally, the researcher presented the actual app, so as to give the museum staff an idea of the areas that pupils needed to visit and the activities that they were meant to complete. It was also decided that the visit would take place on a day when the museum was closed to the public so as to reduce any risk of the pupils being overwhelmed by other visitors. Although the staff confirmed that the museum would be closed, on the day of the visit, an expected group of students appeared in the 'Bristol Places' gallery. The staff confirmed that the actual plan was for the new school group to go directly to the gallery located on the second floor. However, it seemed that the group had preferred to go through the first floor gallery and have a quick look at its exhibits before moving upstairs.

The co-designing approach meant that some of the pupils who took part in the visit were involved in the design of the app- before it was used in the real museum environment at M Shed. During the first stage of the study[4] (period: end of February to April 2017), two groups of pupils were involved in the co-design sessions. Following those sessions, the researcher and the design team worked together (period: end of September 2017 to end of January 2018) to design and develop the game app based on the relevant literature review and the pupils' input from the co-design sessions. However, because the museum visit was conducted almost a year later, the structure of those groups had changed (e.g., some of the pupils had moved to another school or class), and it was not possible for all of them to take part in the museum visit.

While the initial plan was for eight pupils to visit the museum, on the day of the field trip, the total number of participating pupils was seven, as one of the pupils (Charlie) was unable to take part in the visit. The pupils were divided into four groups, with two pupils in each group. As the total number of participants was an odd number, one pupil was paired with a member of staff. The structure of the groups was arranged in accordance with the teachers' recommendations and based on the pupils' level of ability. One of the key purposes of the pupils being divided into groups of two for the visit was to enable the researcher to conduct focused observations (Ciesielska, Boström and Öhlander, 2018). Different levels of cooperation could be observed in the pupils, as referenced below. **Table 13** presents the order of the pupils, who were assigned into one of four groups (1 to 4). Each group comprised two pupils and one teacher accompanied each group.

[4] This refers to the pupils' involvement in the design and development process for the What's Bristol? app.

Table 13 Information about the allocation of the groups and the facilitators.

Group number	Group Participants	Facilitators
1	Aisha & Charlotte	Teacher 1
2	Chloe & Tina	Teacher 2
3	Bruce & Rob	Teacher 2
4	Samira	Teacher 2

Each group was given two iPads and encouraged to explore the gallery separately. Once the pupils were equipped with the devices, they entered the museum's main gallery (ground floor) with a facilitator (a teacher), the researcher, and two research fellows (to record the session). Each group's goal was to interact with the *What's Bristol?* app and to collaborate with their pair by walking around the ground floor. Meanwhile, the rest of the groups was remained in a separate room with one teaching assistant.

6.2 Data Collection and Analysis

6.2.1 Introduction

This section focuses on capturing specific details of the visit experience from both the pupils' and the teachers' perspective in support of the research question in. In practice, the analysis aims to provide a holistic view of the events, actions, and behaviours that occurred during the museum visit while giving details of specific events. As such events will improve the understanding of how pupils with autism responded to the app and will provide further data for the discussion chapter. As shown in **Table 14**, the data presented and analysed here were drawn from in-person observation of the pupils, the video recordings referenced below, the pupils' and teachers' questionnaires, and the in-built data from the What's Bristol*?* app.

Table 14 The research question 2 this chapter addresses, the data collection techniques, and the analysis strategies.

Research Question 2	Data Types	Analytical Approach
Does the use of a co-designed game app contribute to bridging the gap between physical and digital spaces to prolong and encourage independent and social interactions in a museum environment?	1. Questionnaire 2. Video recordings 3. Think aloud 4. Observation 5. Focus group	Qualitative

6.2.2 Analysis of the data from the museum visit

Video Recordings

The video recording technique facilitated a careful consideration of all the pupils' experiences with the museum and the app. Video recordings provided a rich source of data to gain an understanding of the potential impact of an app on the pupils' interaction with the exhibits and the environment. The video was coded (as introduced in section 3.7.1.1) to identify interactions that were linked to moments of engagement. In addition, this section captures and analyses the verbalisations of the pupils while navigating the app and moving around the gallery. These data provided insights into the way the pupils performed the tasks and offered an account of their experiences of using an app. With reference to the video data, and to ensure that the results obtained were consistent, an inter-rater reliability score was established. All video data were rated and assessed by a research fellow according to the coding scheme as discussed in Chapter 3 (Appendix I). To code pupils' behaviours, verbal and non-verbal indicators of engagement between the pupils and the environment were included. The coding process included watching each video of each group separately and noting the sequence of their actions. The second phase of the coding involved recording the duration of each action. To record accurately and then analyse the pupils' behaviours that were coded with the interface and the environment, the total time of the visit was divided into 10-second intervals. A group of spreadsheets was created to demonstrate the interval-by-interval museum experience of the pupils. These can be seen in Appendix P and will be referenced again in the section 6.4.1. In addition, a thematic analysis was performed by transcribing the data of the verbal communications. Extracts from the pupils' verbalisations and the teachers' views are presented throughout this analysis chapter to illustrate the themes.

Questionnaires

As this study focused on evaluating the effect of a museum app for children with autism and their interactions within the museum environment, the attitudes in this research are framed by and centred on the pupils' perspectives regarding the use of technology in the museum. Pupils were asked post-visit questions that sought to capture their views, and attitudes about their museum experience. Open-ended questions were included in the pupils' questionnaires. This gave the pupils the opportunity to reflect on their experiences (for example, "What was the most exciting thing you learned about your city?"). All of the questions are provided in the Appendices (D&E). Pupils' responses were coded into categories. For the open-ended questions, a thematic analysis was conducted, and codes were assigned to describe the thematic content of the comments. The results of the questionnaires were analysed by looking for any similarities within the groups of pupils and revealing patterns in the communication content. The analysis of the pupil questionnaire data resulted in the identification of two main themes: 1) the museum experience and 2) the value of exploring a museum through an app. These themes are discussed in relation to the research question in terms of the effects of the app on fostering interactions.

Focus group

Furthermore, the data collected from the focus group with the teachers after the museum visit enabled the researcher to clarify any misunderstandings and gain a deeper knowledge of how the museum visit was perceived. In addition, a thematic analysis was conducted to analyse the focus group data; this included transcribing the data and using techniques such as the coding of commonly coded data segments. In this analysis, the strategy of coding corroborated previous results from other sources and angles, and it identified the teachers' views in terms of the visit and the use of technology by pupils with autism in a museum environment. An example of the coding process can be seen in **Table 15.**

Table 15 The stages of the coding process and categorization.

Quotes	Codes	Category
"It is a proof of concept that did work very well and worked differently for different children".	Satisfaction in using the app	Bridging the gap between digital and physical space
"When they used the app, after the 2nd introduction, they became familiar with it and really enjoyed going around and observing the exhibits".	Comfort and enthusiasm for playing and exploring	Bridging the gap between digital and physical space
"Also, I think she [Tina] liked when she walked and worked with Chloe when they had to pair up, I think the pair up worked for them"	Engaged in collaborative play	Scaffolding collaboration
"I am positively surprised because we had more deescalate behaviours, and I was pleased with the level of behaviour - it was really positive"	Positive behaviour	Bridging the gap between digital and physical space
"Children found the physical interaction with the bus the most stimulating."	Tactile experience/actions	

Rob: Why would you say bigger? Bruce: Because I just […]. Rob: I guess. Facilitator: Let's find the bridge here. Rob: It might be upstairs (pointing to the 1st floor). Bruce: I know where the bridge is. Bruce: There it is.	Verbal social initiation	Scaffolding collaboration

Observations

The pupils' circulation was tracked (through observations) and observed as the pupils interacted with the environment. Beyond these, the evaluation of pupils' flow provided data regarding the interactions between the pupils interdependently within different artefacts of the museum. The observation sheets included the codes that are associated with recording the pupils' performance: a) the time spent in completing the visit, b) the time spent per exhibit, and c) the path followed through the gallery (see Appendix C). In total, 1 hour and 30 minutes of observation was carried out at M Shed museum. The results are reported for each pupil qualitatively (pupils' verbalisations, behaviours and attitudes) in the following sections. The findings from the observations were used to interpret the data and to allow categories and key concepts to emerge.

The floor layout of the main gallery called 'Bristol Places' (**Figure 59**) was the area used for tracking the pupils' route. The colour-coded map below highlights the areas the pupils were invited to visit in the museum gallery

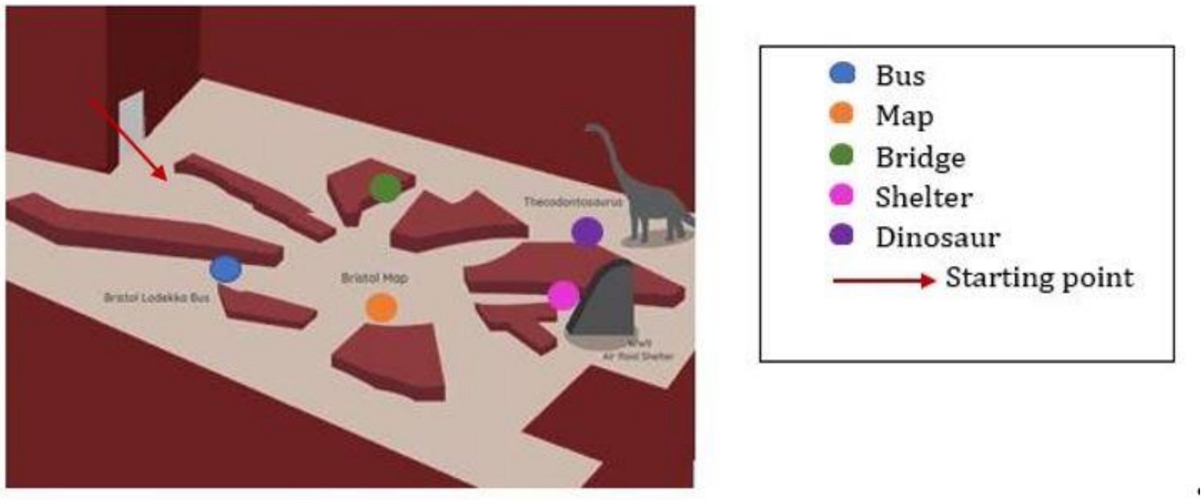

Figure 59 The layout of 'Bristol Places' gallery highlighting the exhibits the pupils needed to navigate through.

6.3 Key findings

6.3.1 Introduction

The four groups of seven pupils in total showed certain similarities and differences in how they used the app and how they approached the interaction and engagement with the museum experience. This is evidenced through the observational and video data, as well as the data emanating from the app that particularly records the timeline of engagement for each pupil. This timeline can be used for triangulation purposes of the key findings. All timelines are appended in Appendix P. When asked (in the questionnaire) whether they enjoyed the visit to the M Shed museum, three pupils noted that they had enjoyed it ‘a lot’, three opted for the answer ‘quite a lot’, and one chose ‘just a little’, as shown in **Table 16** below.

Table 16 **Participants' responses for Q1 of questionnaire 1.**

GROUP 1		GROUP 2		GROUP 3		GROUP 4
Aisha	Charlotte	Tina	Chloe	Bruce	Rob	Samira
Quite a bit	Just a little	A lot	Quite a bit	A lot	Quite a bit	A lot

The fact that Charlotte did not enjoy the overall experience as much as the others could potentially be explained by the fact that she had difficulties in using the app; particularly when she held the iPad in vertical mode as the app was designed to be viewed in horizontal mode. Whilst the question of whether the pupils enjoyed the museum experience per se does not make it possible to draw a conclusion about the specific contribution the use of the app made to that enjoyment. It is nonetheless an indicator that at least for six out of the seven pupils, the app did not serve as a counter indication of their enjoyment of the visit. The groups (considering that group 4 consisted of only one pupil, Samira) spent a varying amount of time in the museum, as indicated in **Table 17** below. The reason the pupils spend differing amounts of time in the museum could be due to the varying degrees of collaboration, among other factors; a greater degree of collaboration led to the group (group 3) spending a significantly shorter time than groups that received less collaboration (groups 1 and 2).

Table 17 **Time groups' spent in the museum using the app.**

Group 1	Group 2	Group 3	Group 4
18 mins 4 secs	16 mins 52 secs	14 mins	11 mins 50 secs

6.3.2 Headline thematic analysis

This section introduces the key themes that emerged from the data and from comparing and contrasting both groups' experience of the app whilst in M Shed museum.

Group 3 was confident about being pro-active in their exploration of the exhibits and moving their visit on, which was mirrored by group 4. Regarding physical interaction with the exhibits, groups 3 and 4 specifically experienced higher levels of motivation through the use of the app when compared with groups 1 and 2 who needed more explicit support from the app in terms of prompting actions and interactions.

The app was highlighted as playing a mediating role in the pupils' museum experience in several instances. For group 4, it could be said that the app and, specifically, the narrative it contained helped Samira identify and make links between the app and the exhibits.

For group 2, the app's audio and visual stimuli influenced positively the pupils' engagement with the exhibits. Moreover, for group 1, it was noticeable that the app provided a degree of structure for the navigation of the exhibition. In completing the tasks prompted by the app, the pupils effectively had an opportunity to focus their attention and proceed in an incremental manner. In so doing, the pupils did not feel overwhelmed by the experience which they might have done without the structure of the app.

Based on this researcher's observations, the teachers' views and the pupils' own perceptions, there appears to be a consensus that the app promoted and prompted the pupils' verbalisations in the museum and during their engagement with the exhibits, albeit to a lesser extent with group 2. In group 1's verbalisations because the content of the verbalisations was relevant to the exhibits and the museum, there was clear engagement with the exhibits. For each of the groups, the role of the facilitator in prompting the pupils and drawing their attention to specific exhibits was highlighted. Like the app, the facilitators were identified as having a mediating role, particularly for group 1 and group 2 (Tina).

There were aspects of the app that were identified as not contributing to either the pupils' enjoyment of the museum visit or their interaction and engagement with the exhibits. The nature of the drag-and-drop activities in relation to the dinosaur exhibit, for example, proved difficult for pupils in groups 1 (Charlotte) and 2 (Tina). Whilst it was not within the scope of this research to identify issues with and make improvements to the app, the levels of functionality may be considered a limitation of the research presented here and point towards future work.

6.3.3 The teachers' perspective

The teachers' views were collated through a questionnaire (see Appendix F) with fourteen closed and open-ended questions and a focus group. The post-visit questionnaire was focused on the teachers' post-visit accounts regarding the pupils' behaviour in the museum and how their observed interactions with the *What's Bristol?* app as a tool to help them feel engaged. Following this, a focus group was conducted to obtain information about the teachers' attitudes and understanding; the two kinds of evidence validated each other and were employed to triangulate and test the consistency of the findings (Morgan, 1997). Importantly, the data from different perspectives and various kinds of evidence served as a point of triangulation for the evaluation while providing a robust picture of the museum visit. Questionnaire and focus group data were transcribed and coded. The teachers' responses were categorised into themes to contextualise the findings.

As the teachers were present throughout the museum visit and observed the pupils, it was therefore important to obtain their overall views of this visit. Both Teacher 1 and Teacher 2 recognised the impact of the visit through the use of the app and indicated that the children exhibited similar levels of behaviour when participating in this study: "…*While at the beginning, they were not sure what to do*", they became comfortable and "as soon as they got through the first question, they seemed to enjoy it and get them on board". The new environment had not prevented the pupils from being engaged with the exhibits and focusing on the visit. Therefore, the pupils managed to control any initial frustration and became more comfortable as the visit progressed.

Pupils' interaction with the *What's Bristol?* app

Both teachers agreed that the pupil's behaviour was similar to their behaviour in the classroom. More specifically, Teacher 2 mentioned:

> They exhibited sensory problems, but this is quite good because you expect a high level of anxiety, as most of them have problems towards transitions and in unfamiliar places" [such as museums] so that is common.

[Teacher 2, Focus group data extract]

Regarding the teachers' responses to the question "What do you think the most interesting time of the children's visit was?", Teacher 1 reported, "*When they used the app, after the second introduction, they became familiar and really enjoyed going around and observing the exhibits*", while Teacher 2 mentioned "*It [the whole experience] was positive; that's what surprised me*". Even those who found it more difficult to access were able to maintain a level of good behaviour. The app may have influenced the way the pupils started feeling comfortable with the environment and observing through the museum. The pupils' attitude changed as they progressed and became more familiar with the interface. This was an important factor in helping the pupils build their confidence in a new situation.

In the second part of data collection, the teachers were asked to provide their views on pupils using the *What's Bristol?* app in the museum. Question 8 asked: "Do you think the *What's Bristol?* app was an effective tool which made children's visit more enjoyable?", and the teachers' responses were either "effective" or "very effective. Elaborating further, in the focus group Teacher 2 indicated:

> It is a proof of concept that did work very well and worked differently for different children. There is [sic] children on the spectrum will benefit from an app whether or not it needs to be a group activity.
>
> [Teacher 2, Focus group data extract]

Moreover, Teacher 2 mentioned that the app appeared to be effective with certain types of users: "*It was proved to work well in medium and higher ones*" [this refers to high and low functioning; with or without learning difficulties]. In addition, Teacher 1 said: "*It [the app] did work; they were really happy at the end*." The analysis of the pupils' attitudes stressed that the app was a useful tool and that all the pupils responded to it well. As mentioned, the participating pupils had different skillsets, however, the app seemed to make the visit engaging for a broad range of pupils.

Content of the *What's Bristol?* app

Regarding the efficacy of the various tasks included in the app for the pupils to acquire information regarding the city's stories, the question "Did you find the various tasks *in What's Bristol?* app well-chosen to help children understand different landmarks of the city?" was included in the teachers' questionnaire. In response, the teachers indicated that the tasks overall were helpful ("a lot" and "quite a bit"), with Teacher 1 reporting specifically as follows: "*The bridge obviously was excellent, the landmarks of the city, the bus was very good, the shelter less, but it did work for them*" while Teacher 2 stated that the "*children found the physical interaction with the bus most stimulating*", and this can be recognised by the fact that "they returned to the bus at the end".

Furthermore, question 12 enquired about learning Bristol's stories ("Do you think *What's Bristol?* app helped the pupils learn some interesting stories about Bristol's past"). Teacher 2 stated:

> "You proved the concept, and it [the app] did act as a little bridge to get them in, and that was good" […] "That's the thing you need visual stimulation because it's a key to understanding; it's a great way of introducing things".
>
> [Teacher 2, Focus group data extract]

According to the teachers' statements, the app gave the pupils an opportunity to build their confidence and interact with the museum artefacts. As highlighted, the digital provision was positioned as a medium for the exhibits and the environment. The visual stimulus also acted as a bridge to shape pupils' engagement and spark their curiosity to explore the exhibitss further. Considering that a field trip can cause great distress to children with autism due to changes to their routine, the app provided structure in the 'unstructured' environment and of the museum visit. This transition could have a significant impact on the pupils' attitude and performance when using the app. Referring to this, Teacher 2 suggested:

> If that barrier is not tackled early on, you will stop them from interacting or engaging in the museum. The app did that because once we went into it, they start moving around and that it is actually good.
>
> [Teacher 2, Focus group data extract]

To reinforce his view further, Teacher 2 addressed the issue in more detail and provided an example of how the pupils had responded to other school field trips in a range of ways: "*We have children in our field trips who never leave your side and not* *really interact, but in this situation, it did work, and that was good*". As the previous sections highlighted, the pupils exhibited emotions of happiness and enthusiasm during the visit, and only occasionally, they were frustrated or needed help. The fact that all the pupils remained focused and motivated is an important outcome for the success of such a visit.

6.4 Thematic findings in detail

6.4.1 Museum experience: Interaction with the environment

The full analysis of pupils' interaction with the environment is presented in **Table 18**, where a headline thematic analysis of the observational notes from the visit has resulted in the identification of key commonalities and differences. The shading in the table represents the key themes identified through the thematic analysis by way of visualisation.

Table 18 Analysis of all the groups' museum experience using What's Bristol? app.

Group 1	**Group 2**	**Group 3**	Group 4
The engagement with the environment and the exhibits was initiated through the combination of explicit prompts for action with the use of the interface.	The use of the app with audio and visual stimuli influenced positively pupils' actions when engaging with the physical exhibits.	The pupils' navigation through the gallery showed their confidence in moving around and observing the exhibits, and it demonstrated their interest in progressing through the game.	The app served as a mediating tool to prompt Samira to engage with the museum exhibits.
Group 1	**Group 2**	**Group 3**	**Group 4**

The use of the app provided additional structure to help pupils navigate their way through the gallery, be confident, and stay focused on performing the activities.	The interface failed to provide support for actions utilising drag and drop activities. This resulted in Tina feeling frustrated, as she did not know whether her actions were correct or not.	The app worked as a medium to motivate the pupils to physically interact with the environment and its exhibits.	The exploratory nature of the visit moving from one exhibit to another worked well as it kept Samira engaged and focused on the completion of activities.
Group 1	**Group 2**	**Group 3**	**Group 4**
The pupils' verbalisations relevant to the museum content indicate a level of engagement with the museum activity.	A limited set of answers and simple input requirements with fewer finger movements improved pupils' progress and enabled easier access.	The physical involvement with the app and the engagement with the exhibits increased the pupils' verbalisations, with them either commenting on the artefacts or repeating what was shown on the screen.	Immediate feedback and rewards gave Samira control and offered her reassurance that she was progressing in the visit.
Group 1	**Group 2**	**Group 3**	**Group 4**

The drag-and-drop activity in the dinosaur exhibit appeared to be complicated and created a level of difficulty for Charlotte. The type of tasks with a limited number of answers and straightforward finger actions, such as point-and-click, or multiple-choice questions, seemed to help the pupils operate the interface more easily.	Chloe appeared to have a directive role, as she controlled and directed the progress of the group work.	The absence of adequate information and clear guidance made Bruce wander around the gallery trying to locate the dinosaur exhibit.	The app's narrative helped Samira identify and make links between the digital exhibits and the physical ones.
Group 1	**Group 2**	**Group 3**	**Group 4**
The absence of feedback on each of the pupils' actions created a series of errors and led to Charlotte experiencing frustration.	The facilitator's presence drew the pupils' attention to certain tasks the pupils needed to complete and provided them with explicit directions for action based on the interface's content	The lack of additional clarifications regarding the map activity led Rob to ask for help.	Explicit prompts as part of the game exploration increased Samira's enthusiasm and independence in the space as her verbalisations illustrated.
Group 1	**Group 2**	**Group 3**	**Group 4**

The facilitator's presence had a mediated role, i.e., to prompt the pupils intellectually to find the right answers, to help them physically execute the tasks when interaction issues occurred, and to guide them through the environment.	The facilitator's presence drew the pupils' attention to certain tasks the pupils needed to complete and provided them with explicit directions for action based on the interface's content.	The pair work of the game seemed to motivate the pupils to stay engaged and facilitated group discussion while they interacted with the device.	
		Adult support was necessary at specific points when the pupils needed help with the requested tasks.	

As illustrated in the detailed timelines (Appendix P), the vertical axis lists the type of interaction and pupils' actions identified in the museum environment, with different colours highlighting the different patterns of behaviour and kinds of interactions. From this process, fourteen action categories emerged as seen in **Table 19**.

Table 19 Further categorisation and explanation of types of interactions.

Categories	Analysis of actions
Happy	Showing signs of active engagement by expressing their happiness verbally or by smiling.
Frustration	Showing signs of disengagement while performing an activity related to the content of the app or temporarily distracted.

Look at screen	Using the app; listen to the audio or read the text, and/or respond to quests.
Look at exhibit	Referring to and looking at appropriate/corresponding real exhibit.
Direct actions	Interacting with the exhibits; manipulating/playing with the exhibits by touching, moving their hands over the exhibit (included or not in the app).
Point	Pointing at the exhibit.
View other displays	Making stops by or observing exhibits not relevant to the app.
Move around/other	Looking around the gallery.
Complete tasks	Finishing each task successfully.
Verbalisations	Watching/listening to the app and reading the content out loud or talking about the exhibit.
Random verbalisations	Talking aloud about other things or not clear verbalisations.
Peer-peer communication	Discussing in pairs about the exhibits and finding out what their partners know.
Teacher support (verbally)	Facilitator providing verbal support to help pupils re-engage with an activity.
Teacher support (physically)	Facilitator touching the screen to help those who have difficulty with the interface.

Furthermore, **Table 20** below shows the visual data of how the pupils behaved and interacted with the environment throughout the museum visit and thus how they experienced the museum overall. The table highlights two emotional responses (enjoyment and frustration), as these were recorded frequently through the observations and video recordings.

Table 20 Examples of pupils' behaviours throughout the museum visit.

Enjoyment			
Frustration			

When examining the observational data for all four groups, it became apparent that the museum experience was different for all of them, but particularly when comparing group 1 with the other groups. This is due to group 1 unexpectedly encountering a group from another school that was also visiting the museum on that day leading Aisha to display signs of stress. Indicative of this were her verbalisations, which demonstrated her being nervous about starting to navigate the interface, and consequently, about the museum visit: "*I do not want to do this*!". The dialogue below presents how the teachers's verbal support provided Aisha with guidance and led her to re-engage using the device.

> Aisha: I do not want to do this!
>
> Facilitator: I will tell you what you can do. Do not worry about the audio [...] will be with you.
>
> Aisha: [no clear speech].
>
> Facilitator: You want me to help you…Okay, I will be with you.

> Facilitator: You should go to one of these exhibits. You need to press one of these pictures [looking at the map of the screen]. You need to find the bus.
>
> Aisha: We found the bus [confidently pointing at and looking at the bus exhibit].
>
> Facilitator: Press 'Next'. Once you complete this section, it is going to come back to this map. All right?
>
> Aisha: Yeah.
>
> Facilitator: If you go to the bus [no clear speech]. How do you feel? Do you want to try? I know you are brave.
>
> Aisha: Yeah [smiling and yawning]. I was shattered in the morning and [no clear speech mumbling].

Group 2, in contrast, needed very little interaction or encouragement from the teacher. The pupils' physical movements, once they entered the gallery, revealed a certain degree of confidence and comfort as they were driven by anticipation to explore this new environment. Group 3, similarly, showed a level of confidence and enjoyment in their museum experience. Both pupils were recorded being enthusiastic to start their visit by focusing their attention on the app once they entered the gallery and when they were comfortable walking around the exhibits using the device. It is interesting to note the teacher's comment pointing out that Rob "*was not sure if he wanted to come* [..] *and we did not want to force it*", who then went on to say, "*It was positive he did; that [was a] positive decision*" (Teacher 2), thus confirming the pupils' responses and the field observations.

As mentioned previously, Charlotte (group 1) had issues in using the device correctly, which may have influenced her negative answer (in comparison with the others) as to her enjoyment of the experience. However, Charlotte's response might also be related to the unfamiliar environment, which initially made her feel uncomfortable, as well as the issues she experienced with the design of the interface and the location of the exhibits, which caused her frustration. This is also confirmed by her teacher, who stated that for Charlotte, "*The comfort with the museum grew as she stayed longer*", as she appeared to be nervous at the start of the visit.

Analysing the data for group 4 (Samira), the museum experience has to be described as a positive one, which is reflected in the answers she gave in the post-visit questionnaire. Samira's positive view of the visit is in line with the video data, which showed a high degree of independence, exploration, and engagement with the physical exhibits. Samira showed her enthusiasm for and curiosity at being in a new environment by listening to or reading the app's content, observing displays, commenting on the app's content, and completing the tasks. This active discovery and involvement may have positively influenced Samira's museum experience. These data are similar to the teacher's view (Teacher 2) on the museum experience for Samira; his comments were positive regarding Samira's situation and her ability to overcome the transition difficulties and adapt to the new situation. The following extract illustrates his points:

> She adapted really good. It would not have surprised me if she had any difficult situation, because of the transition, because she was late to get to the school bus; however, she was able to pass the initial transition and this was really good that she was able to do it.
>
> [Teacher 2, Focus group data extract]

6.4.2 The pupils' experience of using the *What's Bristol?* app

The experience of the seven pupils distributed over the four groups of using the app during their museum visit varied due to a range of factors, which will be referenced throughout this section. The pupils took different amounts of time to manoeuvre through the exhibits, in line with their use of the app, as detailed in the visual representations in Appendix J. Whereas in group 4, Samira, navigated quickly and confidently through the structure of the app, group 2's experience could be considered less productive and was characterised by a number of frustrations and delays. This could have been because of technical issues that Tina experienced due to keeping the screen in portrait rather than landscape as it should have been.

Table 21 below shows the different activities undertaken by the groups as they were using the app. The data in the table show how the pupils interacted with both the app and the museum, as they navigated through them. From the timings alone, it is not possible to quantify the enjoyment the pupils gained from interacting with the app. The types of interactions displayed by the pupils are relatively similar and were conducted in similar sequences (albeit according to different timelines, as shown in detail in the appendices). Some key differences can be drawn from the data, however. For instance, only two of the pupils, Aisha and Bruce, appear to have been listening to the narrator as a discrete task when engaging with the app. In contrast, six out of the seven pupils either dragged answers to the questions prompted in the app or physical representations from one place to another in the app.

Table 21 The pupils' app and museum interactions by group.

Group 1	Group 2	Group 3	Group 4
Aisha: Looking closely at the bus number plate (4:10) (museum interaction) Listening to the narrator (4:30-5:00) (app interaction) Dragging the virtual answers on the screen (4:40) (app interaction) Pointing at the map (8:00) in order to achieve the game objectives (app interaction)	**Tina**: Manipulating the exhibits and pointing at the map (1:40, 3:20, 4:10, 8:40) (museum interaction) Performing gestures such as pressing buttons (4:10) (museum interaction) Observing and touching the horse exhibit (museum interaction) Following app's content (app interaction) Dragging various elements through the screen (app interaction) Clicking on specific points (app interaction)	**Bruce**: Pressing the button of other exhibits (0:50) (museum interaction) Inspecting the dinosaur's bones (4:10- 5:00) (museum interaction) Listening to the narrator (4:30-5:00) (app interaction) Dragging-and-dropping the dinosaur bones on the screen (4:40) (app interaction) Entering the shelter (6:50 museum interaction) Tapping the screen to move to the next page (app interaction) Clicking-and-pointing (7:50) to achieve the game's objectives (app interaction)	**Samira**: Inspecting the bus exhibit externally (looking for the number plate and bus wheels, 2:30-2:50) and internally (counting seats and steps, 3:10-3:20) (museum interaction) Pointing at the map (4:10-4:20) (museum interaction) Dragging the right answer (app interaction) Pointing-and-clicking the right answers on the screen (3:00) (app interaction)

Group 1	Group 2	Group 3	Group 4
Charlotte: Entering the shelter and observing it (3:50-4:00) (museum interaction) Opening the dinosaur's cabinet (9:10-9:20) (museum interaction) Clicking on the screen (app interaction) Dragging element on the screen (app interaction)	**Chloe**: Entering the bus and looking for clues (museum interaction) (1:50) Pointing at the map (museum interaction) (2:50) Dragging elements on screen (app interaction) Clicking the right answers (app interaction)	**Rob**: Touching the bus handle (2:40), inspecting the bus number plate (3:50) (museum interaction) Pointing-and-clicking the virtual answer on the screen (3:20, 3:50) (app interaction) Reading the app's content while at the exhibit (3:00-4:10, 4:40-5:20) (app interaction) Pointing-and-clicking (5:10-5:20, 7:50-8:20) on the app (app interaction)	

All the pupils showed a pattern of interaction with the app that alternated with engaging with the real exhibits in the exhibition. Aisha, for example, was seen shifting her attention between the digital and the real map by pointing at various locations on the physical map and then tapping the screen to click the right answer. **Figure 60** illustrates Aisha observing the map on the floor and doing the activity on the screen.

Figure 60 Aisha explores the map independently.

During the visit, Aisha followed a particular pattern, that is, screen- interaction with the device followed by physical interaction with the exhibits leading to the completion of the activities on the screen. Tasks, such as to select a response from a series of given answers and click-and-point were seen to be easier for her to complete. Aisha also produced verbalisations at various points, which were relevant to the museum content and the activities she had been requested to perform. The same was evident for Chloe in Group 2. Chloe's timeline shows that she adopted the screen-interaction- screen pattern, which shows her confidence to engage easily with the digital content and the physical exhibits. Throughout the visit, Chloe was able to understand the interface's narrative, and she made progress in completing the tasks by following the directions. Chloe was observed engaging first with the interface and then through explicit prompts with the physical environment. **Figure 61** captures a moment when Chloe was exploring the map area. This mode of interaction engaged Chloe and motivated her to explore this area. – a finding that is in agreement with the classroom's observational data, which illustrated Chloe's ability to navigate computer programs independently and be confident in working on tasks without additional support.

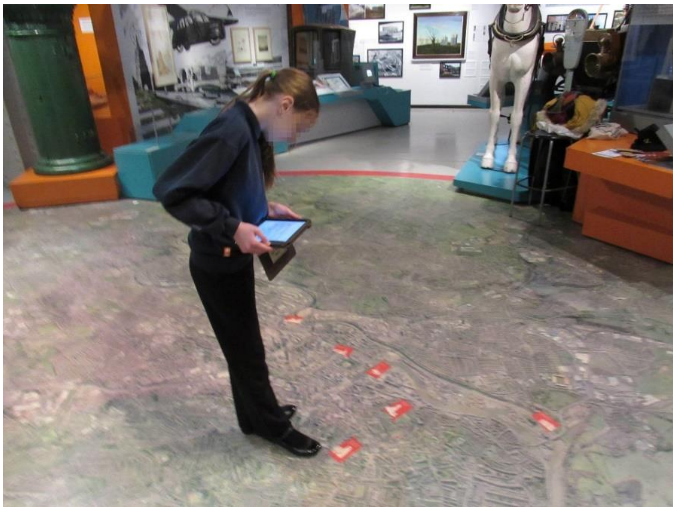

Figure 61 Chloe works independently in the map activity.

Aisha's and Chloe's experience of switching from the virtual to the real map and vice versa was in contrast to Rob's experience. His navigation through the gallery was independent; however, he required the facilitator's support when he became frustrated with the point-and-click activity with the map. Rob was recorded interacting with the environment in different ways based on what the app requested. His behaviour during the activity and his movements through the gallery suggest that Rob made sense of his visit during that time; however, the nature of the map activity made him lose interest. Nonetheless, after receiving the teacher's support, he was eager to complete the visit's set objectives. Rob shifted his attention between the digital map and the real map by observing the exhibit and pointing to different parts of the map. According to the field observations, Rob was observed staying longer than usual in the map exhibit (4 mins and 50 secs); he lost focus due to the nature of the task requested by the app as he needed to compare the two maps (digital and physical) and find some facts to answer the questions. At this point, he became more active in verbalising his thoughts:

> Mmm, I can't find it, and I think I'm losing my interest", and "Honestly, I have no idea. I came excited, but now, the more minutes I am going, the more I am losing interest in this place.

[Data extract, video recordings]

As also shown by the researcher's classroom observations, Rob may find it difficult to concentrate on a task for a long time and can become obsessed with specific types of exhibits (i.e., vehicles). Although he was reported to have lost interest in relation to the map activity, the data indicated his ability to follow the instructions and navigate the interface until all the tasks were completed. He appeared to be interested in looking for all the requested exhibits and worked on the tasks individually, as well as in a group with his pair.

Samira's experience was more akin to that of Aisha and Chloe as discussed above. Through the app, Samira was guided to the map area, where she was prompted through audio and visual directions to explore the map of Bristol. Her mission was to inspect the exhibit, obtain the information required, and compare it with the map that appeared on the screen. The video data revealed that Samira remained engaged by observing the physical map and pointing to different parts of the city. Indicative of Samira's active participation is the increased amount of speech when she responded to the app's requests: "*That's a massive map!", "Maybe I can find [school's location]", "Let's look for [school's location*]". Throughout this activity, she switched her focus easily between the real map and the digital exhibit, while she showed an interest in progressing in the game by clicking on the right answer. Further to the experience with the map activity, Samira was recorded completing these tasks successfully without demonstrating any difficulties or distractions. This indicated she was able to use the app and its interface successfully in addition to making some connections with the environment.

Taken together, the evidence from the different tasks illustrated that the app acted as a medium for Aisha to engage with the museum environment and its exhibits. Aisha spent time using the app to explore the museum; she did so in a structured manner guided by the app and its content. The teacher's support happened only when there was some initial disruption by the other school group at the beginning of the visit. Her movements within the environment and what she said when interacting with the device evidenced some understanding of the content and a willingness to carry out all the activities. Aisha also appeared to work well with the app, and the data revealed that she used this to connect with the activities and to explore the museum as guided by the app. It appeared that activities with a limited number of answers and with point-and-click movements worked particularly well for her, as no errors were reported. The successful completion of the activities along with rewards appearing on the screen led Aisha to express an engaged attitude by verbalising her thoughts ("*Cool*") and/or her facial expressions.

This was similar to Tina's and Chloe's experiences. As the data show, Tina appeared to be happy while observing and touching the exhibits. In Chloe's case, the long period of walking around occurred because she managed to finish her individual activities earlier than Tina did. Chloe then moved away and took this opportunity to explore the space around her by observing different areas of the gallery as seen in **Figure 62**. Chloe was driven to make stops, discover new exhibits that she may not have had any reason to interact with otherwise and map her own pathways. This may have occurred due to Chloe's eagerness and motivation to explore an environment in which exhibits and displays captured her attention while she had time to observe them. A positive outcome is that none of the pupils displayed any feeling of discomfort throughout their navigation through the gallery.

Figure 62 Chloe walks around the gallery.

A similar pattern became apparent for Bruce. Data from the think-aloud protocol, field observations, and video recordings illustrated that the app instructed him to be physically engaged with the space, and to touch, point to, and inspect the exhibits, as well as to look for clues. Bruce was able to make sense of his surroundings and the exhibits by following the pattern of screen-interaction with the physical environment-screen. This means that the screen's content motivated Bruce's engagement with the exhibits whilst it encouraged him to refocus his attention on the screen and attain specific goals (activities). His interaction with the content of the app and his motivation to find the right exhibit can be seen by the fact that he did not hesitate to ask for help when visibility issues occurred with the location of the dinosaur exhibit. This would suggest that he was engaged with the flow of the visit and the app's content captured his interest and made him an active explorer. Bruce also appeared to work well with the app in the map exhibit, and as the evidence showed, the app became the medium that allowed him to connect with the activities that were linked with the real exhibits. Similarly, according to the researcher's observations, it appeared that Bruce was keen on exploring the museum exhibits and walking around the gallery to find the clues without the need of additional help as it seems that the app worked as guide for him to move from one exhibit to another. In comparison with the observational data, Bruce may sometimes need help to progress to the next task. However, one notable achievement was the fact that he walked around the gallery seeking clues by following the app's content; the app may have served as a guide for him and allowed him to move from one exhibit to another.

The experience of the visit as recounted for Aisha, Chloe, and Bruce was mirrored by Samira. Samira was recorded tapping the screen, complying with the requests, and interacting with the exhibits, as seen in **Figure 63**, which gives an example of her journey through the museum. As demonstrated through video analysis, Samira's engagement with the physical environment was initiated by the guidance of the app and explicit directions. For example, Samira was recorded reading/listening to the interface's information, looking for clues about the bus by getting on the bus and counting the steps and the seats, and dragging the correct answers onto the screen to complete the activity.

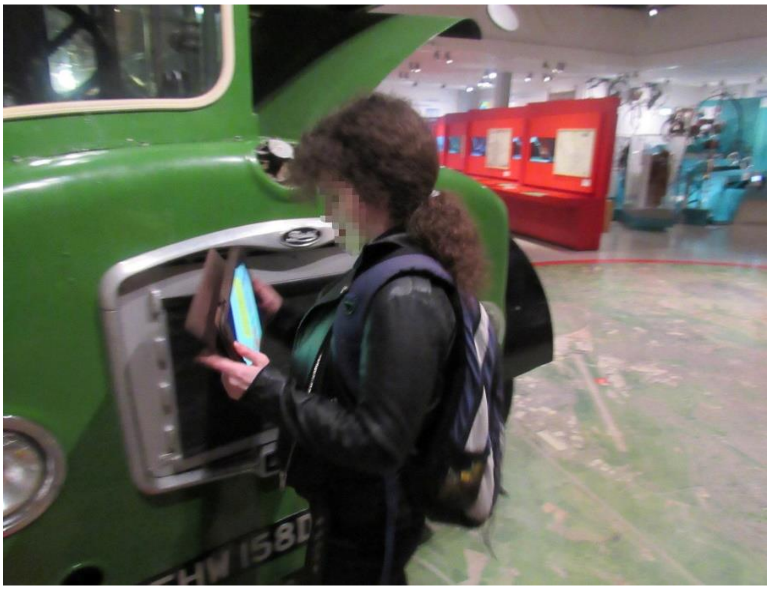

Figure 63 Samira looks for clues in the bus exhibit.

Samira also articulated her thoughts while interacting with the device, which were mainly related to the screen's content (*''I think is somewhere near the bus", "I think the bus right there*") in line with the categories of verbalisation and random verbalisation as presented previously (see **Table 19**). Additionally, **Table 22** below represents an example of how Samira's responses were coded. As can be seen, Samira's verbalisations and communications were interpreted consistently by both researchers (as discussed in Chapter 3). It seems that all the comments were perceived the same; however, there were occasions when Samira's verbalisations were not clear because she was constantly moving. This resulted in some comments being missed or not being coded by both researchers (as highlighted in yellow colour).

Table 22 Example of coding Samira's verbalisations.

Expression of happiness	Rater 1	Rater 2
Smile/cool (while using the device eg., smiling or make a comment	00:28-0:35 unclear 0:52 "I left the app by mistake" 0:56 "I think is somewhere near the bus" 1:15 "How many, how many? I want to count the steps first." 1:39 smiley (once she got the puzzle) 1:43 repeats what she reads 2:06 "Cool" 2:17 "We need to go to air-raid shelter." 2:43 "Dinosaur" 3:40 "I think it's all right" 3:50 "What's next?" 3:55 smiley 6:13 "Done!" (smiley) 8:29 "The bridge? Where is the bridge? I want to see the bridge." 9:55 "I think I know what it is."	0:25 unclear 0:30 repeats what she reads 0:48 "I think I know what it is." 1:39 smiley 1:43 reads instruction from app 2:17 "We need to go to air-raid shelter." Unclear 03:50 "What's next?" Unclear 3:55 smiley 8: 29 "The bridge- where's the bridge? I want to see the bridge." 6:13 "Done!" (smiley) 9:55 "I think I know what it is."
Express emotions (surprise, enthusiasm, e.g., that's' cool, aww, I think I found it)	0:40 "There is a bus I think." 1:07 "I think the bus right there." 4:37 "That's a massive green map."	0:40 "There is a bus I think." 1:09 "It's right there." 4:25 "Ahh. There we are (on the map)." 4:37 "That's a massive green map."

	4:56 "Yep, I can see a few landmarks!"	4:50 "Yep, I can see a few landmarks!"

In contrast, the experiences of Charlotte, Tina, and Rob were less predominantly positive. In other words, Charlotte, Tina, and Rob experienced a degree of frustration and lack of success when engaging with the app, at least in part. Charlotte started her navigation within the space by deciding to visit first the shelter and next the dinosaur exhibit. The timeline and the extract below indicate that Charlotte needed prompting from the teacher, as she was lacking in confidence when navigating the app and when starting the visit with the shelter exhibit. Because of her lack of confidence, she adopted a passive role at this stage and had to be reminded by the teacher to progress in the visit (**Figure 64**).

> Facilitator and Charlotte: [reading out loud the directions of visiting the shelter exhibit].
>
> Facilitator: This way is the shelter [pointing to the exhibit].
>
> Charlotte: Yeah.
>
> Facilitator: Shall we go near to it? [while Charlotte listens to the audio].
>
> Facilitator: [reads aloud the digital content]. So, which one?

Figure 64 Facilitator supports Charlotte to find the exhibit.

As Charlotte finished the first activity, she was directed towards the dinosaur exhibit. Initially, Charlotte was unable to find the right dinosaur ("*I can't find it!*"); there were two dinosaurs displayed in the gallery, and the information given about the exhibit's location was not sufficient to guide Charlotte in the right direction. This resulted in her walking around the gallery for longer than would otherwise have been necessary, as she had been able to locate the dinosaur easily. With the teacher's help, Charlotte arrived at the right location and based on the audio and visual directions given, she reached the dinosaur cabinet. The narrative story prompted Charlotte to interact with the dinosaur's cabinet by first looking at it, reading aloud the query: "*How old is the dinosaur?*", and then looking at the case with the dinosaur bones. Then Charlotte returned to her device and focused on the dinosaur digital activity. In comparison with the character profile, Charlotte managed to overcome her hesitance when undertaking a new task and it was reported that she worked in a focused manner to complete the activities with or without the teacher's help.

Whilst Rob initially got on well with the app, from the video data and the comment mentioned previously, it seems that the nature of the map task confused him and made him lose interest, as he was recorded not doing anything. It indicates that the exploratory effect of a large exhibit like the map discouraged him from interacting with the context. At this point, the teacher, through verbal prompting helped him re-focus on engaging with the task and making progress by collecting the data required to complete.

Although some of the pupils experienced frustrations these were only temporary and should not detract from the positive experience overall. The app was designed to give the pupils a degree of structure when visiting the museum; this structure resulted in the pupils being able to complete many of the tasks and thus engage positively with the museum experience. This was evidenced through data from the pupils, in particular the video and questionnaire data, but was also corroborated by the teachers.

But even where there were difficulties in aspects of the app use, the teachers attested to the positive role the app played in the museum visit. Teacher 2, for example, in reference to Tina's experience, noted:

> Tina's language difficulties could stop her process. I am quite pleased with Tina, to be honest, considering how much she needs [due to her special needs] but

obviously she was an example how difficult this [activity] can be, but it [the app] did work better than I thought it would. She was happy, she was engaged. Following an instruction, Tina was focused and also having some distractions like visually stimulating. If you show them an image, that was it, they get their key.

[Teacher 2, Focus group data extract]

In an attempt to follow an inclusive approach, the teacher's statement recognizes the implications of the researcher's decision to involve all of the pupils in the study - even those who scored lower in the area of language. However, the results showed that Tina could benefit from using a museum app even if her language difficulties were lower than those of other pupils.

Reflecting on Bruce's and Rob's experiences, the same teacher (Teacher 2) emphasized the link to the pupils' behaviour which, in his view, could be explained by the successful use of the app. Teacher 2 noted: "*I am positively surprised because we had more deescalate behaviours, and I was pleased with the level of behaviour - it was really positive*". Even for those pupils who experienced difficulties accessing the activities, he mentioned that they were able "*to maintain a level of behaviour, like Bruce*". This statement highlights the significance of the museum experience via a portable device, as pupils' behaviours were perceived in a positive way during the museum visit. Even if Bruce and Rob experienced some design issues with the interface during the museum visit, they were eager to stay engaged and keep interacting with the app.

For Samira, the experience was a very positive one throughout. The analysis of the data suggests that the use of the app facilitated an exploratory type of visit wherein Samira was encouraged to engage with a specific number of exhibits while acquiring a basic level of information. Samira was recorded working independently and being guided by the app's narrative and explicit directions. Her confidence with the interface and the visit, overall, contributed positively to the museum experience as she displayed signs of independence, enthusiasm, and curiosity (expressed verbally) about the content of the museum. Samira's excitement was shown during her navigation to visit the exhibits in relation to the contextual clues, and this became part of an active discovery in which she had to locate information, create connections between objects, explore different concepts and increase her curiosity about various topics. Through this exploration, Samira appeared to perform all of the activities successfully; this might be because she had not experienced any issues either with the device or with the design of the interface. Her ability to complete the task, when compared to the other groups, indicates her familiarity with the activities used by the app. This data is consistent with the researcher's classroom observations, presented in Chapter 3, specifically the noting of Samira's independent skills and her ability to be focused on tasks.

The pupils' active also involvement in the visit can be demonstrated by their loud exclamations; for instance, when Aisha was manipulating the bridge, she commented, "*Owow that's cool!"* on exploring various versions of it. Samira's engagement and enthusiasm as shown by her interaction with the app and her progress through the visit were also demonstrated by her verbalisations, which occurred when she received her rewards due to her following the instructions correctly and completing the tasks. Hence, it can be concluded that these forms of interaction were influenced by the combination of the prompts provided on the screen, the narrative, the set goals, and a series of challenges. This can be supported by the fact that interactions with the environment were due only to the guidance provided by the app, and the pupils were engaged in activities related to the app. It became evident that the navigation through the gallery promoted the pupil's satisfaction, as they linked the experiences with a sense of personal achievement; there were no indicators of independent exploration.

6.4.3 Pupils' levels of collaboration when using the *What's Bristol?* app

When the app required group 3 to work in a pair, the pupils were asked to reflect on their visit so far. The multiple-choice questions of the activity, which were based on facts and information found previously in the museum, meant both pupils were engaged with the activities, and they exchanged information in order to progress (**Figure 65**). This is illustrated in the following dialogue. The pupils worked together in each of the tasks and after completing the puzzle, they spread out around the gallery to find the last object (e.g., bridge) speaking aloud to their partner.

Figure 65 Group 3 passing information to each other for the pair work.

Bruce: How old was the dinosaur?

Rob: Let me ask the first question.

Rob: Which would you feel if you were in an air raid shelter?

Bruce: Sad!

Rob: Yaa!

Rob: How old was the dinosaur?

Bruce: 210 million old.

Rob: I agree.

Bruce: How many people can the bus carry?

Rob: 73

Rob: Was the city bigger in the old or the new map?

Bruce: I…I do not know.

Rob: Yaa me too!

Facilitator: Do you think it's bigger or smaller on the app?

Bruce: Bigger

Rob: Why would you say bigger?

Bruce: Because I just […].

Rob: I guess.

Facilitator: Let's find the bridge here.

Rob: It might be upstairs (pointing to the 1st floor).

Bruce: I know where the bridge is.

Bruce: There it is.

Rob and Bruce provided further views about their collaborative experiences (Q6-7). They both answered: 'Quite a bit'. The positive attitude group 3 displayed in communicating their thoughts and responses to each other, as the video data demonstrated, is a clear indication of their engagement with the exhibits, which consequently enhanced their interpretation of the gallery's content. It seems that the feature of in the pair-work increased pupils' engagement with the environment and the app's content, as they had to reflect on what they had learnt from the stories. The verbal interplay showed a constant question-and-answer pattern, which led to effective interaction between them and stimulated their interest to move to the next level.

This was mirrored by Aisha and Charlotte. Enquiring about the pupils' experiences of working with one another, their responses provided further insights into their collaborative experiences. Both pupils indicated that they agreed with the practice of working as a group by giving this element the rating, 'Quite a bit'. As the video data illustrated, communication between the pupils mediated through the teacher is an aspect that was also supported by the teachers' comments in the following section. As the teacher was the communication channel for them to exchange thoughts and so offered agency to them in the pair work process; this may be the reason why group 1 seemed to enjoy sharing relevant information. Regarding the pair-work, the teacher highlighted the following:

> In my group, it worked better separately because they find team-work quite difficult," and "The lower ones won't to go around independently or in pairs with another child, so they will be with an adult.
>
> [Teacher 2, Focus group data extract].

As the game progressed, Chloe and Tina proceeded to the next stage and worked as a pair. As presented below, Chloe had the lead role coordinating the task and reading the activity out loud while Tina selected the answers. In the pair work, both pupils were observed contributing to the task by completing the quiz. Their non-verbal interaction can be seen by the fact that they were checking each other's responses and progress through facial expressions.

> Chloe: How would you feel if you were in an air raid shelter?
>
> Chloe & Tina: [both said simultaneously] 'Sad'.
>
> Chloe: How old was the dinosaur?
>
> Chloe: 210 million old? [Clicked on that option when she was unsure].
>
> Chloe: How many people can the bus carry?
>
> Chloe: 73.

Chloe and Tina seemed to like the practice of sharing comments and information about the exhibits. In questions 6-7, both pupils opted for the answer 'A lot' indicating that perhaps the app gave the pupils the opportunity to share some facts. These responses may indicate that group 2 experienced positively the collaborative nature of the visit. Even if the verbal interaction appeared to be led by Chloe, both pupils were keen to learn each other's museum facts. The nature of the task, choosing an answer from a limited number of options, might have also contributed to helping both pupils perform well in this level of the game. The mode of verbal interaction was not observed to be as frequent as that of physical involvement. While Chloe had the lead role in the group experience, the collaborative work encouraged them to stay actively engaged; due to the fact that Chloe was asking questions, they were listening to one another and observing each other's actions through facial expressions. These actions, in a way, may have fostered their curiosity and stimulated their motivation to collaborate and continue further. Teacher's 2 view support the video and questionnaire data as he stated: "*Also, I think she [Tina] liked when she walked and worked with Chloe when they had to pair up, I think the pair up worked for them".* Whilst Tina exhibited patterns of behaviour similar to those seen in the classroom, such as moving around or needing verbal encouragement, it should be mentioned that she was able to remain focused (with some prompting) and was keen to progress to the next step. This was an achievement on Tina's part, particularly given the number of stimuli at the museum and the amount of information and instruction she was given, all of which could have made her quit the exploration.

As the visit progressed, in the pair-work stage, the teacher prompted Samira to visit the rest of the exhibits in order to be able to answer all the questions. Samira was recorded spotting the exhibits and looking for clues. For example, when she visited the dinosaur exhibit, she was recorded opening the cabinet, observing the bones, and then turning to focus on the screen to put the digital elements of the dinosaur in order. It is indicative of her ability that she was able to complete the activity in less time than the others. After this, she replied to the pair questions and exchanged information with her pair as the following example illustrates:

> Facilitator: What do we have to do now is?
>
> Samira: I need to find the dinosaur and area shelter [visiting the exhibits].
>
> Facilitator: Let's try to find them.
>
> Samira: It's right there [pointing at the shelter and then entering it].
>
> Samira: Let's see where the dinosaur is. Dinosaur, dinosaur.
>
> Samira: How old was the dinosaur?
>
> Samira: [clicked the right answer].
>
> Samira: How many people can the bus carry?
>
> Facilitator: Ohh I can't remember; I did not do this. What's the options? What can you remember?
>
> Samira: I remember there was a pretty thing [...]. 15.
>
> Samira: Well done! You got one more puzzle [smiley].

The questionnaire addressed (Qs 6-7) the impact of the task-driven interaction with her pair while exploring collaboratively the city's stories, and for her response, she opted for the value 'a lot'. This response confirms the evidence from the video data, which revealed that Samira communicated her thoughts to and exchanged information with her facilitator. Thus, it suggests an active process of interaction, which evolved through the visit, as she was able to understand the concept and what she was being asked to achieve.

6.4.4 Issues experienced with the *What's Bristol?* app

It is beyond the scope of this research to focus specifically on issues experienced with the app or provide solutions for its further developments. However, it is worth noting that the pupils' occasional demonstrations of frustration were linked to perceived or actual issues with the app, which, as the video data and focus groups with the teachers revealed, led to the pupils experiencing challenges in completing some of the tasks.

The issue of Charlotte holding the device in portrait mode rather than the intended landscape mode, has been referenced already, as it led to limits in the functionality of the app. In addition, there were issues with progressing from task to task. For example, once Tina had finished aligning the dinosaur pieces, the interface did not let her progress to the next step because of an issue with placing the pieces of the dinosaur's silhouette in the correct order on the screen. It should also be noted that in contrast to what was reported in Charlotte's interaction, the screen did not freeze when Tina used it. The correct position of the bones on the screen was indicated by the connected pieces being highlighted to provide visual feedback, as seen in **Figure 66**.

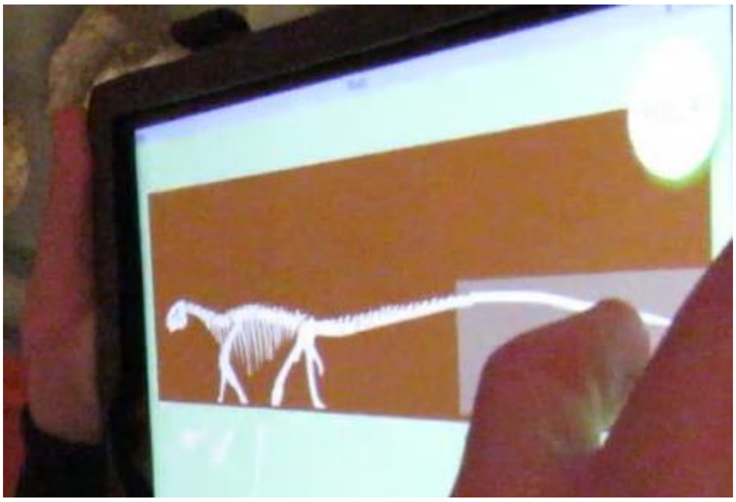

Figure 66 Screenshot of the task while Tina approached the correct position of the bones.

As already indicated, the problem was related to the difficulty of positioning some parts of the dinosaur's figure inside the brown frame while other pieces were not aligned with each other; thus, Tina could not complete the task. **Figure 67** illustrates how the dinosaur's figure appeared on the screen after Tina had finished the task. One reason this may have occurred is that the abstraction of the task was confusing; as she could not relate the real exhibit, with some bones on top of each other, to how the silhouette should look in a digital format. Because of this, Tina needed constant verbal prompting to perform any steps of the task. The presence of a notification message placed additional task-demands on Tina by asking her to keep dragging and dropping the components to make up the dinosaur. This highlights that the interface was not designed in such a way as to provide the necessary context and extra levels of support or to give any explicit notification of the pupils' actions regarding how to overcome the interface's failures. Clearly, this issue added more complexity to the task and led Tina to feel frustrated by having to engage in repetitive actions with the screen. This difficulty might be attributed to the lack of feedback when the components were in an incorrect position.

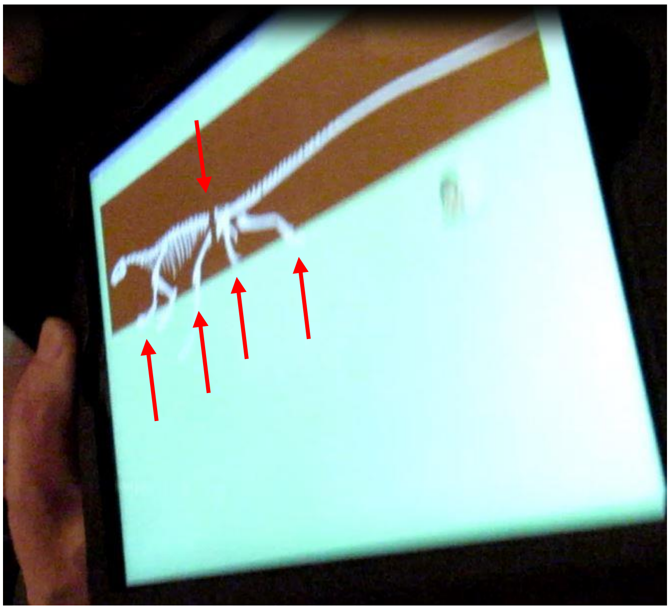

Figure 67 Screenshot of dinosaur's figure after the task was finished.

6.5 Summary

The findings from the research presented here show that the use of the app provided a structure for the pupils to engage positively with the museum exhibits, and with each other. The extent of their engagement varied among the pupils who, as shown in the presentation of the findings, were organised into four groups for the museum visit. Given all the above findings, this study is concerned with understanding the 'how' and 'why' behind the interaction of children with autism with a portable device in a museum environment. Examining what can be achieved with the use of a portable device, several key insights were identified following the analysis of the museum visit.

The museum visit was focused on creating an exploratory visit in which the pupils had an action-based role and were sent on a journey with a clear beginning and end, a structured path, a goal, and various challenges. This journey included digital images and facts and involved developing connections to the physical exhibits through a variety of location-based activities prompting reasoning and observation. These activities were intended to develop the pupils' skills, encourage them to engage with the content, and help them focus on the physical environment. Although the museum visit was a change to their routine, the pupils were seen to take several postures, such as sitting on the bus, manipulating the bridge's handle, and entering and sitting on the bed in the shelter; all these are indicators of their level of engagement. As the pupils were sent to different locations, the continuous requests in a new environment with large numbers of displays could have caused cognitive overload and physical tiredness and consequently may have affected pupils' motivation to keep uncovering stories. However, the evidence highlighted that the use of the app afforded a smooth transition to the new environment and pupils' active participation. With the pupils doing puzzles, solving crosswords, answering quizzes, carrying out memory activities, and finding missing details, the museum visit was enhanced by use of the app, which affected the pupils' experience of the museum.

The thematic structure of the visit channelled the pupils' attention into discovering specific areas of the gallery while helping them gain confidence and feel secure in the unfamiliar environment. In this way, the pupils came to realise those objects existed, and they indicated their interest in exploring more about the stories behind them.

As the video data demonstrated, the pupils seemed to be focused on doing the activities and to be seeking extrinsic rewards as reassurance that they had mastered the game. The use of the reward system contributed to the pupils' level of satisfaction and pride. Their satisfaction was observed through their use of verbal expressions and through their facial expressions (smiling), and thus it was clear they had achieved a degree of engagement with the content.

The analysis highlighted that a variety of activities seemed to contribute positively to the pupils' involvement as they focused their attention on the physical space, observing the exhibits and looking for the information. It was found that activities such as the multiple-choice questions, the crossword, and the point-and-click activities worked particularly well as no errors were reported during their completion. The success of these activities lies in their design, as fewer finger actions were required, and they included tasks with a limited number of answers. In contrast, several issues contributed to the drag-and-drop and the puzzle activities working less effectively than the others. Firstly, the associated exhibit (dinosaur) lacked visibility; in fact, the dinosaur's scattered bones were shown in a glass display case, but the digital activity involved an abstract idea, specifically, that of creating a dinosaur silhouette, which did not represent what could be seen in the actual exhibit. This, in turn, might have created a high level of complexity in the task, as some pupils could not associate the real exhibit with the digital one. Due to the abstraction, the teachers had to explain how the pupils could carry out the activity. Furthermore, the size and shape of the digital bones, the similarly shaped puzzle pieces and the movement of the finger over the screen may have prevented some of the pupils from completing the activity. The lack of instant feedback on each of the pupils' actions also created a certain level of frustration.

As reported in the video and questionnaire data, the group experience encouraged the pupils to stay engaged with the museum content, while it also facilitated interactions between the pupils. The use of the app provided some further insights into the different types of collaboration that occurred among the groups. These include 1) directing - where one pupil guided and controlled the visit by providing the correct answer when/if the pair could not respond (group 2), 2) sharing – where pupils gathered information individually and then shared the information with their partner (groups 3 & 4), and 3) facilitating - where the facilitator was involved in the game and provided prompts as an encouragement for the pupils to acquire a better understanding of the content (group 1). It seems, that through its game-like design, stimulated different levels of collaboration which the teachers thought might not have occurred without the app.

The analysis also emphasised the different roles of the facilitators throughout the visit. According to the analysis, the facilitators were recorded having the lead role, elaborating upon some of the activities and providing prompts to help the pupils obtain a better understanding of the content. Additionally, there were occasions when support was given, such as when there were issues with the interface and the pupils needed verbal and/or physical prompting in order to make progress.

In relation to the research question, and ahead of the conclusions chapter, the findings can be summarised in alignment with the effects the use of the co-designed museum game app has from the pupils' and the teachers' perspectives. The app had predominantly positive effects on all the pupils who used it during the museum visit. The app provided a structure that helped the pupils to navigate the exhibits in an incremental and gradual way. This helped to mitigate some behavioural issues, as well as prompt verbalisations from the pupils beyond their teachers' expectations. The data from the observations and the pupils' questionnaires were triangulated by the teachers' focus groups, where they attested to the positive effects of the app in terms of the pupils' behaviour and engagement. The following chapter provides a discussion of what the museum visit found.

Chapter 7

Discussion

Overview of the visit

This chapter draws together the findings from the research presented in Chapters 4 and 6 to address the research questions formulated in Chapter 1. This thesis explored the impact of a portable device on supporting the museum experience of pupils with autism; it was important to capture how a co-designed app influenced their engagement and exploration. This chapter discusses the findings of a small and specific case study that considered the design, development, and evaluation of a software programme in a museum for seven pupils with autism.

This study investigated the scope of a museum-game app to offer an alternative museum experience. The aim was to incorporate features that could better support pupils with autism when they use a portable device in a museum setting. This study sought to identify the perceptions of pupils and their teachers while they were involved in a museum visit. The evaluation of a museum-game app represents the first study with pupils with autism conducted in a museum context by involving the pupils and their teachers in all stages.

To discuss the findings that emerged from the study, the chapter is organised into two sections. It begins by identifying how the co-design approach influenced and informed the design of the app and what value was added in its evaluation in situ. The findings regarding the opportunities a portable device offers to support the museum experience of pupils with autism and the conditions that may facilitate their participation and improve their experience are then discussed. Issues and challenges reported during the exploration are also addressed.

7.1 Insights into an inclusive participatory approach

Various scholars in the field of autism have highlighted the limited influence of the input of children with autism, especially of those in the lower and medium spectrum, over the design of technology-based programmes (Parsons *et al.,* 2017; Benton *et al*., 2012; Frauenberger *et al.,* 2013). Drawing on the view of Parsons and Cobb (2011, 2014), who recognised the importance and value of empowering children with autism to participate in decision-making to elicit knowledge, the core aim of the study was to adopt a nuanced inclusive approach to develop an ethical and valid interface. It sought to gain a multi-faceted understanding of the study by capturing the perspectives of both the pupils and their teachers. This is a gap that was identified in the existing literature, where the majority of the studies focus on evaluating the impact of such programmes from only one perspective. Within this context, the pupils and their teachers providing their perspectives throughout the process became a central part of this research, which facilitated an ongoing reflection of the design and evaluation of the interface. The co-design, therefore, guided the collection of data and facilitated an analysis that uncovered the strengths and limitations of the app based upon the outcomes.

The direct involvement of the pupils with autism was critical in developing a better understanding of the context in which they will use the app. Embedding structured activities, the pupils informed the design of the app, as did the work of Antle (2013) who investigated the affordances of physical, graphical and tangible interfaces influencing a variety of cognitive skills in children solving a spatial puzzle task. Accordingly, the pupils' contributions in the design of the app were creative and insightful, and incorporating their views and those of their teachers on multiple levels to create an interface proved to be effective; however, some challenges occurred that need to be addressed. The key points identified are summarised below.

Empowerment: The creation of a museum-game app for children with autism was a unique challenge, as no other studies have considered either a design of technology in this context with the pupils being engaged in a continuous goal-directed action or their direct contribution. The close collaboration with the pupils and their input led to an interface that focused on design affordances relevant to their needs. The study's co-design approach addressed the idea of giving power to children with autism, which was highlighted as an essential process in the field of autism and technology (Parsons, 2016; Frauenberger, Good, Alcorn, 2012, Fails *et al*., 2012). The co-design sessions were structured to engage the pupils in the task-orientated activities by encouraging their input and preferences concerning the design of the technology.

During the first sessions, the pupils expressed their preference for a simple interface in which the navigational components are placed at the bottom of the screen and include feedback and rewards through audio and visual cues to help track users' actions and the opportunity of collaboration. Involving these groups has led to a novel technology, as the pupils involved were empowered to think outside the box, and they came up with creative and innovative ideas.

Illustrative examples include the case of Charlie, who provided valuable perspectives relevant to the museum interface. He expressed preferences for a direct connection with the exhibits through the use of an avatar, solving clues through a series of activities completed on the interface and through a location-based awareness system, and customised features. In Rob's case, his stories through his drawings resulted in the integration of game features into the interface. These insights were embedded in the interface: a) collaboration between pupils, b) the incorporation of short- and long-term goals to reach the treasure, c) the pupil's ability to navigate the gallery freely, which increased their value. The analysis confirmed this, as a museum exploration through a sequence of actions, decisions, and interactions with the interface and the environment appeared valuable into sustaining the pupils' motivation to complete the tasks without being distracted by the screen. Thus, adopting a participatory approach contributed to making the connection between the theory and the practice, as some important insights informed the design and helped the pupils build their confidence when the visit occurred.

Challenges: As reported, useful recommendations were proposed by the pupils with the majority of the preferences confirming the findings in the literature. However, concerns were raised as some of the ideas were not consistent with the literature about the design features of the technology-based programmes for children with autism. There was particular concern regarding the non-linear navigation of the environment for the pupils, as it was felt this would lead to a lack of structure, which was considered an important element to guide the pupils through the space and the activities in a well-defined manner (Weiss *et al.*, 2011).

The design of the app, through a structured route, enabled the pupils to move around and explore the gallery by choosing between two paths to visit the exhibits of interest, enabling them to fulfil their goals. This created structured but non-linear navigation in which pupils would not feel overwhelmed by the new environment and the large number of exhibits. The evaluation reported that the majority of the pupils understood the functionality of navigating the space by clicking on one of the icons that represented the exhibits. However, the optionality of the navigation created instances of hesitation for less capable pupils such as Charlotte, who lacked the skills required to orientate herself with the visual layout of the museum and choose an order in which to visit the exhibits. This suggests the need for a linear movement control where the pupils in the medium spectrum could be given clear directions about where to go.

The implementation of a co-design approach in the creation of a museum-game app had a direct impact on the researcher's understanding of designing *for* and *with* children with autism. The constraints described above illustrate that the emphasis on a user-centred approach not only provided ethical and practical insights but also raised issues regarding the differences in the requirements and expectations of various stakeholders. This, then, can have an impact on whose views should be prioritised in terms of the design of the programme as argued by Parsons (2016). Other studies have indicated similar challenges and questioned whether the use of a technology programme with children with autism can apply cooperative approaches to user-centred design (Parsons and Cobb, 2014, p.437). Druin (2002, p.19) commented that "the impact that technology has on children may not be as significant as the impact children can have on the technology design process". Reflecting on this, the scope of the participatory design was not only to elicit the tacit knowledge of the pupils to answer our research questions but also to empower them in the design process. This can be confirmed by the feedback from the teachers who claimed that such an approach reinforced the pride of ownership and empowerment. Moreover, it could be argued that the process also represents a degree of social learning and collaboration in the way Durall et al., (2020) have described. Because of the involvement of the pupils in this co-design process, and the co-creation that resulted from it, innovation in technology-enhanced learning could be said to have taken place in this social learning space.

This study followed a “social justice agenda” (Parsons and Cobb, 2014, p.437), and aimed to design a usable and accessible interface that would support pupils with autism within a museum environment by adopting an inclusive approach. As Keay-Bright (2007) proposed, the input produced by the pupils required ‘mindful consideration’, as it was not always possible to give their views too much prominence. Due to this, the researcher made decisions aligned with the literature and with the teachers’ views regarding the need for structure and limited actions. The positive reactions of the pupils, as presented in Chapter 6, could be a result of their involvement in the co-design of the app, given that they had invested both time and energy in the design process, or of the expectations they had of the visit through their previous connection with the app. It could also be due to the design, which influenced positive outcomes. The present study expands the research on the use of a museum-game app as a medium by evaluating the effect of its use in a museum context.

7.2 Connecting children with autism with the museum exhibits through the *What’s Bristol?* app

As part of the museum visit, the pupils were required to work towards a goal and ‘move’ between two spaces, namely, the digital and the physical. The focus group and video data reported that once they had become accustomed to the use of the app, the pupils started moving around the space to observe the exhibits. The teachers acknowledged that the app became less of a distraction, as it supported different kinds of interactions for the pupils. As stated by Economou and Meintani (2011), mobile devices can pose a “risk of overshadowing the exhibits and the museum content itself” (p.97). This study acknowledges that the use of digital technology to experience a museum space increased the complexity of the visit. However, it also created the opportunity for a hands-on experience, as the pattern of interaction with the exhibits alternating with interaction with the screen, was achieved.

This could be based on the scaffolding nature of the app, which was aligned to the sequence of the museum exhibits. This is supported by Parsons and Cobb (2011) and

Moore *et al.,* (2000) who argue that the value of audio and visual stimuli in technology programmes make them potentially valuable for children with autism who have a natural affinity with visual processing. Although these features were likely to influence the pupils' ability to participate actively in the museum exploration, the findings suggest that this was not the case. These characteristics, alongside various features such as attractive content, a combination of activities, and a goal that the pupils needed to achieve, offered some control over the environment. These, then, created a state of flow that promoted attention, intense involvement, verbal expression, and a willingness to complete the required tasks, all of which is in line with the literature on the use of scaffolding as a strategy in prompting children with autism (Murdock *et al*., 2013; Esposito *et al.,* 2012; Escobedo *et al.,* 2007).

The pupils' questionnaire provided positive responses, with six out of seven pupils reporting that they liked the practice of being engaged in a novel experience of visiting the exhibits through an app. This finding was supported by the teachers, who noted that the pupils' behaviour during their navigation through the space was both positive and surprising, as the pupils became motivated to explore further. Both teachers repeatedly cited words and phrases such as "positive", "enjoyed", "happy", "worked well", "interaction" and "engaged" to demonstrate how positive the museum experience through the app was and to describe the pupils' attitudes regarding the visit.

This is an important finding, as new sensory experiences such as in a museum setting can act as barriers, especially for children with autism (Kulik and Fletcher, 2016; Langa *et al*., 2013). Along with this, individuals with autism are known to have executive functioning issues and struggle with regulating their behaviour and performing cognitive tasks, such as problem- solving, sustained attention, and organisation (Ozonoff *et al.,* 1994) skills that are considered important for individuals to engage in goal-directed action. Furthermore, children with autism may face difficulties in social engagement and may show repetitive behaviours or narrow interests (Dawson, 2004; Bodfish *et al.,* 2000). This may result in a lack of attention towards activities when using computer programmes (Mora-Guiard *et al*., 2016). Building upon Antle's (2013) views, the findings in this study indicated that the pupils used their bodies to explore while the activities became "multisensory unity of action, perception, cognition, and emotions" as described by Rijn and Stappers, (2008, p.8). It became evident that the app acted as a bridge to connect the pupils with the environment through active movement rather than reducing interaction and engagement. Navigating through a physical environment allowed a deeper understanding of the pupils' surroundings which appeared to be useful for connecting the digital exhibits to the physical ones (Mora-Guiard *et al.*, 2016); thus helping pupils to perform cognitive tasks and progress the game. The analysis echoed Antle's (2013, p.31) view that "children (and all humans) create meaning through action"; the interplay of wide range of physical and digital interactions and cognition in a real-world context provided opportunities to support the pupils to successfully perform, engage, and reflect. For instance, Aisha was reported searching for the bridge, interacting with the exhibit and being satisfied by the sensory experience of touching it which involved action, perception and emotion. Charlotte, Tina, and Bruce experienced what a shelter looks like to click on the correct answer, showing signs of enhanced attention. While the social impairments that characterise children with autism are associated with a lack of sustained attentional engagement with social stimuli (Dawson, 2004), this study showed that in cases such as Group 2, this did not lead to withdrawal or disengagement; on the contrary, it created greater confidence.

To date, several studies in the museum field have stressed the importance of organising art-making activities for children with autism (Woodruff, 2019; Kulik and Fletcher, 2016; Schleien et al., 1995) through specialised programmes (Mulligan et al., 2013). In these studies, the authors found that art-based activities motivated children with autism to explore museum exhibits and connect art-making with the museum experience. However, the pupils' perspectives were not considered, and thus a holistic understanding of how children with autism perceive a museum visit did not result. Whilst previous studies have focused largely on developing pre-visit orientation materials and creating art-making activities for children with this condition, the present study has showed how the use of a museum game-based app can act as a medium during visits to a museum. The evidence obtained from the video recordings, the think-aloud protocol, and the questionnaires, captured the voices of the pupils in real time and provided important insights into how a digital-based activity can enhance children's with autism museum experience by motivating them to interact with the digital content and the physical exhibits spread across the gallery.

As Langa *et al.,* (2013) point out, a museum experience can be effective if the activities encourage the independence of children with autism in exploring and experiencing exhibits in a safe environment. Price *et al.,* (2003, p.170) argue that "engagement with a learning environment facilitates exploration and conversely exploration promotes engagement". While the outcomes are encouraging in terms of the strategies for designing museum experiences to support families of children with autism, this study represents a step towards emphasising the value of the *What's Bristol?* app as an alternative interpretative museum tool for such children. The evaluation showed the ability to transform the objects into stories and create a series of activities related to them to enhance the experience. The app was designed to provide information directly by making references to the exhibits and mediating the digital effects of their interactions with the exhibits. As the video data revealed, the pupils' verbalisations and actions indicated that they were able to connect the digital content with the physical environment; the app and its contents became external representations of the real exhibits that scaffolded the interaction with the environment.

This study provided insights into the role of a digital service for pupils with autism in a museum setting and argued that to create an exploratory, playful museum experience requires that the technology not replace the role of the museum exhibits but rather act as a medium promoting the children's interactions with their physical environment. In so doing, the interaction with the app shows the effects of the pupils' physical actions in the digital space. The data confirmed that the combination of activities and their characteristics (i.e., child-environment, and child-screen) attracted the pupils' attention, and their familiarity with the story kept their attention on carrying out the activities and demonstrated knowledge gains. The pupils became a central part of the activity, and throughout the visit, they were able to transfer their attention from the process of action (exploring the physical exhibits) to reflection (carrying out the activities digitally). This approach is consistent with Kolb's (1984) model, which argues that learning is a continuous process that involves observation of and reflection on relevant events. As such, the app enabled the pupils to experience the real exhibits through activities that provided the potential for new ways of exploring, engaging, and learning. Building on Escobedo *et al.,'s* (2012) and Bauminger *et al.'s* (2007) work, the findings from this study suggest the integration of digital platforms for children with autism outside classrooms. The results indicate that all pupils were interested in seeking clues and earning rewards to progress the game. The value of the storytelling activity as part of a three-mode structure (story-tour-activity) as described by Wickens (2012) was confirmed in this study; the structure combined short narrative stories, hands-on activities, and a guided multisensory experience. The data showed that this structure gave the pupils a sense of comfort as the stories were related to the activities, which gave them a degree of control. Hence, the app presented a dynamic environment that the pupils found stimulating; it held their attention, but also facilitated physical exploration within the gallery, as evidenced by the findings presented in Chapter 7 and in line with the findings by Esposito et al., (2017); Christinaki et al., 2014; Murdock et al., (2013); Yuill et al., (2013); on the empowerment of children with autism through mobile apps and games.

7.2.1 Facilitator's mediation

Although the app was designed *with* and *for* two groups of pupils with autism, observations of the pupils' behaviours revealed the need for adult support in various parts of the visit. Some pupils experienced difficulties with the communicative demands and the nature of the requested activities. Reflecting on these difficulties, pupils would be given a variety of facilitation types, both *indirect* and *direct*. The type of facilitation depended on what was needed to aid the pupils in directing their attention to the action required or to an exhibit of interest within the environment, thus accomplishing a level of performance.

The results demonstrated that *indirect* support occurred when the teachers intervened to clarify activities and, when and where necessary, encouraged the pupils through prompts that went further than the interface's instructions. For example, pupils with lower verbal abilities, such as Tina and Charlotte, tended to need help frequently in progressing through the game; hence, they received a significant amount of facilitation. When the pupils showed less spatial ability concerning locating the dinosaur exhibit, the role of the teacher was to prompt the pupils verbally to navigate around the gallery and/or to assist them in understanding a course of action; for example when Tina needed a further explanation of how to assemble the dinosaur's silhouette. The use of *direct* support was reported when Bruce, Tina, and Charlotte encountered difficulties with the interface, and the teachers initially provided verbal support to explain why a mistake had occurred and then physical support to help them connect the digital elements to make progress in the visit. The teachers in this study recognised that their input was important in monitoring the flow of the visit and regulating the pupils' exploration when necessary to prompt them to make progress. These findings are consistent with the co-design observations, which recognised that the nature of the facilitator was to provide support to articulate pupils' ideas and proposals when necessary as part of the design process. However, the teachers expressed their enthusiasm for the behaviour some pupils with medium functioning autism exhibited while exploring the space.

Transition refers to a change from one situation to another and is considered a complex process for children with autism. Difficulties with generalising skills when uncertain events occur pose particular problems and result in challenging behaviours such as inflexibility in thought and action when transitioning (Stoner *et al.*, 2007; Bodfish *et al.*, 2002). In this study, this new activity involved visiting an unfamiliar space and carrying out a series of activities; this prompted reasoning, observation, and diverse forms of interaction with the environment. The fact that all the pupils understood the goal of the visit and displayed task-focused behaviour working towards a goal can be considered an encouraging outcome given the unfamiliarity of the context and content. The pupils worked both individually and in pairs, regardless of the varying levels of support from the teachers, which shows that they were immersed in the museum activity and made a sustained effort to complete the visit. These findings are encouraging because they suggest, firstly, that the app acted as a motivating factor to engage the pupils with the museum content and activities and, secondly, that the teacher's input guided some pupils and ensured that their focus and interest were maintained to complete the visit.

Such findings support the argument that input from the teachers can enable children with autism to participate in actions with the interface and interactions with the museum environment, and this should be regarded as an integral practice, providing opportunities for them to enhance their exploratory behaviours and experience the museum in a meaningful and supportive way.

The degree of support the teachers provided varied and was determined by the pupils' diverse needs and characteristics; as the study indicated, pupils who were in the lower or medium spectrum displayed a need for further guidance and help. Throughout the visit, the teacher's role was to be as non-intrusive as possible to reinforce the idea of the pupils carrying out the activities independently and to provide a responsive and supportive role as and when required. This study supports the findings of prior research that the teacher's initiation and monitoring is a critical part of a museum exploration process. This provided pupils with autism with adequate information relevant to a current action and situation and explicit prompting to assist them in making the appropriate responses accordingly (Parsons *et al.,* 2015; Ke and Im, 2013; Weiss *et al.,* 2011; Piper *et al*., 2009).

Although the app was designed to provide a focused and structured exploration, some issues that meant that the teachers needed to intervene and provide support. Parsons *et al.*, (2006) cited the importance and validity of the teachers' presence for children with autism when using technology-based programmes and stated that "this requirement does not represent a weakness in the functionality" of a program (p.202). On the contrary, the scaffolding of the interface's content and interpretation of their actions when facing unknown situations are valuable for increased success and involvement. This study demonstrated this, as the teachers' influences were important to control the pupils' behaviour and prompt them to become more independent throughout the visit. Thus, this study suggests that a museum-game app is likely to offer a context in which engagement, interaction, and exploration can be fostered and successfully scaffolded by the teachers.

7.2.2 Diversification to foster museum engagement

The findings from this research found that the pupils rated the museum visit as a positive experience and enjoyed using an app to explore the museum's content. This was highlighted by several respondents reporting positive feelings about being in the museum, using words such as 'comfortable', 'safe', and 'fun'. Furthermore, the teachers described the museum experience as pleasant in terms of the pupils' performance and indicated that the use of the app seemed to have a positive impact on the pupils' transition in such a new environment. The teachers remarked that the pupils were found to be actively participated in the exploration after they received the instructions, as they moved rapidly from one location to another. They also compared the pupils' conduct during this visit with their conduct during other field trips, and highlighted that some pupils who normally would not have been engaged in such activities had become engaged due to the use of the app.

In keeping with the findings of previous research (Esposito *et al.,* 2018; Moore *et al*., 2000), the results of this study confirm the importance of various embedded features, such as simple instructions and the additional functions of the interface. The integration of behavioural strategies such as rewards and feedback, and the gradual increase in the difficulty of the tasks contributed to leveraging pupils' motivation and offered them the opportunity to perform well throughout the visit. As the video data demonstrated, the reward system embedded in the app was effective in increasing the pupils' satisfaction and reassurance, indicating that a degree of engagement with the museum content and activities was achieved. While some studies suggest the page buttons should be placed at the top of the screen for easier navigation (Brown *et al.,* 2011; ETSI, 2005), this study followed the feedback of the pupils in the co-design sessions; they preferred the buttons to be at the bottom. Based on the field observations, the pupils felt comfortable interacting with the app and demonstrated a level of control over the interface. They were able to perform well with the consistent navigation page buttons at the bottom of the screen and the tasks; which in turn, scaffolded an interaction with the exhibits.

Adherence to routines is suggested to play a significant role in helping children with autism to feel secure and in providing structure and predictability. The literature documents that changes to routines occurring in the environment or unfamiliar activities with no specific rules prevent children with autism from adapting to a new situation and can trigger anxiety (Gomot and Wicker, 2012; Bodfidh *et al.*, 2000). Thus, consistency, structure, and predictability can be considered effective strategies for success with a new situation and can help children feel reassured. It was encouraging to report how the pupils in this study experienced a new environment and situation. Although the museum visit could have been a challenging activity, the data indicated that the pupils became active explorers, willing to participate in activities with multiple stimuli. The findings provided evidence that the museum exploration through an app supported a smooth transition to the new environment, although this has to be read in line with Rehman *et al.*, (2021) who argue that these benefits cannot be ascribed to the use of educational apps with children with autism per se but need to be evaluated on a case-by-case basis.

Pupils' behaviour and performance in this study demonstrated that they gained insights through their senses, as they displayed signals of focused interaction with and curiosity about the physical environment. Possibly, the pupils felt comfortable during the visit because the technology gave them predictable and consistent rules while allowing them control over the external stimuli they experienced, and it managed to keep them focused on achieving their goal. For example, Samira showed instances of excitement every time a new challenge appeared on the screen, and she turned around to share her excitement verbally while she moved faster around the space to locate the next challenge. This study, therefore, demonstrated the potential of a digital service that makes effective use of the affordances of structure and predictability in motivating children with autism and exploring possibilities for their involvement and engagement in hands-on and play-based activities.

Digital activities through play have demonstrated touchscreen-based programmes to be effective environments for helping children with autism to be engaged and maintain interactions. Previous research studies have tested the development and implementation of touchscreen-based devices to engage high functioning children with autism, but these have been restricted to single activities, such as drawing (Yuill, Rogers and Rick, 2013; Murdock *et al.,* 2013) or doing puzzles (Hourcade *et al.*, 2011; Battocchi *et al.,* 2010; Piper *et al.,* 2009). In keeping with suggestions by Mechling *et al.,* (2009), the current study sought to explore additional ways for children with autism to be engaged in touchscreen-based activities. It goes beyond previous studies and provides evidence that the incorporation of a variety of activities on a portable device including point-and-click tasks, multiple-choice questions, and crosswords was well received since the pupils completed the requested tasks. This indicates that combining activities through an app did not affect the exploration of the physical space while it promoted the transition between the physical and digital space. This is a noteworthy finding, as no other study has examined how a technology-based platform and a series of activities affect the behaviour of children with autism (in the medium spectrum) in relation to a new environment such as a museum. The activities seemed to stimulate the pupils' interest to a certain degree, as they were activated to move through the physical space to discover the stories of the exhibits, and their interest was sustained throughout the visit by observing the exhibits and seeking the information they required to carry out the activities. The teachers' comments support this notion; they reported that these activities helped the pupils to remain focused and complete all the requests.

Thus, the findings from this study demonstrate the importance of providing a range of activities rather than a single activity. With the combination of different activities through various prompts such as pictures and audio, the pupils may become more familiar with a task. These results help expand the limited research available on the use of a technology-based programme in a museum environment as a means of promoting active participation for children with autism (Swartzenberg, 2019). The data demonstrated a functional relationship between the use of the app and pupils' ability to transition easily within tasks, (moving from one task to another) and completing them successfully, thus addressing issues of transitioning from task to task highlighted by previous studies (Sevin, Rieske and Matson, 2015; Murray, 2015; Murdock *et al.,* 2013).

Considering that the attention demands of multi-step tasks may create difficulties for children with autism who are known to experience problems in shifting their focus between auditory and visual stimuli (Quill, 1995) and focusing on task, the app provided several modalities. These include visual and tactile modalities which the literature has shown to be effective ways successfully to prompt individuals with autism to initiate and complete multi-step tasks (Mechling 2009; Pierce and Schreibman 1994). The app appeared to support practices of creating an environment that maintained the pupils' interest and facilitated their actions during the task through the use of visual cues (e.g., completing each step of an activity and/or answering the first, second and third questions).

One significant finding of the study is that all pupils showed an interest in completing a series of activities, which has not been explored in-depth in previous studies (Deng, 2017; Fletcher *et al.,* 2013; Yuill *et al.,* 2013; Mulligan *et al.,* 2012). This suggests that the provision of museum content through multiple prompts such as pictures and audio may serve as a motivating factor to assist pupils in the medium spectrum in task performance and to enhance their ability of pupils to complete the tasks. This combination relies on the visual strengths of children with autism (Parsons and Cobb, 2011; Moore *et al.,* 2000), which enable them to learn with more ease and be motivated to perform tasks when reinforcing stimuli are integrated into the app.

7.2.3 Scaffolding collaboration

One finding identified in the research presented in Chapter 7 was the collaboration prompted and facilitated by the app, which involved the pupils exchanging information with a partner, participating in an activity, and exploring another exhibit. These modes of interaction involved a constant motivation to communicate, which enhance the understanding of the pupils with autism. The analysis showed that communication among the groups was achieved in different ways, with further insights in terms of the collaborative types. This study identified three types of collaboration as follows:

1. *Facilitating:* where the facilitator offered guidance to gain basic knowledge of the content and prompted the pupils to recall previous parts of the visit (Group 1).

2. *Directing:* where Chloe controlled the task by sharing the correct answer when Tina did not respond (Group 2).

3. *Sharing:* where the pupils gave each other information and exchanged their knowledge confirming their answers together (Groups 3 and 4). In Group 3, Rob and Bruce had a question-and-answer dialogue, which was followed by looking collaboratively for the next exhibit (i.e., a bridge). This interaction of sharing, commenting, and searching promoted curiosity at the first instance, and then captured the pupils' attention, which led to enhanced understanding and meaning-making. The same attitude was adopted by Samira, who exchanged her thoughts regarding the exhibits and shared her knowledge with the facilitator, who took the role of her peer.

The results of the analysis illustrated the pupils' perceptions and behaviours towards the group work activity while using the app in the museum. The video data and field observations showed that pair work through questions and conversation helped the pupils to construct an understanding of exhibits that were related to similar topics. Although some children with autism can present with issues related to social skills (Baron-Cohen, 2000) while demonstrating different social interactions (Wing, 1988), the pupils in the current study remained engaged and followed the instructions. In particular, five out of the seven pupils reported that they enjoyed the practice of sharing and working towards a mutual goal, while the video data revealed that all the groups showed an interest in working collaboratively and remained engaged in the activity throughout the visit. However, the enforcement of collaboration was less effective for pupils who had greater difficulties in social communication, such as Group 1. Group 1 appeared to derive the least benefit from the more collaborative aspects of the group work. This is because compared to the other pairs they were less communicative with each other and adopted a passive approach until intervention by the teacher was required for them to progress in the task. These findings are consistent with the literature (Beukelman and Miranda, 2013; Keskinen *et al.*, 2012; Dawson *et al*., 2004) which highlights that children with high cognitive impairments in expressive communication found it challenging to communicate with their peers and needed the facilitator's support. Activities such as initiating and maintaining interactions with peers can prevent them from perceiving others as partners in situations where social interactions occur.

The difference in the groups' behaviours might be attributed to the built-in demands of the group work to anticipate turn-taking, sharing, and action/response to act or negotiate together. The pupils might have experienced a cognitive or sensory overload during the task and might not have been able to use their social skills. This interpretation is aligned with the central coherence theoretical account of autism (Happe, 1994); according to which difficulties in multi-sensory integration can lead to complications in the processing of contextual information in an unfamiliar social situation. During the group work, the pupils' involvement was task-focused, and they needed to agree to move to the last challenge. This continuous socially mediated process in which the pupils were required to observe and reflect on relevant objects played a central role in the process of meaning-making towards achieving a common goal (Vygotsky, 1978). According to Vygotsky's theoretical stance (Tudge, 1992), an essential aspect of the learning process is collaborative play and interaction, which will bring a greater understanding of a particular task. This is because through action, children can access their zone of proximal development and their knowledge, which depends on their social environment.

However, this study concluded that all pupils irrespective of whether they received support from the facilitator, adapted easily to the style of group work and organised themselves by taking turns throughout the activity to read aloud the questions, maintain a conversation, click on the answer, and work collaboratively to solve the final clue of the visit. Some of the pupils such as Groups 3 and 4, were more likely to explain their observations that were on-task, pass on information aloud, and negotiate an agreement about their different ideas, which suggests they were focusing on the functional aspects of the group activity. The goal to look for something, make comparisons, and participate in a joint activity was an active form of involvement. For instance, when Bruce answered a question by saying "Bigger", his peer, Rob, commented, "Why would you say 'bigger'?", to which Bruce responded, "Because I just [...]". Then, Rob motivated Bruce to progress to the bridge exhibit, proposing a location where they might find it. Another example is when Samira was communicating with her facilitator (as her partner) about what she had learned from her exploration. These findings correspond to findings in studies by Gal *et al., (*2016), Yuill *et al*., (2013), Battocchi *et al.,* (2010), and Piper *et al.,* (2009) who found that a joint performance interaction through the development of a shared story and activity positively affects children with autism to enhance the creation of social interactions with peers. The study's observations confirm the outcomes of the co-design sessions in which the pupils expressed the preference of working in a group activity and sharing information. *What's Bristol?* app included several features that may contributed to pupils' positive social interactions. The comprehensive and sufficiently narrative storyline set the mission and captured the pupils' attention. This kind of interaction helped the pupils to remain focused on the goal, as attention skills and content knowledge were required to advance the visit. While collaboration became an integral part of the visit to complete the game, the app also enabled individual work; the pupils could still perform the tasks on their own (e.g., when clicking on the right answer) or engage in interaction with their partner (e.g., when listening to the final challenge). This may indicate that the app presented a dynamic environment that the pupils found stimulating, eliminated distractions and facilitated physical exploration.

These results extend previous work in this field and support the potential of co-museum activities to facilitate collaboration among children with autism (Gal *et al.,* 2009). The findings show that a museum visit augmented through the use of an app supports and offers opportunities for children with different cognitive skills (medium-to-high functioning autism spectrum conditions) to experience collaborative play by sharing and interacting with their peers to strengthen their knowledge. This study is the first to capture the collaborative behaviours of children with autism while using a museum-game app and shows how they behaved while they were in constant movement visiting different areas of the gallery. The collaborative dimensions of the visit through the app, involving constant dialogue, problem-solving, and a turn-taking approach, were found to be motivational factors in helping the pupils to explore and reflect. This helped them maintain their attention and cultivated the feeling of working towards a common goal, such as initiation and interaction with a peer, which are considered weak areas for some children with autism. The use of the app successfully amplified these interactions, as working together to solve the challenge became the focus of a joint effort. It thus became a tool that pupils with autism could interact with as it empowered them to discuss, explore, play, and negotiate. The co-presence motivated the pupils initially, and motivation was key to learning (Tudge and Rogoff, 1999), as various types of collaboration took place to support effective group work.

7.3 Issues and challenges

The pupils' exploration of the museum, engagement with the content, and interaction with the exhibits showed the app's positive effects during their museum visit. However, design and technical challenges arose as the pupils progressed through the visit. The challenges that occurred in this study are discussed in relation to the impact they had on the pupils' experience.

One challenge perceived in this study was that the chosen museum activities did not enable all the pupils to work independently, as some issues with the software occurred. Being engaged in a drag-and-drop action is a beneficial approach for children with autism (Chen, 2012; Hourcade, Bullock-Rest, Hansen, 2012; Battocchi *et al.,* 2010). However, this study found that the drag-and-drop activity appeared to challenge some pupils, such as Tina, Charlotte, and Bruce, who found it difficult to drag the dinosaur's bones across the screen with their fingers. The picture did not follow the finger's movement, which led to the pupils becoming frustrated. A similar issue was observed with the puzzle activity in the bridge exhibit, as Tina could not move the puzzle pieces on the screen. This issue is confirmed by the analysis of the post-visit questionnaire, which indicated that two pupils gave a low score for ease of use of the interface, and by the comments of the teachers, who reported that some of the pupils experience moments of stress.

Four potential reasons for this are as follows. First, the pupils were asked to perform an abstract activity, as they could not relate the real exhibit to the digital version. Second, this activity required pupils to put constant pressure on their fingers and perform complicated finger movements across the screen, and some users may lack fine motor skills. Third, the lack of instant feedback on each action led to a series of errors and uncertainty, as the pupils did not have control when linking the elements. Finally, the size and shape of the digital elements and the similarly shaped puzzle pieces in the bridge exhibit may have prevented some of the pupils from completing the activity, as the elements were not big enough to help them navigate them easily (Sitdhisanguan *et al.,* 2011). These issues highlight that an abstract approach to tasks is less effective; so activities need to be simple at a developmentally appropriate level, without constant finger pressure, with limited motor movements and an additional level of visual/auditory cues as a means of assisting the children to perform multi-step tasks. These types of support could help children with autism who have different language and motor abilities to provide feedback for their actions and perform the activities.

Although the app focused on a structured exploration rather than free play (Cohen and Volkmar, 1997), the navigation system appeared to be less clear on some occasions. Through the observations and the focus group, a failure to identify the dinosaur's location was highlighted and impacted how some pupils navigated the gallery. The pupils' attention was captured by the visibility of a dinosaur-shaped exhibit that was located at the entrance of the gallery and introduced an area of Bristol to the visitors. This seemed to confuse the pupils, as two similar dinosaur objects appeared in the gallery, which affected their ability to find the right location. To address this issue, the app was designed to represent the spatial layout of the museum precisely, thus directing the pupils to identify the position of the dinosaur, which was in a hidden area. Nonetheless, despite the use of audio and visual aids to provide guidance (Parsons and Cobb, 2011), participants such as Bruce and Charlotte found the information inadequate to scaffold navigation. The lack of clarity in this activity seemed to prompt increased exploratory behaviour.

This issue may be associated with a flaw in the app's design, which failed to serve its navigational purpose; the lack of clarity and clear physical orientation had an impact on some pupils' experience, as it did not provide the information necessary to navigate the gallery successfully. As people with autism have difficulties with spatial navigation and are less likely to explore an environment (Smith, 2015), the absence of additional external representations, such as multiple digital prompts as suggested by Mechling and Seid (2009), affected the pupils' performance and their ability to move forward. This issue clearly demonstrates that the representation of the museum's spatial layout is less likely to guide children with autism in the right direction. It seems that continual prompting combined with additional audio and visual cues on the screen is critical for aiding such children in identifying the position of the exhibits. However, none of the pupils appeared to be concerned about moving around, and none wanted to withdraw from the visit.

In sum, the discussion of the findings from the primary research conducted in two phases, the preparatory co-design stage and the actual museum visit, has focused on the effects of the use of a co-designed game app on fostering interaction for mid-high functioning children with autism within a museum environment. The interactions ranged from verbalisations representing a change from previous (largely classroom-based) behaviour of the pupils and enjoyment to increased levels of collaboration among the pupils within their group settings. Prompted by the use of the app, pupils improved their interaction with the physical space, the virtual space and inter-personally. This was in line with some of the wider literature but also extended previous research, especially that by Hoskin *et al.,* (2020), Swartzenberg (2019), Fletcher *et al.,* (2013), Yuill *et al.*, (2013), Piper *et al.* (2009), Bauminger *et al.,* (2007) and highlighted the affordances of a museum-game app for children with autism in a museum setting. Overall, evidence of the pupils' enjoyment and participation can be viewed as a significant outcome, which paves the way for considering a co-designed museum-game app as a tool to encourage the active participation and engagement of children with autism in a museum.

7.4 Summary

The present chapter and Chapter 7 have presented, analysed, and discussed the forms of engagement between pupils with autism and the museum environment. This chapter explored what can be afforded through a museum game app to enhance pupils' museum experience and identified what conditions are pertinent to the active participation of such children into the museum space. To address the research questions, different sources of data allowed key insights to emerge, and these were explored in greater depth. It ensured that the data were triangulated, and solid conclusions were made regarding what occurred (from multiple perspectives). The outcomes were supported from different angles and confirmed a correlation between the app and a degree of engagement with the exhibits.

While the possibilities for further research relevant to designing technology programmes for children with autism in formal settings are interesting, this study was a step towards expanding our knowledge about the use of a co-designed game app as a mediated tool in facilitating the museum experience of children with autism. The results suggested that the *What's Bristol?* app, integrated into this study represented an alternative and engaging way of exploring the museum environment. This study revealed that the app worked as a medium, directly connected with the exhibits' content, as it provided structure, instructions on what to look for and how to interact with the exhibits, and interpretations of the exhibits' content. Given that individuals with autism are often sensitive to various stimuli, both the pupils' acceptance of using a platform in a different context and the influence of a portable device on their performance completing a series of museum-based activities were noteworthy.

The pupils' involvement and participation in the museum context cannot be obtained by simply using a device, but it can be achieved by encouraging various forms of interaction to occur through problem-solving activities that require reasoning and observation, group collaboration, and interaction with the museum objects via physical activities. It appeared that the pupils needed structure and a goal in their visit to overcome the difficulties they encountered being in an unfamiliar environment. This structure enabled them to feel more secure and to start their navigation, while the various tasks motivated them to explore what was behind the showcases. To achieve this, audio and visual effects with stimuli played a role in enhancing the pupils' interest, as they provided simplified information and assisted the pupils to obtain knowledge by completing reasoning tasks through using the tool. Observing children with autism being engaged and well-regulated with visual, auditory, and tactile stimuli is a positive outcome. This is the first study that considers the pupils' perspectives from the design of the interface to the evaluation in the museum environment. The contribution of this study lies in the fact that the pupils' voices were central to the research and helped inform the study. The following chapter revisits the research questions according to the analysis and provides concluding comments and reflections on the study.

Chapter 8

Conclusion

Introduction

This thesis aimed specifically to address knowledge gaps around the design and development of a game-app for use in a museum with children with autism. This chapter reviews the main findings of the thesis on the research questions and the objectives set at the beginning of the study. The effectiveness of a portable device to support the experiences of children with autism in a museum is discussed and the key contributions to knowledge and original claims made by the study are presented. Finally, the limitations, challenges of the study, and design recommendations are discussed in support of future directions for possible research in the field.

8.1 Addressing the research questions

As articulated in the introduction, this thesis aimed to explore the experiences of children with autism in using a museum-game app as part of their visit. Based on the results of the qualitative approach, the main findings are divided into three sections that reflect the research questions of the study.

8.1.1 RQ1: What are the benefits and barriers to the effective involvement of children with autism in the design of a museum-game app?

Research Question 1 addressed the co-design of a museum-game app, which was explored in Chapter 4. Grounded in the participatory design field, bottom-up insights were obtained by two groups of pupils with autism to support the ideation and design of a museum-game app to facilitate museum exploration for pupils with autism. Data were collected through field notes and audio recordings and triangulated with the teachers through a focus group who were involved in the co-design sessions. A series of co-design activities were conducted, and the pupils were invited to provide their opinion and produce ideas for the interface.

The results of the study indicated that embedding different opportunities contributed to the pupils' involvement while producing feelings of enthusiasm. With active-based support, the pupils started taking an interest in the requested tasks and felt empowered to express their preferences by replying to the questions or having their say. Letting the pupils know the underlying values of the study (i.e., being part of the design of an interface used by children) gave them a shared awareness of the importance of the practice. This led to a sense of ownership that their ideas were of value in building an app. This factor captured the pupils' interest, which was sustained throughout the sessions. Even for those who felt frustrated by the nature of the tasks, their involvement can be considered a positive outcome as they were able to express their views, but they needed the teacher's support to make their voices heard.

As a result of this analysis, a new framework was developed to meet the needs of children with autism in the medium-to-high spectrum and help designers and researchers in this field coordinate the co-design sessions successfully. This framework describes the different factors for undertaking design activities with children with autism in the medium-to-high spectrum in a school context. The importance of placing children's strengths, needs and interests at the centre of the technology design process is highlighted by this framework. It became evident that a collaborative approach between researchers, teachers and children is important to achieve this goal. The findings indicated how important the development of a rapport was for the pupils to accept the presence of an adult during the co-design sessions. This familiarisation process enabled the development of a relationship in which the pupils felt comfortable interacting with the researcher and, consequently, with the design activities. Through this, their strengths and interests were identified, which led to the construction of knowledge. Further, the framework emphasised the importance of adopting a flexible approach for the delivery of the sessions. The pupils were encouraged to undertake the tasks through the familiar environment, the use of visual stimuli, and adaptable language, all of which enabled them to feel safe.

The need for a more flexible and supportive approach to be considered in the technology design process became evident because different modes of expression can result in the pupils uncovering their creativity through idea generation. Different materials and more activity-based support bridged the gap between pupils' opinions and the researcher's understanding and this additional support facilitated the elicitation of their ideas. This experience highlighted the positive impact of the presence of adult support on pupils' participation levels especially for those who were less communicative and needed additional encouragement and clarification regarding the requested tasks.

8.1.2 RQ1a: How might the involvement of mid-to-high functioning children with autism inform the design process of a museum-game app?

Research Question 1a focused on generating pupils' ideas in terms of the design of a museum-game app. Data were generated through various co-design techniques that helped the pupils express themselves and provide suggestions of what the interface should look like. The final designs demonstrated pupils' ideas and reasoning. The analysis of the direct and indirect feedback and the design outputs derived from the co-design sessions required careful consideration as some of the new ideas presented were not applicable or understandable. The proposed design outputs highlighted several implications for the design of museum technology for children with autism. The pupils expressed their opinions about colourful interfaces, feedback, customised features, and rewards. However, the majority of the pupils did not incorporate any colour in the paper-based interface design, or they included limited colour options. Furthermore, their input suggested some novel ideas, such as the location of the buttons at the bottom of the screen. Some of the pupils came up with a detailed game idea including a multiplayer mode, non-linear routes and short-long term goals, while others preferred to focus on menu screen features such as the integration of different users, the incorporation of an avatar with customised features, and the use of various activities to guide the players to different objects through a location-based awareness system.

8.1.3 RQ2: Does the use of a co-designed game app contribute to bridging the gap between physical and digital spaces to prolong and encourage independent and social interactions in a museum environment?

The findings relating to this research question were presented in Chapter 6 and discussed in Chapter 7. The important second research question provides opportunities for conclusions relating to the application of the *What's Bristol?* app that had been co-designed by children with autism during a real-life visit to the M-Shed museum in Bristol.

Data from the respective visit were gathered through observations, questionnaires video recordings as well as a think-aloud protocol and triangulated with a focus group of teachers who had accompanied the pupils during their visit. The seven pupils reported their levels of enjoyment as overwhelmingly positive, with six of them reporting they had enjoyed it and only one reporting limited enjoyment. Beyond this, there are important conclusions that have implications for theory and practice.

The analysis revealed that the engagement with the *What's Bristol?* app increased the pupils' verbalisations. This was corroborated by the teachers, who conceded that the app helped the pupils' behaviour, their verbalisations and thus their engagement. In terms of the museum experience, the app helped the pupils to manoeuvre the exhibits in parallel in the app and the real museum. Various forms of problem-solving activities that require reasoning and observation using the device contributed to several forms of engagement with the physical objects and prevented the pupils from being isolated. Similarly, the pupils exhibited a higher level of collaboration, which could be ascribed to the use of the app. All data analyses showed a preparedness for collaboration that was facilitated and strengthened by the app. That said, where there were occasions that required a level of abstraction, the use of the app led to higher levels of frustration.

Correspondingly, the app did not contain an additional feedback element, which was identified by the teachers' analysis of the pupils' experience as a cause of frustration.

In conclusion it can be said that the app provided a useful structure and scaffolding that enabled greater levels of engagement and interaction with the physical environment, verbalisations and collaboration of and between the pupils, even though the way the app was constructed at that point caused some frustration in the pupils that was mitigated by the teachers' mediation.

8.2 Implications and contributions of the study

Based on four groups of pupils and their teachers, this study sought to understand how a museum visit mediated through a technology programme is perceived by children with autism. The study contributes to our understanding of pupil's perspectives when using a co-designed museum-game app. It sought to address gaps in the existing knowledge and research questions that arose from the current research concerning the prevalent use of novel touchscreen programmes for children with autism. The following section elaborates on how and why this research is important.

The section emphasises the need for a holistic approach in which children with autism have the role of agents and highlights the full journey of the pupils' interactions with a technological aid in the museum gallery. It contributes to the literature by identifying gaps about what design affordances contribute to our understanding of museum technology for children with autism. This thesis contributes to a limited body of existing research that explores how portable devices outside of formal settings, specifically in a museum context, can supplement traditional museum visits. The implications of this thesis are related to four areas: a) museum practice, b) technology design for visitors with autism, c) methodological contribution, and d) co-creating knowledge.

Museum practice

While the museum sectors' practices are centred on developing sensory friendly programmes for children with autism, this research aimed to go further, building an inclusive technology-driven programme to enhance the museum experience of children with autism. The role of museums to be socially inclusive is reflected in the approach this study followed, as the interface was co-designed with two groups of pupils with autism.

Building on this, the thesis considered the role of a co-designed game app used by seven pupils with autism and demonstrated its potential to bridge current gaps between children with autism and museum experiences. The findings and the analysis chapter suggest that a museum visit through a mediated technology platform reconfigures a traditional formal exploration as it provides insights into the pupils' responses, physical actions among the exhibits, interactions with the app, museum activities and peer work. This supports a view expressed by Langa *et al.,* (2013) highlighting the powerful role of digital provisions to enhance the experiences of children with autism by allowing them to have equal access and become active explorers in their visit. The evidence demonstrated that the pupils' engagement was achieved through their physical and verbal involvement while using the app; the app fostered various types of interactions such as navigating the space independently, observing, manipulating exhibits, collecting information, and reflecting on their experiences through several activities. Holding a device and targeting specific artefacts in the gallery as part of the co-design process helped the pupils to orientate themselves in selected exhibits.

The outcome of pupils' engagement with the space and its exhibits and the opportunities for social interaction with each other contribute new insights into how this new environment may be explored. This study suggests that a portable platform is a means for children with autism to have a structured exploratory visit to perceive the space as an opportunity to become active agents physically and cognitively and to share their knowledge with their peers. Expanding the digital services in museums for diverse audiences and further examining the role of a technology platform for pupils with autism would enable this work to be extended. The technology's potential as an alternative way of supporting children with autism in museums could be further explored, building on the work presented in this thesis. Further data would provide a greater picture of the pupils' behaviour to address the use of digital services in a museum. This further examination could have implications for using a touchscreen device in an informal environment which might be beneficial to developing such programmes for children with autism.

Technology design for children with autism

Touchscreen devices are an interesting area of research into improving and expanding the skills of individuals with autism, as they provide the potential for and challenges to the investigation. Nevertheless, the use of an app in a different context to allow experience-centred interactions for children with autism is an area that remains relatively unexplored in the field of design research. When faced with the question, "How can we create an inclusive interface that meets the needs of children with autism?", this work acknowledged the importance of building partnerships with various stakeholders as a way of developing a product that can accommodate the pupils' expectations. The design of the app was informed by design affordances related to technology for children with autism and by suggestions derived from the participating pupils and their teachers. The implementation and evaluation of the *What's Bristol?* app highlighted several design elements that have potential implications within the technology design. These implications, which are summarized below, reflect on the investigation process and can be viewed as starting points for creating interfaces tailored to the museum context. Accordingly, this set of recommendations aims to support researchers and scholars in creating digital-based experiences as a way of diversifying a museum visit by embedding interactive and playful experiences for children with autism.

The first consideration from a design perspective concerns the distribution of interactions between the digital and the physical space. In this study, a variety of activities were integrated into the museum exploration, which required constant transitions between the digital and physical space. Instead of performing a single activity on the screen, the exploration of the space moving from one exhibit to another through a series of activities encouraged the pupils to explore what was around them. Integrating various activities in combination with the stimuli provided by the platform was an effective way to enhance a traditional museum visit and encourage the pupils to explore, learn, and interact with the exhibits and each other.

These practices consequently shaped how the pupils experienced the visit while building connections between the exhibits and the interface. Object-based orientated digital platforms are thus likely to provide visits that can enhance accessibility for children with autism. This contributed to the pupils' interaction and engagement with the space and gave an interpretation of the outcomes of their interactions with the exhibits. This approach created an experience that piqued pupils' curiosity and fostered their engagement with the environment. Such observations support the idea of a museum interface that affords opportunities for continuous actions and interactions without risking the pupils becoming isolated by interacting only with the device. To encourage such behaviour, museum interface should encourage various types of behaviours with both spaces, the digital and the physical, to establish a meaningful connection between the pupils and the museum content. Understanding of how children with autism behave and respond using an app while performing a variety of activities that entail physical exploration is now greater. This may underline the argument that if children with autism can overcome the initial difficulties a new environment can pose, then the app can be used as a safe space.

Another recommendation is related to the chosen museum activities. The findings indicated that pupils appeared to interact differently with the interface and the tasks; as some pupils may have more limited motor or cognitive skills than others, this might create a level of difficulty for the pupils to continue the tasks on the screen. This is consistent with the heterogeneity of the target population which means that the same interactive tasks may produce a range of performances from the target users. The engaging features and tasks of an app may result in disengagement in certain cases. In this study, it was found that activities that required complicated finger movements on the screen caused frustration to some pupils (e.g., a lack of clarity regarding the dinosaur figure and the size and shape of its silhouette). Thus, the study suggests the need for an adaptive and individualised design environment with the activities and content to accommodate the diverse needs of children with autism. As some museum activities may be more appropriate for some children with autism than for others, a flexible approach that allows children to choose certain kinds of activity and comfortably adjust the interface according to their needs (e.g., shape and size of elements) is important. However, this personalised environment may cause anxiety for children with autism, and customisation features need to be carefully considered to ensure the benefit of having these choices. These aids will help provide structure with only limited chances for divergence while helping to enhance pupils' interaction with the interface.

Another recommendation considers the feedback given by the interface. The evaluation indicated that the pupils relied on the feedback appearing on the screen to progress. This was achieved by the app providing feedback in the form of visual (text and cues) and audio (speech) aids. The pupils experienced a positive outcome after successfully completing a task (e.g., finding the correct answer to a request). However, the study identified that continuous feedback is required to help the pupils be aware of their current situation and what they are expected to do. A scaffolded interface could provide additional assistance if they were to carry out the task incorrectly, e.g., in the dinosaur exhibit they could be guided regarding what they should do and how to complete an activity. Providing additional guidance regarding the actions needed would allow children with autism to feel more secure about their next movements, and they would be aware of whether they were making progress or not.

Methodological contribution

One of the main contributions of this study is the methodological approach adopted to substantiate the findings and the conclusions. Details are provided about the methods needed to plan and employ the evaluation of a touchscreen-based programme in a museum setting. A key point in this analysis is that the participatory design approach followed and the combination of methods (i.e., focus group, questionnaires, video recordings, field-observations, and thinking-aloud) provided an in-depth understanding of 'how' and 'why' the behaviours and interactions of the pupils with autism occurred with a portable device and its role in their museum exploration. These insights offer a full perspective of technology-mediated engagement in a museum environment for these groups and provide the basis for museum professionals and future researchers to understand how a museum exploration through a digital service is perceived and delivered through various forms of representation. Future work can apply this methodology and evaluate and improve the museum digital experience of children with autism. This work, therefore, offers an original contribution to the limited amount of museum and autism-based research by considering the views of the pupils and their teachers in situ.

Co-design approach

Reviewing the literature on designing technology for children with autism identified that the practice of co-designing process or how a platform was developed is hardly discussed. To address this knowledge gap, this study adopted a multi-dimensional and holistic approach (Parsons *et al*., 2017). This thesis gives insights into the co-design process and practices. The design of the interface was inspired by the participatory design framework and involved children with autism in the process. In this study, the design team had an active role along with the researcher and they become involved in regular meetings with the school staff to fulfil the pupils' expectations and needs. The process involved was iterative as the design team's goal was to have a clear understanding of the requirements of children with autism.

The importance of this work lies in the development and evaluation through the iterative design of an interactive platform that presents a game-type app for children with autism. By defining and understanding the needs of children with autism, we can gain important insights into how best to support them and to scaffold a meaningful and enjoyable digital experience. A child-orientated approach the places children with autism at the centre of the design endeavour can be conceived as an important way of bridging the gap and informing the design.

This study provides evidence and identifies important aspects to create an appropriate environment in which children with autism can be actively involved in the co-design process. This has implications in the area of a participatory design approach. Through this study, a greater understanding of the factors that can influence the experience of co-design sessions is provided. A key point in this study is that children with autism became active agents and contributed to the design of the museum app. The findings that various aspects such as creativity, teacher support, suitable environments, visual means and building relationships facilitated pupils' engagement in the interface design process require further examination (i.e., more data). The results of this study indicate that technology cannot work in a vacuum; the collaboration of different stakeholders is necessary to give shape to a programme that considers the needs of children with autism.

8.3 Limitations

A case study approach was adopted to present the purpose, approach, the process, and analytical frame of the research. The study produced data and captured the complexity of the experiences of a single case group, allowing the researcher to obtain an understanding of the phenomenon. Empirical evidence indicated the experiences of children with autism in using the app within the museum; however, several limitations should be acknowledged.

This study introduced the idea of co-design technology for children with autism within a museum. However, this work has been concerned solely with the process rather than focusing on the outcome within the setting. Through this approach, several insights were provided by multiple informants. Regarding RQs 1, 1a & 2, knowledge was obtained from the pupils involved and the study adopted a user-centred framework; however, the study did not consider the pupils' views on their participation at the early stages of the process or their reflections about the co-design activities. Obtaining information about the success of the activities and the tasks included to generate pupils' opinions and ideas could have been useful. The theoretical framework that is one of the outcomes of the study could be transferable to the co-design approach. The proposed design insights can act as a reference for examining their impact on informing the museum technology design process. The qualitative and reflective nature of this study is likely to provide different interpretations and approaches; however, each decision taken has been supported with scientific evidence to prove its validity and reliability.

A limitation of the work reported was that the study included only a limited number of participants throughout the process, and only a single case was conducted to answer the research questions. Due to the small sample of participants and because the study was conducted in a specific type of school, a special educational needs school, the results are representative only of this school context. In terms of the pupils' abilities, this work focused on children with autism who were able to communicate their ideas verbally, and they understood the wider concept of the research and the researcher's role during the co-design sessions. Given the broad range of skills and weaknesses among children with autism, and as the evaluation of the interface was carried out in one particular museum, the findings need to be viewed with caution and cannot be considered transferable to all museums or all children with autism. A different type or size of the museum or the involvement of pupils with less communication skills would produce different results.

Another shortcoming was that the study was limited in length. To address RQ 2, data were collected over the course of one day. Due to concerns regarding the timing, the content of the app was not adjustable; new tasks could not be added to the app to repeat the study as part of the intervention. These factors limited the study's effectiveness as an intervention programme for a specific number of weeks and meant its impact with pre-and- post analysis could not be measured. A longer intervention and the opportunity to adjust the content of the interface would have provided a richer and more consistent overview of the study.

The use of video analysis strengthened the study as it generated a rich data set, which resulted in interesting findings. The video data captured how the pupils interacted with the environment and the exhibit elements and provided detailed data on pupils' behaviour in both verbal and physical communications while moving around the gallery and interacting with each other. The comprehensive analysis allowed the researcher to code the behavioural data and ensure proper categorisation. Unfortunately, an equally detailed analysis of the videos could not be performed due to occasional background noise and the moving camera could not record the voices clearly. So, the external reviewer and the researcher could not transcribe all the verbalisations. Despite the technical issues, the video method was beneficial as it enabled the researcher to revisit the data for further analysis and offered a complete picture of pupils' experiences.

A final limitation to be highlighted here was the lack of a control group in the study. This represents not only a methodological limitation but also a limitation concerning the outcome. Given the lack of a control group, it is impossible to say how the pupils' responses would have compared with those of a group of children who had not had the benefit of using the app during a museum visit. Although the pupils' observations and responses were triangulated by the use of teacher focus group, and those teachers know the children well and could contextualise their behaviours and responses to those experienced in the classroom, the lack of a control group still represents a significant limitation for the validation of the findings.

Similarly, the findings were not juxtaposed to a museum visit by the seven pupils involved without the use of the app. This could have been an option for a control process but was deselected as a methodological approach in favour of the triangulation of the teacher data and the pupils' co-creation of the app. Future investigators may consider the introduction of either a control group for validation or a control process, as described above.

Notwithstanding the limitations discussed above, the evidence collected, analysed, and discussed combined with the overall contribution and original insights into an overlooked topic help to pave the way for future research in the field. These results can be considered encouraging while further research is required to establish a greater degree of accuracy of design-based settings. To do this, larger samples including groups of typically developing children, over an intervention programme of longer duration, and the implementation within different contexts will contribute to validating the generalisability of the present findings.

8.3.1 Challenges

Several issues arose within this work. One of the challenges was the failure to recruit more schools, which led to the involvement of only one SEN school. While the researcher attempted to contact as many schools around Bristol as possible, only two responded and the eligibility criteria established in this study excluded the second school. This resulted in the production of only a limited interpretation of the impact of the interface with a low number of pupils with autism taking part in the study. That said, and despite the small number of participants, the triangulation of the pupils' data with the teachers' perspectives, as well as the researcher's observations, nonetheless provided a valid and robust data set with which to address the research questions. Moreover, in line with Vasileiou et al. (2018) it is the lack of discussion in the context of empirical qualitative research that is considered a methodological challenge by some, rather than the size of the sample. In the context of the research presented here, it is contended that the sample size represents data saturation in relation to the research aims and objectives.

With regard to the inclusion criteria for the specific pupils participating in the research, and in support of the methodological considerations on inclusion criteria specified in the methodology chapter, it is important to reiterate the strength of the sample based on the criteria, and, critically, the teachers' recommendations.

In this study, obtaining parents' or guardians' approval and ethical consent to observe the pupils in the classroom and participate in the research was a delicate subject. Following the principles and procedures required by the Ethics Committee, the file with the ethics documents could not be shared with the parents. The school addressed the issue that the information documents and language level were advanced and complicated for the literacy level of some of the parents to support their understanding of what the research was about. These two factors could affect the parents' ability to make an informed decision, agreeing with what was outlined in the ethical forms. In consultation with the school staff, the researcher addressed these concerns and prepared a simplified version of the consent form while various strategies took place for communicating the research.

The researcher attempted to approach the parents in various ways; for example she attended school events to which the parents were invited, approached them at the end of the school day, put the forms into the potential participants' bags, and contacted the parents by phone to state that their signature would be required, still only a few parents responded to the request. Thus, a limited number of permissions were obtained. This led to a limited representation of children with autism in the study. Given that the study concerned vulnerable groups, the ethics procedure and the consent forms might better have been simplified for those parents and guardians who have cognitive limitations or any other form of disability.

Parsons and Cobb (2014) argue that multi-stakeholder engagement is an identified challenge in the technology design process. Due to the diversity of the people who took part in the technology process (e.g., designers, teachers, and the researcher), different views were expressed for the design of the technology. A series of meetings were arranged at the design development stage and different opinions were expressed from different backgrounds regarding interface components that should be integrated. This raised a challenge concerning how the integration of pupils' views can be achieved regarding the design of the technology. This issue agrees with Parsons and Cobb (2014), who claimed that the development of technologies for this target group is a rare pursuit, and it remains unclear who is best placed to advise on how the technology can and should be developed. As this study's goal was to be inclusive, priority was given to the views of teachers who were aware of the pupils' abilities and needs while attempts were made to give a voice to the pupils at the early stages of the project.

8.4 Extensions and further development of the *What's Bristol?* app

Throughout this work, upon reflection and based on feedback, specific suggestions have been made for further work required to improve several aspects of the *What's Bristol? app*. Some of the features presented in this section are aimed to help future researchers design interfaces for children with autism; while these changes arise from the limitations of this study, some of them illustrate generic principles that can be applied to any interface, as illustrated below.

- Applying a user profile that allows users some freedom in making customised changes will be helpful to the engagement of children with autism with the interface. This can be done through customised feedback, changing various features of the main character, and/or giving them the option to select a character to interact with.
- A different difficulty level should be introduced based on the skills and abilities of children with autism to overcome a challenge that affects how the pupils will progress. This can be achieved by using a combination of colours and pictures to convey information about increasing difficulty levels. Modifying the difficulty of the

task so the children can practice and execute the same challenge but in a different context can demonstrate a variety of approaches that can be integrated to complete a task according to the users' skills and abilities; thus improving task performance.

- The activities should fit the abilities of children with autism, so for pupils with fine motor or cognition issues, activities with fewer movements can help to make an interface as easy as possible.
- The game should be extended and include a variety of activities that the pupils need to complete so that they can explore further various exhibits of the museum.
- Visual indications of changes and transitions about where each spot is located and when the pupils need to move to another floor or area will allow ease of navigation for those who can are not as proficient as others and might get stuck navigating the interface.
- Buttons or icons should be introduced to provide further explanations for terms and/or objects of the museum which are difficult for those who have limited understanding to comprehend.
- The present platform included both individual and collaborative work. It would be interesting to develop a multiplayer game with typically developing children capturing their sharing experiences and interactions.
- Introducing a level of feedback integrated into the app would point the users towards correcting errors and provide alternative pathways and approaches in their manoeuvring of the real-life exhibition space when using the app.

8.5 Future considerations

This research provides the starting point for considering the potential of portable digital services as a tool for achieving the desired outcome of facilitating the engagement of children with autism within the museum context and fostering a positive attitude towards the exploration itself. This thesis has highlighted several directions that could be further investigated.

The pupils' viewpoints and preferences about the design of a museum-game app are central to the findings of this study. As Parsons *et al.*, (2015) argue, knowledge co-creation represents an effective practice of placing the equal involvement of children with autism at the centre of the research and recognise that *"a more democratic participatory research space may offer important epistemological opportunities"* (p.267) with a beneficial effect on influencing the design process for the better. This view emphasises a shift towards more inclusive practices that develop agency and empowerment by enabling various stakeholders to provide their insights into such design processes. Since gains may be made by adopting a more inclusive approach, a thorough examination of needs and expectations when children with autism visit a museum would be useful. This could inform knowledge on how best to design and support such groups in a museum setting. Furthermore, the inclusive design approach that this work adopted has resulted in the development of a framework that can have a direct impact on the co-design practice; however, it was not examined in detail. It might be of interest for future scholars to build upon this and examine the present framework and work recommendations for other aspects that can be modified.

Several museums, including the museum involved in the present study, have started using initiatives to raise awareness of accessibility and to make museums autism friendly. However, by exploring the above-mentioned museum-game app, this work created a much more bespoke, tailored and individual interactive experience for more meaningful engagement and interaction with the museum exhibits. It highlighted that appropriate technological design has the potential to support the active participation of children with autism within a museum context. From this perspective, this approach offers museums opportunities to motivate visitors with autism to engage in inquiries, scaffold their interactions with the exhibits, and discover information supported by technology. In this way, the target group is prompted to construct their own meanings through different modes of interaction. The role of museums is to offer opportunities for play, exploration, and learning for the public, including people with autism. For example, art and play-based activities proved to promote the learning of children with autism as a way of integrating them into the museum community (Woodruff, 2018; Langa *et al.*, 2013; Mulligan *et al.,* 2013). The findings presented in this study highlighted that a game-based exploratory activity through an app can be applied to visitors with autism. Future research might extend these initial findings and consider the provision of new modes of interaction with the environment, such as developing, sharing, and documenting their content.

This work has indicated that specific design features proved to be useful for the engagement and active participation of children with autism. The experience obtained from the study in combination with the characteristics of children with autism led to the identification of such recommendations, which can inform further practice for the design of portable devices for children with autism. One example is the importance of structure and consistency when children with autism experience a new situation as they need to be in a controlled environment. This thesis has highlighted that a shift from digital to physical space had the potential to encourage continuous actions and interactions. Future scholars can use the outcomes of this study to create technology-driven museum activities with customised features at various stages of the game. These could be useful for making changes based on the pupils' needs and creating a more personalised experience. This, in turn, will inform knowledge on how best to design technology platforms for children with autism.

This work has followed a systematic approach and offered insights for museum professionals into better understanding how to design and develop platforms aimed at children with autism. Using portable devices to support such children is a promising starting point for museums to integrate this approach across various museum settings. The ability to practice hands-on museum activities through a portable device has great potential for children with autism who feel stressed in unfamiliar contexts. Further work could build on the systematic methodology this study has adopted and could be piloted and evaluated with a larger sample in another context, such as a science museum, and take place over a longer period, to establish further evidence of the needs of children with autism and the effectiveness of using portable touchscreen devices in museum settings.

The findings provided insights into the types of collaboration that occurred during the museum visit; the app provided a context in which turn-taking, sharing their experiences, and working collaboratively towards a goal can be encouraged and practised, this aspect could be interesting to explore further. Future work might consider examining this area by developing innovative interfaces with embedded features and content that can promote social skills in children with autism. This examination might provide greater details as to how a collaborative visit is perceived by children with autism and what kind of activities support group work in an unfamiliar environment such as a museum. This is important to this target group as issues with joint attention and maintaining social interactions can be extremely problematic and a source of anxiety. Further research may be worth pursuing in this area to understand whether a museum app facilitates social interactions for children with autism in a different context; a question that was beyond the scope of this research.

8.6 Conclusion

This thesis contributes to the body of knowledge on digital inclusive design and provides insights regarding the current state of designing and co-designing technology for children with autism. It has resulted in the development of a software platform by adopting a participatory design approach and actively involving various stakeholders in the design process throughout, most importantly the pupils themselves. This approach allowed the participating pupils and teachers to express their views, share their ideas related to the design of the platform, and finally, evaluate its impact. Through this process, the pupils became active agents and had a direct impact on the design of the app.

What's Bristol? app was designed based on current best practices and the feedback provided by the participating children. The use of a portable device has provided some important insights into the effectiveness of the *What's Bristol?* app as a means of supporting the visits of children with autism and engagement with museum exhibits. The app offered opportunities for different forms of interaction to occur through problem-solving activities that require reasoning and observation, collaboration, and interaction with the museum objects via physical activities. The practice of interacting with the exhibits themselves through a variety of activities was well received and worked as a motivating factor to maintain attention and interest. Additionally, the opportunity the pupils encountered to focus on exhibits in a targeted manner was an additional factor that contributed to fostering exploration and helped prevent the pupils from becoming overwhelmed. Where issues were either not addressed by the app or at times caused by the app, the mediation of the teachers was important and must be built into future research or applications of this research.

Digital services provided by the museums are common-place and aim to target a variety of visitors. This is the first touchscreen-based app that has been developed to enhance the museum experience of children with autism and encourage them feel engaged in a museum, fostering collaboration with others as they experience the museum and improve their behaviour. Importantly, the app increased the pupils' levels of verbalization, which could have implications for the introduction of technology-based applications in other areas of their lives. This study provides grounds for optimism that portable devices may act as motivational drivers to support children with autism in a museum environment, and potentially beyond. Therefore, it stresses the importance of an inclusive design approach to meet children's expectations. To deliver personalised and accessible novel technologies, a consideration of the needs of children with autism and conditions is required, as well as an understanding of what the introduction of such technological solutions can, and cannot, contribute to the experience. This can be achieved through a multi-disciplinary approach in which various stakeholders from diverse backgrounds shape the technology design.

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Appendices

Appendix A List of key guidelines of user interface design for children with autism

Review of current bestpractices	Key Points	Sources
Consistency-Structure	- Brief tutorial of the activity - Introduce of new elements gradually (audio and/or visual features) - Clear form of guidance of the activities - Break the activities into smaller tasks - Structured situation	Darejeh and Singh, 2013; Weiss *et al.,* 2011; Davis *et al.* 2010; Silver and Oakes, 2001; Hayes *et al*, 2010; Cohen and Volkmar, 1997
Predictability	- Set consistent expectations and cues to help users predict the outcome	Davis *et al.* 2010; Weiss *et al.* 2011
Content and visual comprehension	- Simple content - Content along visual features - Short text and break up content with numbered lists and sub-headings - Use of symbols or icons	Putman and Chong, 2008; Friedman and Bryen, 2007; Hayes *et al*. 2010; Department of Health, 2009
Customization	- Enable the users to make changes that match their specific needs by changing sound, size and/or colour of the font	Friedman and Bryers, 2007; Millen *et al.* 2012; Putnam and Chong, 2008; Brown *et al*. 2011
Interactivity	- Interface simple with a few elements for the current task	Putnam and Chong, 2008; Brown *et al*. 2011; Davis *et al.* 2010; Rogers, Sharp and Preece, 2011; Darejeh

	- Use of clear and large buttons with icons and /or text - Visible functions - Big buttons and icons in a click option - Screen layout large and ability to zoom in and out	and Singh, 2013; Friedman and Bryen, 2007;
Navigation tools	- Simplified navigation - Use of location awareness system - Consistent navigation page buttons (eg., exit, back, and help buttons) - Place the buttons on the same place (on top) - Direct manipulation of the interface	Brown *et al.* 2011; ETSI, 2005; Friedman and Bryen, 2007; Sitdhisanguan *et al.* 2012; Davis *et al.* 2010
Feedback	- Provide immediate feedback for every point of their actions - Use of rewards with visual feedback - Prompts via audio, textual, and/or visual - Presence of onscreen characters for guidance	Rijn and Stappers, 2008; Whyte, Smyth and Scherf, 2015; Hayes *et al.* 2010; Davis *et al.* 2010
Multimedia features	- Multimedia modes with simple layout - The integration of animation, and/or sounds - Audio and visual formats to convey information and/or the content - Possibility to maximize and minimize the pictures	Darejeh and Singh, 2013; Abbott and College, 2007; Rijn and Stappers, 2008; Sitdhisanguan *et al.* 2012; Frauenberger*et al.* 2013; Putnam and Chong 2008; Hayes *et al.* 2010; Brown *et al.* 2010

Design colour layout	- Balance between the background and foreground - Keep a consistent layout - Use of good contrasts	Britto and Pizzolato, 2016; Sitdhisanguan *et al.* 2012
Game elements	- Narrative storyline with medium and long-term goals - Collaboration as a team - Ability of cooperative gestures	Whyte, Smyth and Scherf, 2015; Habgood and Ainsworth 2011; Kapp, 2012; Weiss *et al.* 2011; Parsons and Cobb, 2014; Hourcade, Bullock-Rest and Hansen, 2012

Appendix B Brief review of the museum experience through the use of mobile media

The tendency for treasure hunt games has been applied by various museums around the world. Museums such as the Melbourne Chinese Museum and British Museum provide a paper-based treasure hunt game as a guided activity (see the websites http://www.thatmuse.com/en/musees/index/9/british-museum and https://chinesemuseum.com.au/treasurehunt/,**Figure 1**). Another example is the Breadcrumbs app; a collaboration among different museums in London where tourists are sent to explore objects from English museums.

Figure 1 Example of a paper-based treasure hunt game in Melbourne Chinese Museum.

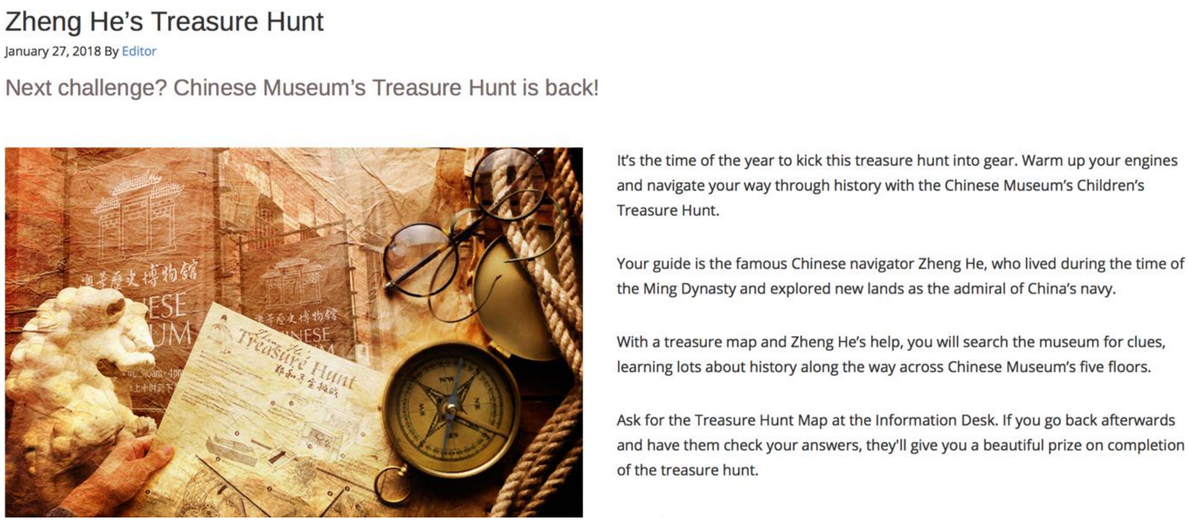


Figure 2 Example of a paper-based treasure hunt at British Museum.

Mobile technology has become a pervasive part of the museum services and transformed how treasure hunt gaming can provide opportunities for improving the visitor's experience (Economou *et al.* 2015). Mobile devices with multimedia-enabled features allow any information to be conveyed through text, sound, video, and/or text. These devices made possible to track locations and participants in real time, enable users to communicate each other, and provide cues via various formats (Kohen-Vacs *et al.* 2012).

Over the past decade, there has been an increased interest in the development of treasure hunt game variants. For example, Radeta *et al.* (2017) designed and compared two different mobile approaches; a story orientated and a game. The aim of the study was to compare which approach is effective in terms of engagement, enjoyment and learning outcomes in a natural museum setting. The audience of this study was 16 children aged between 10 to 12 years old. The content of the gamified app was presented via written text on the mobile screen while in story-driven the information was triggered by the beacons and appeared through narration and some short and hand-drawn animations (**Figure 3**). Proximity sensors were also placed in the objects the visitors needed to explore.

Figure 3 Screenshot of the interface.

The design of the game app was treasure-hunt driven and the children were invited to search around the museum for thirteen marine species in order to collect the points. Once in proximity area of a beacon, a digital picture and an animation are displayed on the mobile's screen. The children are invited to find three curious scientific facts. Everytime they complete a task, they would receive their visual points. Once they collect all species, children are asked to answer a quiz. Data collected through observations in action. To evaluate children's learning, pre and post-test quizzes were used while to measure their enjoyment, and engagement user evaluation toolkits were employed (Smiley-ometer and Again- Again Table).

The findings from this work reported that both type of games had a positive impact on children's enjoyment, engagement, and motivation. However, the game experience was noted to be more interesting. The authors highlight that the children became excited once digital icons appeared into their devices and acted as a motivation to walk around the gallery and search for more clues. The children were observed to be interested in taking self-portrait with the marine species than observing the artefacts. During the game, the children were noticed to speak aloud about the museum artefacts. Reflecting on this experience, the authors mention the children's excitement, however, difficulties in engaging them with the content were detected. The interface design with a good balance between audio and text is an aspect that the authors recommend in order to effectively engage the children. One of the limitations of this study is that the evaluation of these apps was conducted through observations while the scales (Smileyometer) cannot fully reveal the enjoyment and engagement of children using the app through the museum tour.

In their work, Kuflik *et al*. (2014) presented the *Treasure Hunt* game, a treasure hunt mobile game for the Hecht Museum, which was developed based on user-centred principles. The system was enhanced by location-based services and QR codes technology, and the goal of the game was to create a user-friendly interface that enabled the children to be engaged and to have a fun experience. The structure of the game is as follows. The users are given several clues that they need to find the given objects. When the user arrives at the correct position, multiple-choice questions are then presented and can be answered by looking for facts about the given objects. The evaluation conducted by the museum staff reported the children's enjoyment in playing the game, and in some cases, there were players who played more than once. However, in Kuflik *et al*.'s (2014) work, there is no information about how the user-centred framework was applied to design the game. The present work focused mostly on transferring a treasure hunt game from a paper to a digital-based format. In addition, the absence of a formative evaluation of the system is because it was not in the scope of the study. Therefore, further work is needed to formally assess how such games can support participation and engagement among diverse audiences such as children with autism, an issue that this study will address.

Laine *et al.,* (2010) described the design and architecture of the *Myst* game platform, which has been used in various locations including museums. The platform is a multiplayer game that has a number of game-like features whereby the users can experience the same surrounding environment. The game is structured by a range of context-sensitive enigmas, such as text-based queries and take-a-picture tasks that the players need to solve as illustrated in **Figure 4**. Unsuccessful answers decrease the user's total point score. The authors highlighted that a flexible design needs to include a) a variety of contexts (physical locations), b) a variety of content types (various media types), c) different players, and finally d) various interactions between players and non-players. Preliminary findings through a questionnaire have shown that this type of platforms motivates users to interact with the physical context and help users build their own connections with the exhibits. The players were reported to interact with the environment while solving enigmas through the platform. The authors stressed that interaction with the physical context is also an essential part of pervasive games.

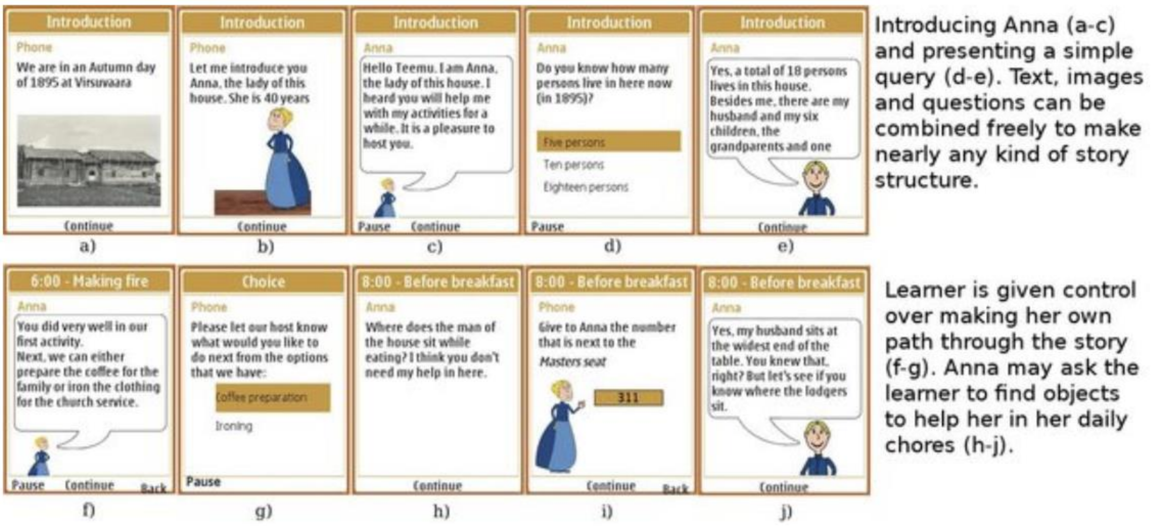


Figure 4 Screenshot of presenting the main character of the game and the first query.

This section aimed to provide an overview of how museums have embraced state-of-the-art technology in their exhibitions to mediate visitor meaning making pertinent to the artefacts and to broaden access to new visitor groups. It becomes clear through this review that various technology programs have been developed the past years as a means of creating new opportunities for the visitors to engage with the artefacts. As discussed, portable digital technologies offer a sense of customization including various multimedia techniques and search functions that can hold visitor's attention and interest.

Appendix C Observation Notes

Observation Sheet Template

Date: 12/03/2018

Observer's name:

Group:

Names of children:

<table>
<tr><th>Specific Focus</th><th>(initial of name)</th><th>(initial of name)</th><th colspan="5">Any additional comments</th></tr>
<tr><td>Tracking Time</td><td></td><td></td><td colspan="5"></td></tr>
<tr><td>Approximate time spent at each location (i.e. area of interest) in mins.</td><td></td><td></td><td>Bus
Init. Name:
Time:</td><td>WWII
Init. Name:
Time:</td><td>Dinosaur
Init. Name:
Time:</td><td>Map
Init. Name:
Time:</td><td>Bridge
Init. Name:
Time:</td></tr>
<tr><td>Total time spent by each group</td><td></td><td></td><td colspan="5"></td></tr>
</table>

General Observations about the session:

Appendix D Questionnaire 1

My Name: -------------------------------------- Date: -------------

This is an opportunity for you to share your thoughts and feelings about your field trip. I would like to find out what you think about your visit to the museum.

There are no right or wrong answers; just say what you think.

Please help me by filling in this questionnaire. Please answer the following questions by ticking **(✓)** ONE answer in each question.

When you are done, please return your completed questionnaire to your teacher or me.

1. Did you enjoy the visit to M Shed museum?

- ☐ A lot
- ☐ Quite a bit
- ☐ Just a little
- ☐ Not at all

2. I would like to visit museums more often after my visit to M Shed museum.

- ☐ Yes
- ☐ No

3. How did you feel after visiting the museum? **Please tick as many boxes as you want.**

- ☐ Excited
- ☐ Comfortable
- ☐ Safe
- ☐ Fine
- ☐ Not Bad

4. Did you enjoy experiencing different objects in the museum by touching and playing?

- ☐ A lot
- ☐ Quite a bit
- ☐ Just a little
- ☐ Not at all

5. Did you like discovering Bristol’s history at the museum?

☐ Yes

☐ No

6. Did you enjoy working with your classmate?

☐ A lot

☐ Quite a bit

☐ Just a little

☐ Not at all

7. Did you enjoy sharing your knowledge about the museum’s objects with your classmate?

☐ A lot

☐ Quite a bit

☐ Just a little

☐ Not at all

8. If not, why didn't you like it? Share your thoughts below.

9. How easy was it for you to work with your classmate to find the answer to the puzzle's task?

- ☐ Very easy
- ☐ Fairly easy
- ☐ Quite Difficult
- ☐ Very Difficult

10. Do you have any favourite object from the spots you visited?

- ☐ Yes
- ☐ No

11. If yes, tick the spots you enjoyed the most?

- ☐ Bus
- ☐ Dinosaur
- ☐ WW II
- ☐ Bristol's Map
- ☐ Suspension Bridge

12. What was the most exciting? thing you learned about your city? *Use the space below to write or draw your thoughts.*

13. Please describe how would you rate the overall museum visit on a scale from 1-5.

 **1 2 3 4 5** 

	1	2	3	4	5	
Fun	☐	☐	☐	☐	☐	Boring
Awesome	☐	☐	☐	☐	☐	Awful
Safe	☐	☐	☐	☐	☐	Uncomfortable
Sociable	☐	☐	☐	☐	☐	Isolated
Easy	☐	☐	☐	☐	☐	Difficult

15. Is there anything else you would like to write about your museum visit?

Use the space below to write or draw your thoughts.

Please check that you have marked all of the sentences.

Thank you very much for sharing your thoughts with me!

Appendix E Questionnaire 2

My Name: -- Date: -------------

This is an opportunity for you to share your thoughts about your experience using *Whats Bristol app at the museum* and whether it helped you to understand better interesting stories of your city.

There are no right or wrong answers; just say what you think.

Please help me by filling in this questionnaire. Please answer the following questions by ticking (✓) ONE answer in each question.

When you are done, please return your completed questionnaire to your teacher or me.

1. Did you like using ***What's Bristol*** app during your visit?

- ☐ A lot
- ☐ Quite a bit
- ☐ Just a little
- ☐ Not at all

2. Did you find *What's Bristol* app easy to use?

- ☐ Very easy
- ☐ Fairly easy
- ☐ Quite Difficult
- ☐ Very Difficult

3. Did you feel confident using *What's Bristol* app during your museum visit?

☐ Yes

☐ Not sure

☐ Not at all

4. Did you have fun doing the activities through What's Bristol app?

☐ Yes

☐ No

5. Was *What's Bristol* app a helpful tool to learn some fascinating stories about Bristol's history?

☐ A lot

☐ Quite a bit

☐ Just a little

☐ Not at all

6. I would definitely like to use an app in the museum again.

☐ Yes

☐ Not at all

☐ Not sure

Please check that you have marked all of the sentences.

Appendix F Teacher's Questionnaire 3

Teacher Name -----------------------   Date --------------------------------

I am interested in learning your opinions about the current field trip at M Shed Museum. This questionnaire is of great value to my research project and aims to evaluate the effectiveness of *Whats Bristol* app. All the responses will be kept anonymous and confidential

Please take time to read each question carefully and respond by either putting a tick (✓) in one of the boxes below in each question or writing your opinion.

Thank you in advance for your time and cooperation.

1. Do you think the children were happy to visit M Shed museum?

- ☐ A lot
- ☐ Quite a bit
- ☐ Just a little
- ☐ Not at all

2. How do you think the children felt being at the museum? Tick **more than one** if needed.

- ☐ Excited
- ☐ Comfortable
- ☐ Safe
- ☐ Fine
- ☐ Not Bad

☐ Any other comments (write below)

----

3. Why do you think this? *Use the space below to specify.*

4. Did the children you work with behave in a similar way to normal (i.e. in the classroom)?

☐ Yes

☐ No

5.If yes, can you please describe what happened?

6.What do you think the most interesting time of the children's visit was? *Use the space below to write your thoughts.*

7.Do you think children felt comfortable working in pairs to explore different areas of the museum?

☐ A lot

☐ Quite a bit

☐ Just a little

☐ Not at all

8. Do you think *What's Bristol* app was an effective tool which made children's visit more enjoyable?

☐ Very effective

☐ Effective

☐ Somewhat effective

☐ Not so effective

☐ Not at all effective

9. Do you think the children found *What's Bristol* app easy to use?

☐ Very easy

☐ Fairly easy

☐ Neutral

☐ Quite Difficult

☐ Very Difficult

10. Was the information content of the app understandable for the children?

☐ A lot

☐ Quite a bit

☐ Just a little

☐ Not at all

11. Did you find the various tasks in *What's Bristol* app well-chosen to help children understand different landmarks of the city?

- ☐ A lot
- ☐ Quite a bit
- ☐ Just a little
- ☐ Not at all

12. Do you think *What's Bristol* app helped children learn some interesting stories about Bristol's past?

- ☐ Yes
- ☐ No

If not, use the space below to explain why.

13. Overall, do you think the children enjoyed their visit to M Shed?

- ☐ A lot
- ☐ A little
- ☐ Neutral
- ☐ Not at all

14. Is there anything else that you would like to comment on?

Thank you very much for sharing your views with me!

Appendix G Usability Questionnaire 4 (children with autism)

Help us improve the application

CircleONE answer for each of the following questions.

		Yes	No		If you want to say more, write your thoughts here
1. Overall, was the language easy to understand?		☺	☹		
2. Was the size of the letters easy to read?		☺	☹		
3. Were the tasks easy for you to move on to the next task?		☺	☹		
4. Did you find the use of buttons (e.g. back, next) useful in finding your way and going to the previous or next pages?		☺	☹		

5. ***Were the buttons enough big to click on them?***		☺	☹		
6. ***Did you like the colour choices?***		☺	☹		
7. If not, which colour did you not like?					
8. ***Could you understand the mission of the game from the instructions given?***		☺	☹		
9.***Did you like the option of text and sound being available in the game?***		☺	☹		

Thank you very much for your time to test the test- version of the app.

Appendix H Usability Questionnaire 5 (teachers)

Help us improve the application

Please tick off ONLY one answer in each of the following questions.

1 Did you find the text easy to read?

- ☐ A lot
- ☐ Little
- ☐ Not at all

2 Did you find the text comprehensible?

- ☐ A lot
- ☐ Little
- ☐ Not at all

3 Did you find the audio comprehensible?

- ☐ A lot
- ☐ Little
- ☐ Not at all

4 Were the instructions concerning the mission of the game clear?

- ☐ Quite clear
- ☐ Fairly clear
- ☐ Quite difficult
- ☐ Very difficult

3 How easy were the tasks based on the children's skills and abilities?

- ☐ Very easy
- ☐ Fairly easy
- ☐ Quite difficult

☐ Very difficult

6 Did the children have any difficulty in finding or clicking the buttons?

☐ Yes

☐ No

7 Did you find the balance between the background and foreground good?

☐ Yes

☐ No

If not, please explain briefly.

8 Did the children need your assistance during testing?

☐ Yes

☐ No

If yes, please specify in which part of the app.

9 Did you notice if the children got confused during testing?

☐ Yes

☐ No

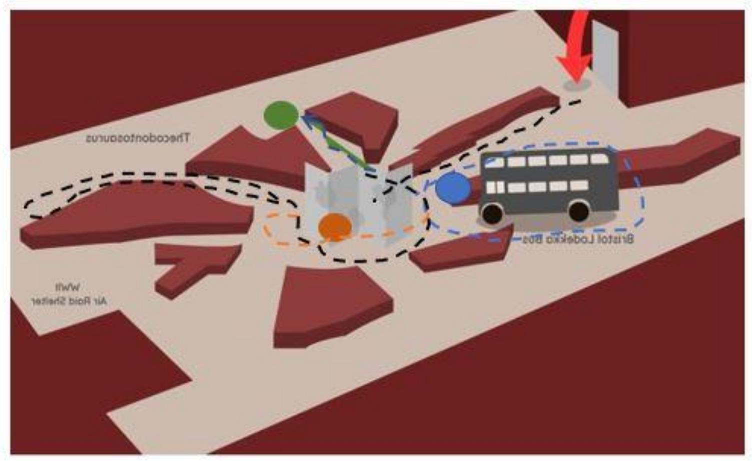
If not, please explain briefly.

Thank you very much for your cooperation.

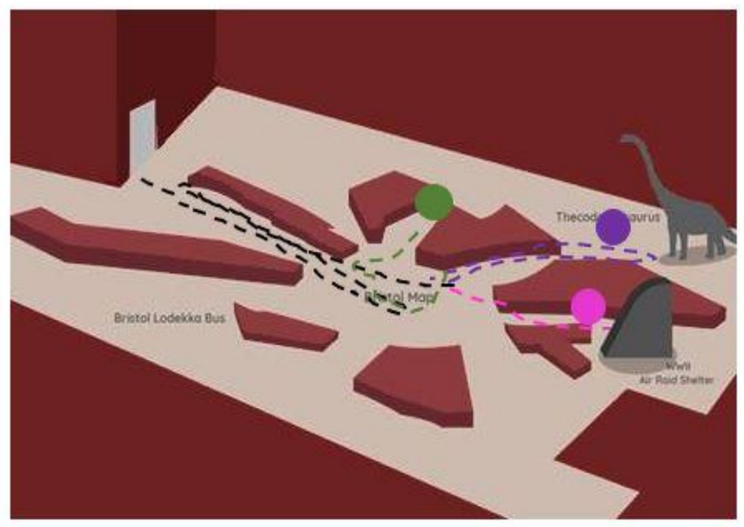
Appendix I Coding Scheme for Video Recordings

Behaviour Type	***Frequency***
Emotions (visible expressions of pleasure)	
Smile/laugh/cool	
Express emotions (surprise, enthusiasm e.g. I like it, I/we found it)	
Read out loud the screen text	
Emotions (of stress)	
distressed	
bored	
confused	
uncooperative	
Physical Interaction	
Look at the displays (refer to things around them)	
Performing gestures (e.g. click buttons, touch displays)	
Play/touch with other displays (not included in the app)	
Interaction- Collaboration	
Express their thought (what they say)	
Engaged in turn-taking	
Place together information about objects	
Look for facilitators' feedback/help	

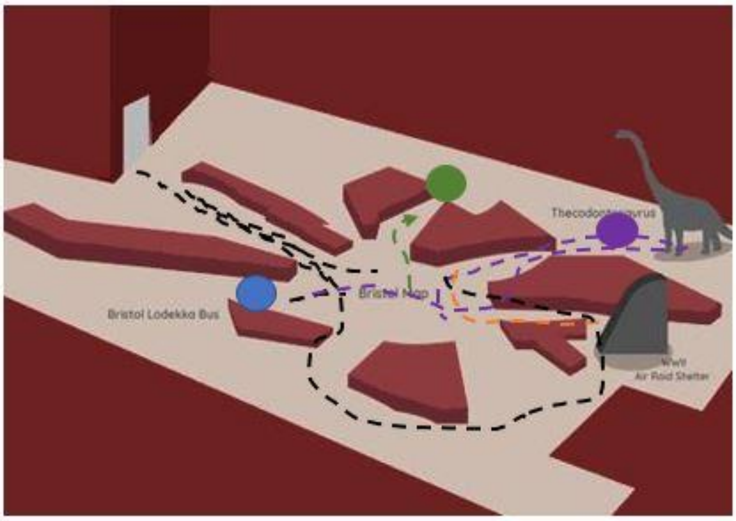
Appendix J Visual routes of the pupils during the museum visit.



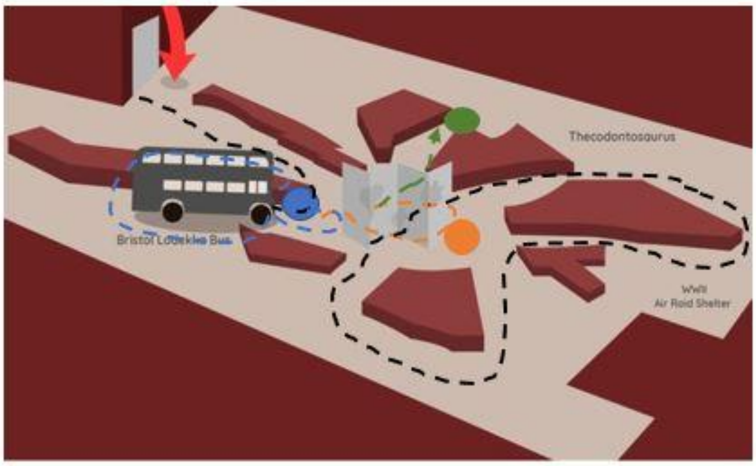
Aisha's route in the gallery.



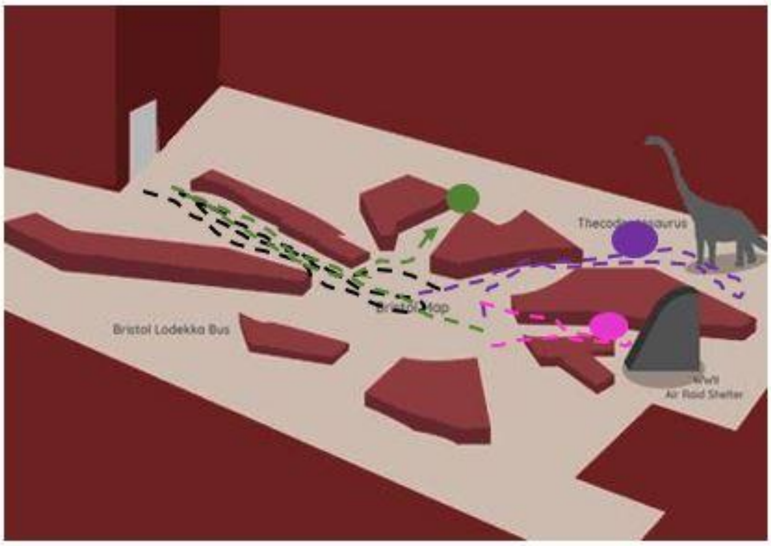
Charlotte's route in the gallery.



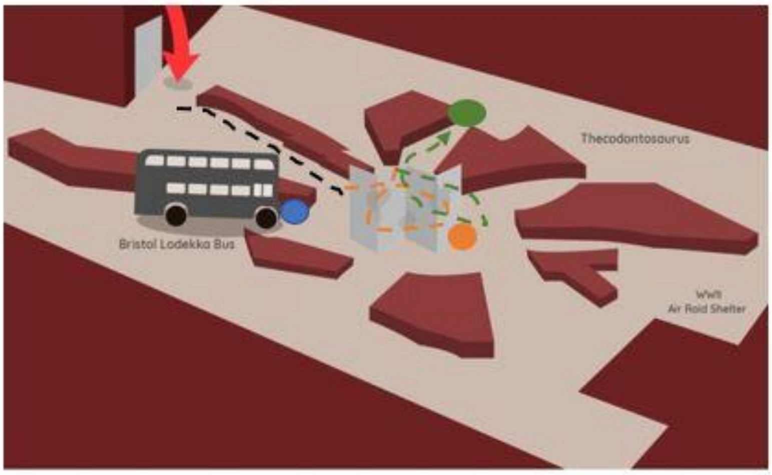
Tina's route in the gallery.



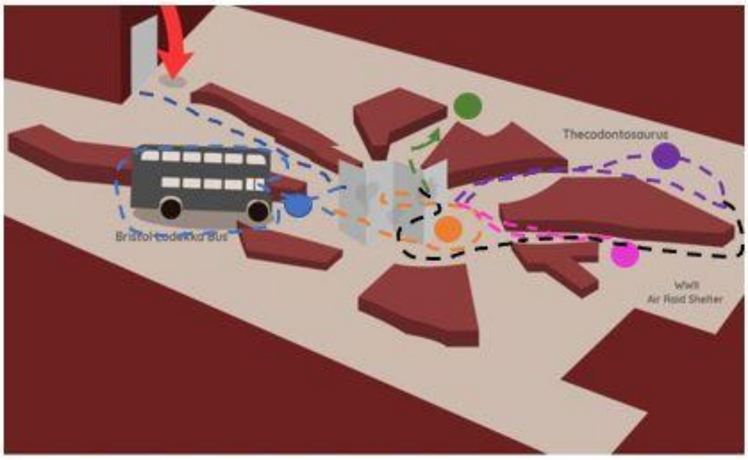
Chloe's route in the gallery.



Bruce's route in the gallery.



Rob's route in the gallery.



Samira's route in the gallery.

Appendix K Consent Form for Parents/Guardians of the Children involved in the research project

University of the West of England

Principal Investigator (s)

Dimitra Magkafa

Department of Arts and Cultural Industries

Dimitra.magkafa@uwe.ac.uk

Project Title

An exploration of touchscreen devices for young people with autism to help improve their social skills and encourage engagement.

Consent to Participant in a Research Project

This study aims to examine the relationship between touchscreen devices and children with autism in a new environment in this case museums. The main objective of the research is to examine the experiences of children with autism in using a museum app as part of their visit. One specific aim of this project is to design and develop a museum application used by your child in the classroom and then in the museum environment. The project will take place for a period of between 2-6 weeks in 2017. Data will be gathered through interviews, observations and questionnaires. Through observations, I will be taking photos and videos of your child using the device to find out whether the application is an enjoyable experience for your child. The video materials will be used by me to describe and interpret the participants responses using the application. When the study is complete, results will be presented at academic conferences and written up in journals. Names of participants will remain totally anonymous, as will any pictures taken (faces blurred). If you are interested, you can request a report (either online or hardcopy) with the summary of the findings.

Confidentiality of the Data

Your child's personal details and responses will remain anonymous and confidential at all times. All data will be stored securely on password- protected computers and the transcripts from interviews/questionnaires will be saved in locked cupboards at the University of the West of England. Recordings from the interviews or audio/video data will be kept safely and identified by a code until the end of the study. On both occasions (i.e. at school or the museum), I will videotape some activities in order to discover how your child behaves using the app; and as above, participants will remain anonymous by covering their faces with photo- effects. Then, once the project is complete the electronic files will be permanently deleted and the printed work will be shredded. The immediate research team (myself along with my supervisors Dr Nigel Newbutt and Professor John Cook) will be the only personnel who have access to the data.

Location

I will be working in school with the teachers and your child. A museum visit will happen at M Shed Museum, Princes Wharf, Wapping Rd, Bristol BS1 4RN.

Disclaimer

Your child is not obliged to take part in this research and his/ her participation is entirely voluntary. If you agree to take part, your child can leave at any point and it is not necessary to give a reason. There will not be consequences, at all, if your child does not want to continue with the study. Choosing not to participate will not affect your child's performance or participation at his/her school.

Dimitra Magkafa

Department of Arts and Cultural Industries

University of the West of England

Coldharbour Lane, Frenchay, S Block, Room S8304

Bristol BS16 1QY

Email: Dimitra.magkafa@uwe.ac.uk

Dear Parent/Guardian,

I am a doctoral candidate in the department of Arts and Cultural Industries at the University of the West of England under the supervision of Dr Nigel Newbutt. The purpose of this letter is to request your permission for your child to be involved in a study. The project will be linked to the History curriculum and will be looking at how children use and interact with a touch screen device in a museum. Your child's class and the schoolteacher will participate in this project, which will be conducted at the M Shed Museum. My study is not going to interrupt the planned activities of the school.

Before you decide to take part in this study it is important for you to understand why the research is being done and what it will involve. Please read the following information as well as the **participant information leaflet** and **parent/guardian consent form.** After you have read more about the research project, we hope you would like your child to be involved.

The research project will be carried out into three stages. The first stage will include the technical part; direct contact with the participants, designers and teachers will give me important information about the design guidelines of developing technology. The second stage will be during the springtime for one –two weeks when a pilot study will be done in the classroom space. After the feedback from that session, the study will take place in the M Shed Museum in September- November 2017. Before and after the second phase, I will take information from the group to ask about their experiences of using the application.

In order to make the sessions an enjoyable experience for your child and to reduce any discomfort, risk assessments will be carried out in the museum space in advance. Your child will have the right to stop being involved in this study at any time. Some participants might find it difficult to have a recorded interview. If such a situation happens and is noticed by the researcher or teachers, the recording will be stopped and the project will continue only if the participants wish to do so.
I hope the information summarized in all documents allow you to decide your child to get involved in this study. If you need any further information, I would be glad to answer any of your questions/queries via the details given at the top of the letter.

Thank you for your time,
Ms. Dimitra Magkafa
BA, MA, MRes

**Please return the envelope with the participant information leaflet and consent form provided in this pack.*

Consent to Participate in the Research Project

Please fill in your and the child's name and tick the boxes to indicate that you freely consent your child to participate in this research project.

I .... confirm that I am the parent/guardian of...This is my written consent for my child,... to be a participant in this project described in this form.

☐ I confirm that I have read the Participant Information Sheet relating to the nature and purpose of the research project and the role of my child's participation in it.

☐ I give consent for my child to be audio taped during any interview and observation covering their faces.

☐ I give consent for my child to be videotaped during any interview and observation covering their faces.

☐ I give consent to my child being photographed during the sessions in the classroom and the museum.

☐ I understand that my child may leave from the research at any stage and this will not affect his/her role within the project, either now or in the future.

☐ I understand that while information gained during the study might be published, my child's identity will not be recognised and his/her personal status will remain confidential.

☐ I understand that data will be held confidentially, in a secure place and in a password-protected computer in the form of hard and electronic copies of transcripts and audiotapes. These data will be accessible to the researcher team only.

☐ Iunderstand that I might contact the Research Director if I require further information about the research, and that I may contact the Research Ethics Coordinator of the University of the West of England If I wish to make a complaint relating to my child's involvement in the research.

☐ I consent to my child take part in this research project which has been fully explained to me

Participant's name and Parent/ Guardian's Name (CAPITAL LETTERS):

Parent/Guardian signature:

-------------- ---

Investigator's name:

Investigator's signature:

Date: --------------------------

Statement by the researcher taking consent

I have provided a brief and clear information to the parent of the potential participants before
requesting the signature(s) above. I have assured that the person understandswhat is being requested of his/her child as a participant in this study and the procedures in which his/her child will be involved have been described. I confirm that the parent was given an opportunity to ask any question about the research project. I confirm that the individual has not been coerced into giving consent and the consent has been provided freely and voluntarily.

A copy of this Informed Consent Form has been given to the parent or guardian of the participant.

Print Name of Researcher---

Information Letter Stakeholders

Dimitra Magkafa

Department of Arts and Cultural Industries

University of the West of England

Coldharbour Lane, Frenchay, S Block, Room S8304

Bristol BS16 1QY

Email: Dimitra.magkafa@uwe.ac.uk

Dear All,

I am a PhD researcher in the Department of Arts and Cultural Industries at the University of the West of England under the supervision of Dr Nigel Newbutt. The purpose of this letter is to provide you a brief overview of the topic being studied and to ask you to participate in this project. For my doctoral thesis, I am interested in examining the impact of audio- visual and multimedia technologies as a means of supporting children with autism spectrum condition in a museum setting. By doing this, I will consider the development of a touchscreen application to be used in a museum environment museum, based on the design preferences of children with autism. As such, I would like to arrange two- three sessions with you so that I can gain your opinions and suggestions. Your input will be an invaluable part of the proposed project so as to make an accessible and approachable application for the children.

The research for this project will take place during this year 2017. At this stage, I am observing children during their ITC school class and I am taking notes how they react to and engage with electronic systems. My role is purely observational. The participation of children and teachers and other stakeholders will provide important insights on this topic. Taking part in research is voluntary and you may withdraw from the study at any point whilst your personal details will remain anonymous. All data from this project will remain confidential and will be used for research purposes only. If you are interested in learning more about the project, you can contact me at any time through the details at the top of the letter.

Yours Sincerely,

Dimitra Magkafa

THE RESEARCH

The purpose of this research project (part of a PhD) is to investigate the role of touch screen devices (such as iPad) as a means of motivating social development and cultural interaction for children with autism spectrum condition. Furthermore, this work seeks to examine how audio-visual and multimedia technologies can support learning in a museum- based setting. In order to investigate this, the project will design and develop an application. This will be then tested in a museum-based setting, the views and experiences of users.

Your children's involvement is likely to help us to investigate the possibility of touchscreen devices to be used by children with autism in a museum environment.
It is hoped that the current project will give us greater understanding into the special design guidelines required for the design of an application tailored to children's special needs. As a result children might benefit from feeling more included in museum communities. It is also hoped that museums will be interested as few studies explored the issue of inclusion for this target group in the museums. As such, this is the first study to address the impact of digital platforms on a museum setting.

BACKGROUND

Assistive technology (AT) is one technology methods being offered to help people to improve their social and communication skills in addition to delivering educational and behavioural services for people with autism. There are different types of assistive technologies – one being tablets or hand-held devices.

Recent studies suggest that such devices are powerful tools and can facilitate and support a variety of skills. Their visual features and easy-use provide opportunities for learning and improving people's daily life (Kagohara *et al.* (2013); Stephenson and Limbrick (2015).

Apart from studies involving the role of assistive technologies in schools or home settings, there is a lack of research of digital services in a museum- based setting for people with intellectual disabilities. On the other hand, museums are institutions, which promote learning experience through interaction with exhibits. Consequently, a wide range of visitors are likely to gain different skills and to enjoy a museum visit, including people with autism.

Procedure of the Study

Phase 1

In order to design and develop the application, a series of meetings with teachers and experts in designing assistive technology for this group will be arranged. The purpose of these sessions is to clarify the specific design requirements needed, the content of the application, the role of users and what would be helpful for them.

Phase 2

By using a pilot study, outcome data will be collected and will help us to find out the efficacy of the iPad app and to formulate any of its features for the next phase. The data will be collected at the school classroom during IT class. At this stage, I will be present in the classroom and in cooperation with teacher I will take some notes and I will record pupil's responses using the touch screen device. Your daughter/son will participate in an interview with myself and will fill out a questionnaire after the session. The interview will take place in the school class and the interviewer (myself) and the teacher will be present. I will ask questions and will encourage them to talk about their experiences using this app in the classroom. I do not intend to ask them to share personal information or stories that are not appropriate to share. If your child does not wish to answer any of the questions, she/he may declare that and I will move on to the next question.

Phase 3

After collecting and reviewing the data, I will make some changes (if necessary) and afterwards I will run the project in the M Shed museum. In this setting, I will observe how your child experiences this device around the space of the museum as well as their visit being recorded. Questionnaires will be given to the pupils to fill in before and after the sessions (in their classroom) in order to explore in depth how they perceive this app as a means of informal learning. The interview will be audio recorded as long as parents' permission is obtained. If you would prefer to avoid observation of your child or not to talk to him/her, no questions will be asked and there will be no consequence for your child.

**A related aspect to consider is that the current project has been reviewed and received ethical approval from the University of the West of England.*

Appendix L Field notes

Green Class

Date	**22/02/2017**
Activity	This was the 1st co-design session with the green class. The session lasted for 40mins and it was carried out in the classroom. Robert first presented the task to the students. Then, I started explaining further about the nature of the project and what we have to do all together. This session was structured using PowerPoint slides. The questions were about the functionality of the application such as accessibility and navigability (e.g. what rewards they prefer, the

	font type etc.) whilst I provided some examples from existing apps to help them answer the questions.
Participants	Mr Robert (teacher), Miss Amelia (teacher assistant), 6 children (Rob, Tom, Matt, Jason, David, Andrew).
Reflections	The teacher was always prompting them and saying how cool this project is, as they will be the designers of an app and they will be the first people using it. All the children were engaged and appeared to be keen to reply to the questions. Despite having provide them with some sticker notes to write down their preferences and then sticking them onto the board (for interactivity reasons), they preferred the teacher guide them by scribing to the board the questions and answers. The teacher drew a building depicting the museum and then he provided written the questions to which the children had to reply. When I was asking them questions about the menu actions and the layout of the questions, Andrew and Jason said: "*We want the simplest way*". All the children were well- behaved but in some cases Rob needed assistance when giving his opinion, which was provided by the teacher assistant. After the end of the session, the children had some free time to play.
Follow-up Actions	I needed to run another session asking them questions about other functionalities of the app.

Blue Class

Date	**22/02/2017**

Activity	It was the 1st co-design session with the Blue class. The session lasted for 50mins and it was carried out in the classroom. Miss Maria provided a brief introduction about today's sessions and I started describing what the children had to do. This session was structured using PowerPoint slides. I asked them questions about the accessibility and navigability of the app (like what rewards they prefer, the font type etc) and I provided some examples to help them give their own opinions.
i	Miss Maria (teacher), Miss Emma (TA), 6 children (Charlie, Aisha, Hanna, Charlotte, ina, Chloe, Bruce Samira).
Reflections	All the children got involved in the session and were happy to provide their own thoughts. During the session, they were focused on listening to the questions. However, some of them found some difficulties in replying and they asked for help to understand what I was asking for. The assistance was given by the teacher assistant and teacher of the class. In this class, they liked the idea of using sticker notes for answering the questions and giving their own ideas. Once they were writing down their thoughts, they went to the whiteboard and stuck their answers each time to the answer they preferred. When the children could not understand the meaning of the question, the teacher and I would try to state the question in a simpler way in order to help them.
Follow-up Actions	I need to run another session asking them questions about other functionalities of the application.

Green Class

Date	**07/03/2017**
Activity	It was the 2nd co-design session with the Green class. The 2nd session was again with the form of Q/A via PP slides and it lasted 50 mins. At the beginning, I did a summary recap and I presented briefly what they said in 1st session. Then I wrote today's task on the board.
Participants	Mr Rob (teacher), Miss Amelia (TA), 5 children (Rob, Tom, Josh, Andrew, David).
Reflections	The questions seemed to confuse some of the children and some clarifications were required. All the children replied to all the questions but some of them got bored. For example, Rob couldn't focus and he fell asleep. Meanwhile Josh was saying: "I don't understand this question". They preferred again to reply the questions by scribing to the teacher on the board both questions/answers (Q/A). The structure of the questions was mostly closed/ multiple choice, however, we had some follow-up questions where the children suggested their own ideas like what kind of pictures they prefer as a feedback.
Follow-up Actions	After the session, Mr Rob and I were decided that it was important to organize the next session in a different way- to be more creative and allow the participants to have a more active role.

Blue Class

Date	**07/03/2017**
Activity	It was the 2nd co-design session with the Blue class. The 2nd session followed the same technique- presenting the Q/A via PowerPoint slides. After this incident, I did a summary of the first session and I presented briefly what they said using PowerPoint slides. Then I wrote today's activity on the whiteboard.
Participants	Mr Maria (teacher), Miss Emma (TA), 7 children (Charlie, Aisha, Hanna, Charlotte, Tina, Chloe, Bruce, Samira).
Reflections	I started asking them questions but in some cases the children got confused with the questions, so the teacher and I tried to help them simplify the questions. They were very engaged in the session and they liked the option of writing down their preferences and sticking them to the board. Some of them (Charlotte and Aisha) drew flowers on their sticky notes as a gift the researcher. The children mostly answered all the questions. However, Tina in one question didn't want to answer whist Bruce was always asking assistance by his teacher assistant in order to answer the questions. Despite the frustration at the beginning of the session, all the children were well behaved and stayed engaged until the end of the session.
Follow-up Actions	Based on this activity's findings, I need to organize a session where the participants will have more active role and they will be able to show their creative side.

Green Class

Date	21/03/2017
Activity	At the beginning, I summarized what we have done the last two sessions and I reminded the participants again what kind of app we should create and where it will be used. I wrote on the whiteboard what the tasks are for today's session in order to have available any information need during the session. This session was more creative as they had to draw how the app would look like. I order to understand better, I provided them some visual supports through PowerPoint slides. These slides had some examples of how designers sketch a prototype of the app. Empty A3 sheets, cut-outs images (like home exit buttons, chest treasure boxes, swords etc), glues, scissors were given to the children. The session lasted for 30 mins during the Art class.
Participants	Mr Robert (teacher), Miss Amelia (teacher assistant), 6 children (Rob, Tom, Matt, Jason, David, Andrew).
Reflections	The participants understood from the very beginning the task this session. However, they needed my guidance to start sketching out the prototypes. The teacher, teacher's assistant and I started working closely with the students while explaining to them in detail what they had to do. All the children started making the prototypes, however, Andrew exhibited a refusal behaviour and withdrew from the activity. Tom and Jason were sitting at the same desk, so they were exchanging some ideas about the sketch. They were curious about the nature of the task and asked me: "*Why do we need these sketches for the app?*''. I explained to them that this session was going to help me understand what their preferences were

	about the usability of the app. Jason required assistance at various times and he seemed not sure what to write in the boxes. David semed cooperative and worked well. He worked independently; no assistance required. It was observed some repetitive behaviour when he was filling up the boxes with green colour. Rob worked really well and completed the task well ahead. He was very independent throughout the activity and he seemed willing to learn more about the app in order to extend the story. I reminded him that the app was going to be used in M-Shed museum and then he asked me "What's M-Shed about? And then he said: "Ok so because the museums have many objects we can have a lot of options for the users.'' Based on the given cut-outs, he had an idea about how the users could progress to the next level. Then he asked: "Can we use colouring options?''. I said: ''Yes'' and he drew it on his paper. This session was structured by giving them step by step guidelines on how to make their sketches. However, I wanted to give them space to be more creative, that's why they had to draw something else as an option. Generally, participants just followed the instructions without trying to go a step further. OnlyRob was more eager to think outside of the box and suggest ideas about the structure of the app.

Blue Class

Date	**21/03/2017**
Activity	In the beginning, I summarized what we had done the last two sessions and I reminded the participants again about what kind of app we were creating and where it should be used. I wrote what the tasks for this session were in order to make available any information they night need during the session. This session was more creative as they had to draw what the app would look like. In order to better understand, I gave them with some visual supports through PowerPoint slides. These slides had some examples of how designers sketch a prototype of an app. Empty A3 sheets, cut-outs images (home exit buttons, swords and chest treasure boxes), glues, scissors were given to the children. The session lasted for 30 mins.
Participants	Miss Maria (teacher), Miss Emma (TA), 7 children (Charlie, Aisha, Hanna, Charlotte, Tina, Chloe, Bruce, Samira).
Reflections	The examples provided at the beginning of the session were proved to not be helpful for them in understanding what they should do. So, I gave them some instructions how to start. Because of the time limit, we decided that it would be better to focus on drawing only three squares (like an app looks like) and to fill out those squares. In the first square, they had to put the app's name and to glue the user's icon, then based on the title given on their apps, they created two categories (themes) that the users could select when they use the app. All the children were focused on that task and then I gave them the cut outs images to start putting their ideas

	on the paper. The children were very happy to use/put all the cut outs on their sketches. Some of children (Samira, Chloe, Charlie) worked well independently whilst the others were looking for my guidance. Charlie was, at times, loud and hyperactive getting up and down from his chair. He worked well and managed to extend the original story of the app. Bruce named his app 'Pokemon Go' and when the teacher asked him to change the name because it did not match the history of Bristol he said: "*Pokemon has been used for a couple of years, so its old*". Samira was very focused on the task and progressed through the task to the completion without any prompt. She was able to deal with the instructions and completed the task quickly. She was loud talking about the app (no clear speech). She proposed as rewards to have a coin starting with the letter M (initial letter of the museum). One of the children (Tina) seemed to struggle with the requested task and asked for help in each step of the activity. At various points, she became easily distracted and started moving around the class speaking to her friend and laughing loudly. She did complete the task but she needed constant encouragement. Once the task started, Bruce raised his voice and requested assistance as he could not understand what he had to do. He specifically said: "*I don't understand what this is*", "*But I do not understand what I need to draw now*", "*I do not know how to design it*". The TA of the class spent most of the time with him encouraging him to draw his ideas. Aisha and Charlotte were sitting next to each other. They were willing to do the activity and were smiling every time completed a step. However, they got stuck at various steps of the task and

	they were looking at me and asked for help several times. Both of them could not progress the task without following my instructions. They struggled to put their thoughts on the paper and asked for me to write down the themes of the exhibition artefactswhat features the app wanted to have (no progress in thinking out of the box).

Green Class

Date	**3/04/2017**
Activity	The 4th co-design session was structured by presenting some low-tech prototypes on PowerPoint slides. Meanwhile, hard copies of those prototypes were given to the children. This session lasted for 60mins. Before starting the session, an introduction was given about what they had done so far (in the last sessions). The teacher reminded to the children how important their input was as this app was going to be used by visitors at MShedmuseum. I gave them some information about the museum whilst I told them briefly what kind of objects the museums includes. Then, in consultation with the teacher, it was decided that the session need to have the following structure: I presented the low-tech prototypes on PowerPoint slides and the teacher wrote the children's answers on the whiteboard.
Participants	Mr Robert (teacher), Miss Amelia (teacher assistant), 6 children (Rob, Tom, Matt, Jason, David, Andrew).

Reflections	The questions were mixed open/closed giving them the opportunity to express themselves. - About the future character: They said: Jack Sparrow. - They preferred the buttons to be at the bottom. - The layout of categories to be as a list - Rewards; I gave them some options and I reminded them what they had already decided. However, they mentioned the coins and then the pieces of eight (which are the coins of pirates and the swords). After all, they decided the coins or if it is possible pieces of eight. - About the feedback: Tom suggested he would like to see the feedback through audio and visual features. of them voted the Lenny face while the others didn't participate in this activity. - About the colour background: They said prefer to have the option to customize the colours. When I finished the session, Rob, who was really interested in the design of the app presented some of his ideas that I could add to the app. At the beginning, it was verbally but he decided that it would be better to explain it using a PP presentation. Transcription of the dialogue: "*I came with the idea that every time get a key to unlock the treasure chest which could contain…* *He said: "The users need to get two items in order to open the first box and then four to open the golde none. One of those boxes can be a trap for them. Its gonna be poisonous".*

	If you get 3 keys, you can win one treasure chest, if you get 5 keys you can unlock the final treasure chest. If you pick the right treasure chest, you can get a creature and the TA added like spiders. Then Rob said that I don't think that its gonna work for the museum, so I thought about something like inventions such as car or a plane'' Then TA commented: "when you win, you can collect inventions… Then he recommended that "*this part of the game can be a multiplayer game, so more people could play together in one game".* He continued: "*the players can select one of the categories written on the 2nd square. He suggested having a scavenger hunt and quizzes as options*. This session appeared to be very engaging. The participants gave their own input for different features of the application. Also, the participants seemed to have an active role as design partners during the session by suggesting alternative ideas. I think that the children had already understood the content of the app and in this session, they wanted to contribute by giving some suggestions about the functionality of the app. The low-tech prototypes were very successful way to understand different parts of the app. Interestingly, one of the participants gave a lot of suggestions about the content of the app.
Follow-up Actions	

Blue Class

Date	**3/04/2017**
Activity	The 4th session was structured by presenting some low-tech prototypes on PowerPoint slides. Meanwhile, hard copies of those prototypes were given to the children. This session lasted for 60mins. I followed the same procedure as in the Green class. Then I hovered over the children and I explained to them in detail what each of these images were. The last part was to decide and stick their notes on the whiteboard. The questions were mixed open/closed giving them the opportunity to express themselves.
Participants	Mr Maria (teacher), Miss Emma (TA), 7 children (Charlie, Aisha, Hanna, Charlotte, Tina, Chloe, Bruce, Samira).
Reflections	- About the future character: They said: They didn't comment about the character of the app - They preferred the buttons to be at the bottom. Charlie commented: "I prefer on the corner at the bottom, so the users will easily pressing them". - The layout of categories to be as a list. - Rewards; I gave them some options and I reminded them what they had already decided. However, they preferred the coins whilst Samira commented: we can have coins with M which could be in small pieces (from M-Shed Museum) - Feedback: they said visual icons (e.g smiley faces).

- About the colour background, I gave them different colours and replied: *Can we have different colours*?- preference of customization.

Aisha and Charlotte were not able to progress with their task needed more direction. Bruce found again hard to work on the tasks. He asked teacher's help a couple of times: *mmm Is it ok? Not sure…if its correct*". Tina appeared to be engaged in the activity. There were several times that she moved around the class smiling (hyperactivity). Chloe was focused on the activity and able to reply to all the questions. She did not provide any further ideas.

During the session, Charlie was very engaged and excited and he wanted to give some further suggestions.

Charlie wanted to make some comments about the character of the app.

Transcription of dialogue:

He said: "*Basically you have different characters and on top we can have a search bar and the user can select one of those (black guy, white lady, child) and on the corner you have a little thing with the face of the character. So, you can select which one you want male or female. I'd go for female*.

Researcher: "If the app provides one character"?

Charlie continued: "*So you can have some other options for the players to select which one they want*".

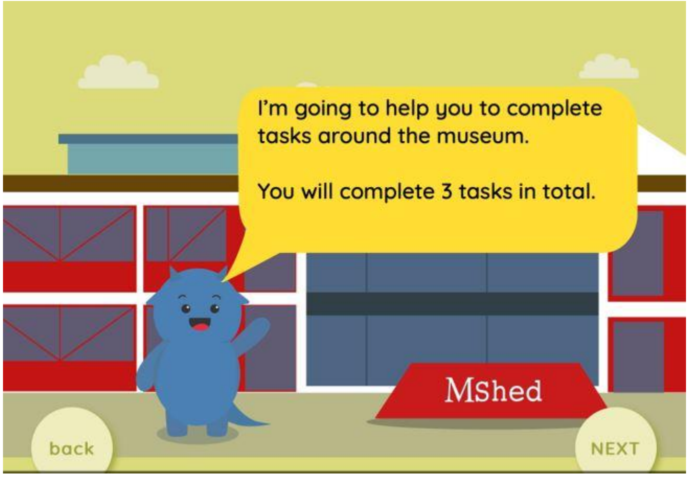
Researcher: "*Like what? For example, different items of clothing to dress up the character*"?

Charlie: "*Yes, why not? Or different eye colours. Now they need to scan the barcode which is around the museum and then a quiz will pop up*".

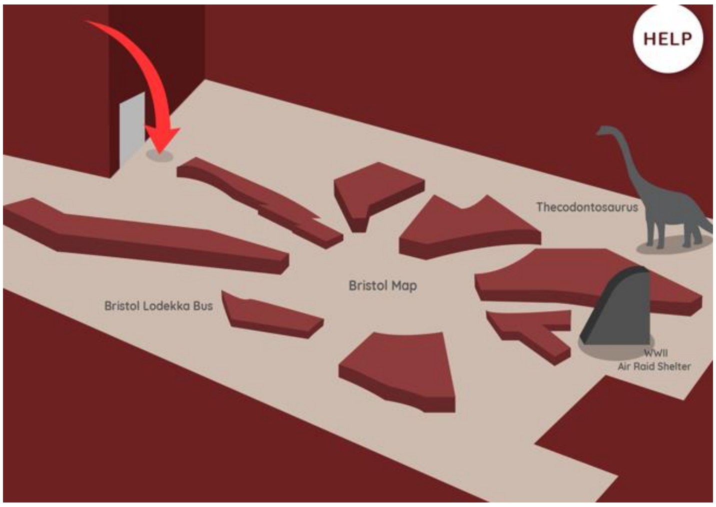
	Researcher commented: "*When you answer correctly the quiz, you will go to the next level*"? Charlie said: "*For the next level, you keep doing that over and over again scanning the barcodes and at the end to find the treasure*''. Then he wanted to make some comments about the first page of the screen. He said: "*On top at the corner, there will be a tiny button, click on that and say find the hidden treasure*" Based on the results, this session was very engaging. Some of the participants gave their own suggestions about the features of the app. Also, the participants were having an active role as few of them suggested some alternative ideas.
Final Thoughts	The participants gave their own input for different features of the application. Also, the participants seemed to have an active role during the session by suggesting alternative ideas. The children have understood the content of the app and in this session, they wanted to contributed by giving some suggestions about the functionality of the app. The low-tech prototypes were very successful way to understand different parts of the app. Interestingly, two of the participants gave a lot of suggestions on their own.

Appendix M Screenshots of the *Whats Bristol?* App

What's Bristol? Screenshot introducing the pupils to the game.



What's Bristol? Screenshot introducing how many tasks the pupils are required to complete.



What's Bristol? screenshot showing the museum objects the pupil (player A) needs to visit.

Appendix N Synthesis of a set of design guidelines

The current best practices are presented in the left column along with the key points of how these can be embedded in an interface. The middle column summarizes the feedback obtained from the co-design sessions in the present study, and then the third column describes the elements embedded in the final version of the interface. Some sections are left blank is because they were not essential to gain direct feedback from the pupils involved.

Review of best practices	Key Points	Feedback from this study	Features embedded
Consistency-Structure	- Brief tutorial of the activity - Introduce new elements gradually (audio and/or visual features) - Clear form of guidance of the activities - Break the activities into smaller tasks - Structured situation		- Split up the activities in smaller tasks - Guidance to find the artefacts - Alien's verbalisations and visual actions are consistent such as command buttons (*help, next, back*), layout and icons
Predictability	- Set consistent expectations and cues to help users predict the outcome		

Content and visual comprehension	- Simple content - Content along visual features - Short text and content broken up with numbered lists and sub-headings - Use of symbols or icons	- Simple information - Format of questions via text and sound	- Information through visual medium. - Short texts with digital images in close proximity conveyed information. - The content was displayed in the format of lists. - An audio track with Walli's voice was used as an additional tool to transfer information relevant to the content
Customization	- Enable the users to make changes that match their specific needs by changing sound, size and/or colour of the font	- Customization through different characters, or functions of the character, foreground and background and layout (input controls)	- Personalization of the character of the game.
Interactivity	- Simple interface with few elements for the current task - Use of clear and large buttons with icons and /or text - Visible functions - Large buttons and icons in a click option - Large screen layout and ability to zoom in and out		- Use of clear and large buttons to be visible to the users. - Simple screen layout with a small number of features - Large screen layout
Navigation tools	- Simplified navigation - Use of location awareness system	- Menu action (either or top	- Navigational components in the form of buttons with *next* and *back* on each page whilst a *help*

	- Consistent navigation page buttons (eg., *exit, back, and help* buttons) - Place the buttons on the same place (on top) - Direct manipulation of the interface	or bottom) - Location awareness system through various museum activities	button was provided every time the player could not respond correctly to an answer. The buttons were placed at the bottom on the corner of the screen and the *help* button was displayed on the top right side
Feedback	- Provide immediate feedback for every point of pupils' actions - Use of rewards with visual feedback - Prompts via audio, textual, and/or visual - Presence of onscreen characters for guidance	- Feedback through images - Type of feedback: faces - Rewards through sounds and images	- Immediate feedback on every point of the pupil's performance, and an audio track is played simultaneously with a voice recording. - Use of feedback via audio clip and picture. A *help* message appears and gives more information regarding what the pupils should do in case of incorrect responses - Use of sound and images as a reward (puzzle pieces)
Multimedia features	- Multimedia modes with simple layout - Use of sensory rewards through sounds and vibration - The integration of animation, and/or sounds - Audio and visual formats to convey information and/or the content - Possibility to maximize and minimize the pictures	- Integration of visual features such as animations, images and/or videos - Use of visual supports	- Use of visual images and audio to support pupils' actions
Design colour layout	- Balance between the background and foreground - Keep a consistent layout	- Customised colours for the avatars'	- Balance between the background and foreground

	- Use of good contrasts	features	- The navigational buttons (next and back) were displayed in different colours with the background (intense background, light foreground. The text boxes of the interface are in a yellow background for those with reading difficulties.
Game elements	- The integration of multimodal features such as gestures, movements, and audio-based and facial expressions - Narrative storyline with medium and long-term goals - Collaboration as a team - Ability of cooperative gestures	- Short and long-term goals - Multiplayer features - Instructions	- Storyline - Two-player game - Cooperative gestures - Instructions

Appendix O Visual Story preparation for the visit

Trip to M Shed museum

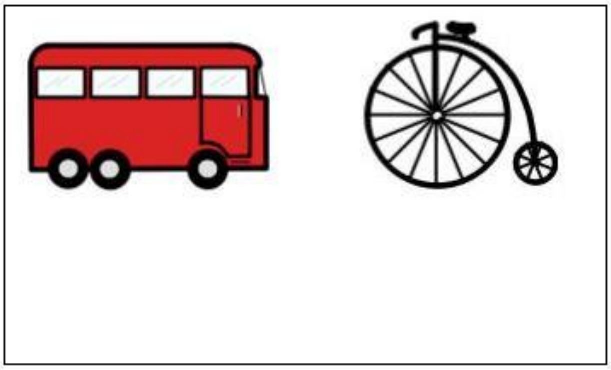
On Monday, we are going to M Shed museum.

This is a photo of the entrance of M Shed.

Trip to M Shed museum

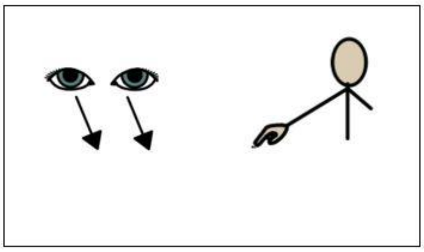
You will be with your teacher and your classmate at the museum.

Trip to M Shed museum



You will learn interesting stories about Bristol by using an iPad app.

Trip to M Shed museum



You will look at things, touch, and go around the gallery with your iPad.

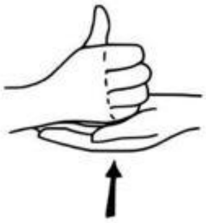
Trip to M Shed museum

You will have your own iPad but you will need to work with your classmate to solve the mystery.

Trip to M Shed museum

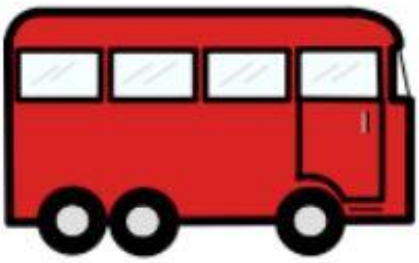
The museum has two floors but you will explore the ground floor of the museum.

Trip to M Shed museum



If you need help, you may ask your teacher or Dimitra to help you.

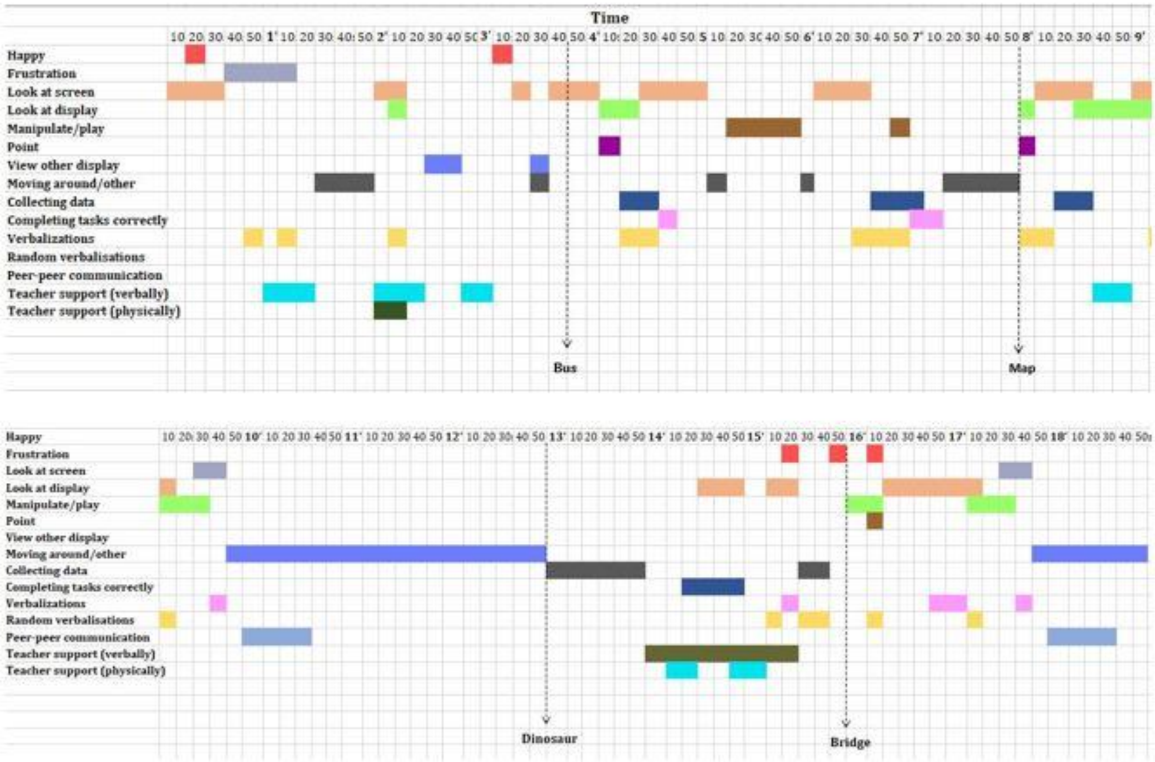
Trip to M Shed museum



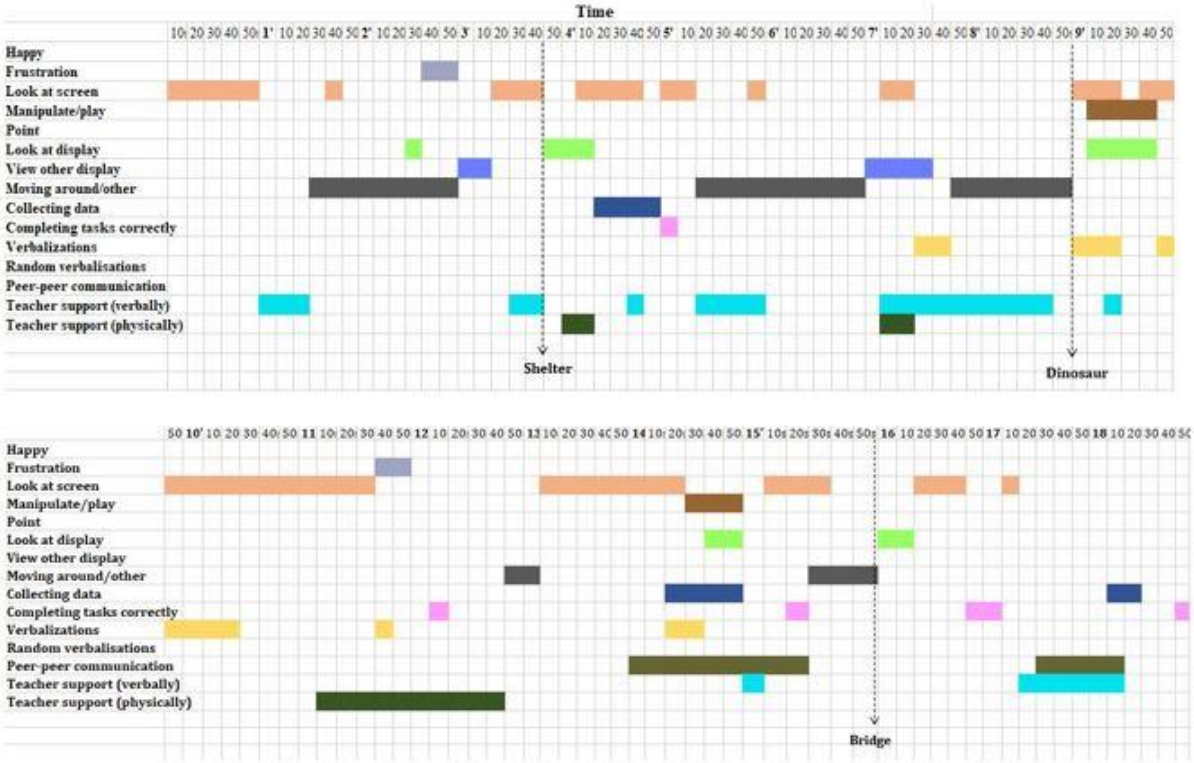
Once you finish, you will get on the bus to go back to school.

Thank you and see you soon!

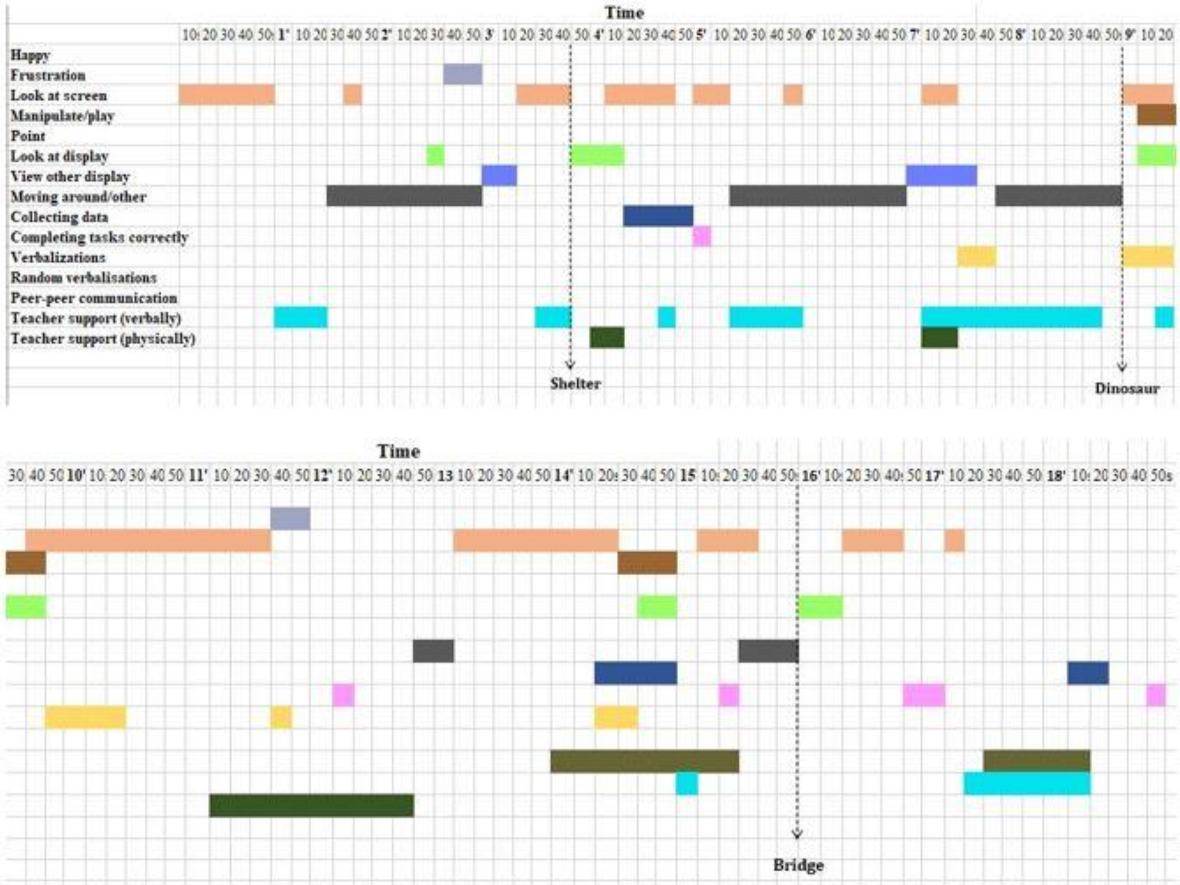
Appendix P All groups' timelines during the museum visit.



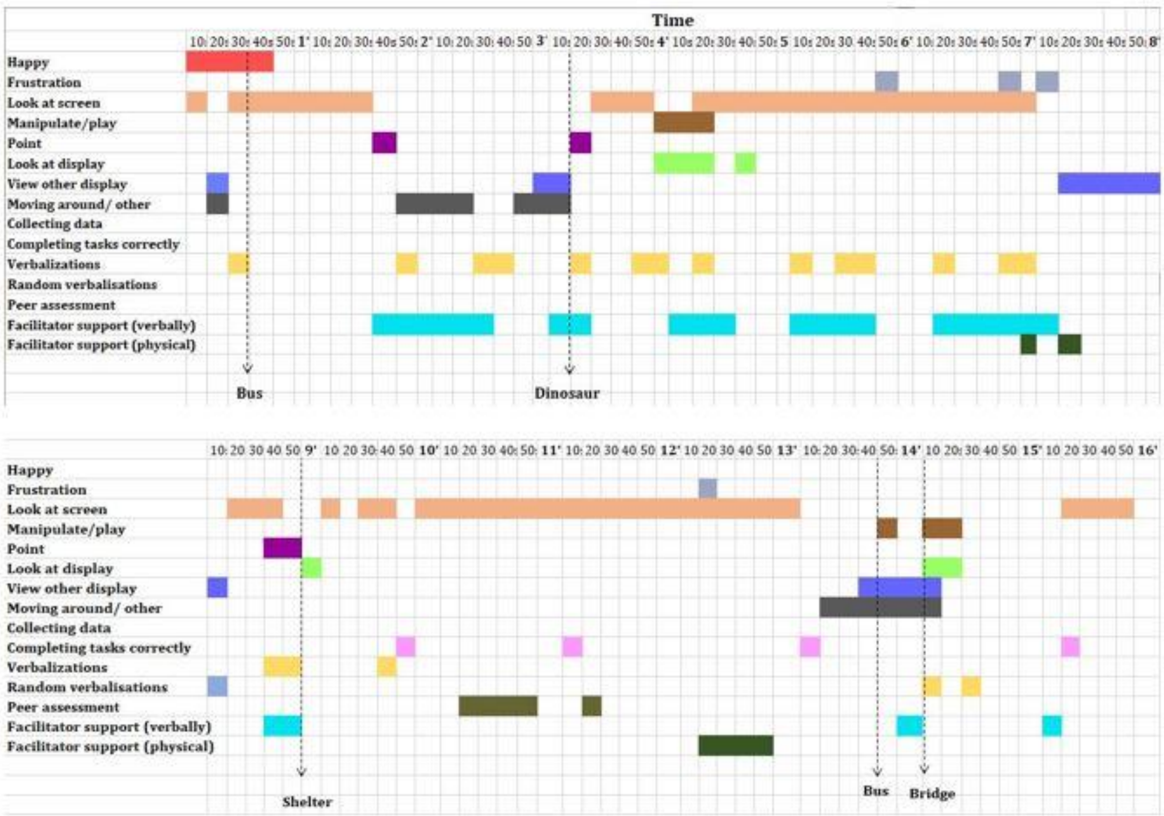
Group1 timeline for Aisha during the museum visit.



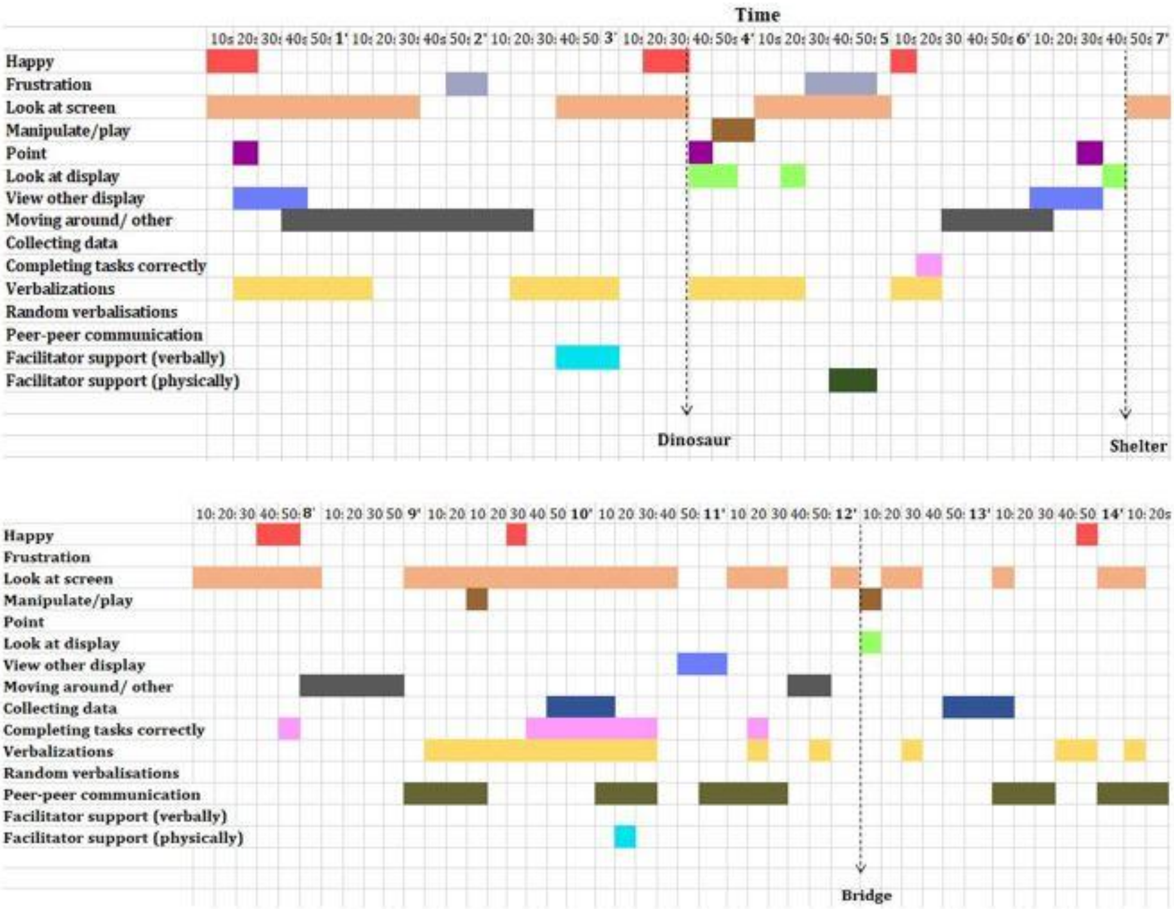
Group1 timeline for Charlotte during the museum visit.



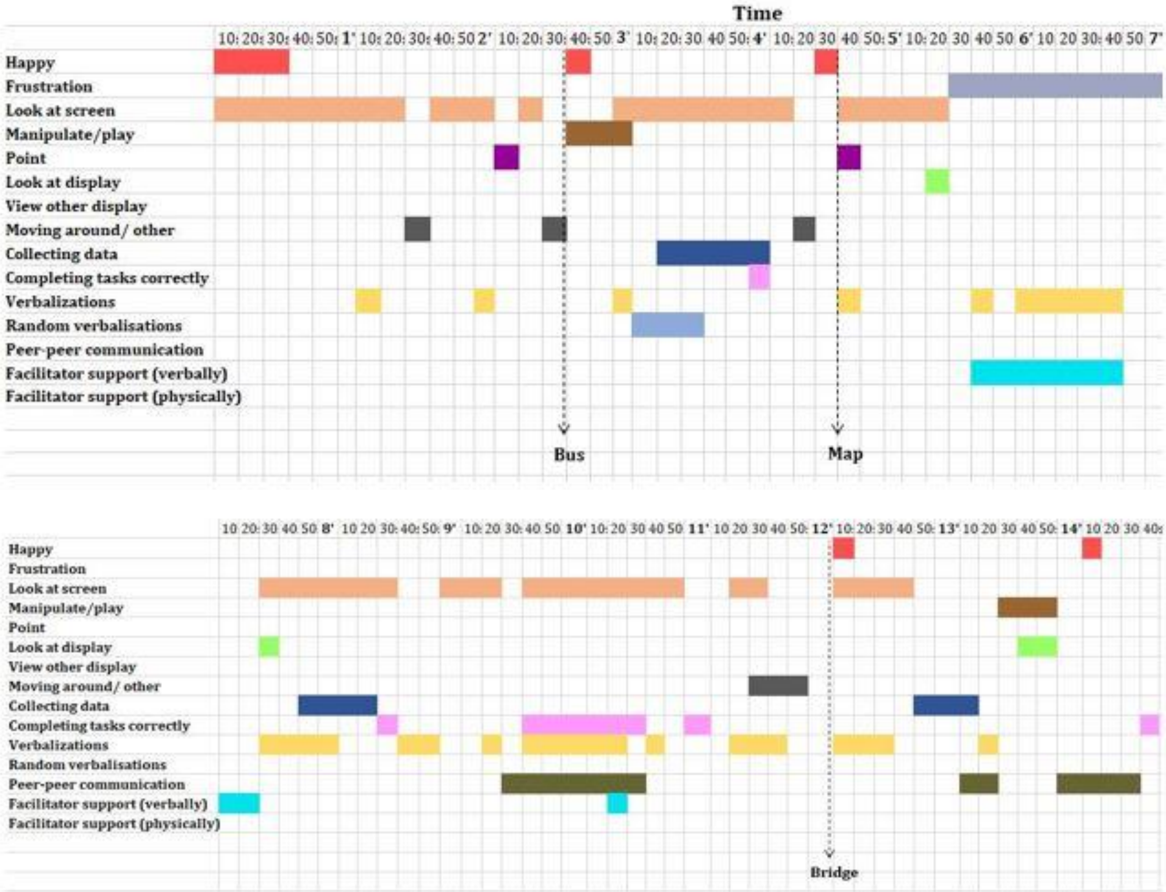
Group 2 timeline for Chloe during the museum visit.



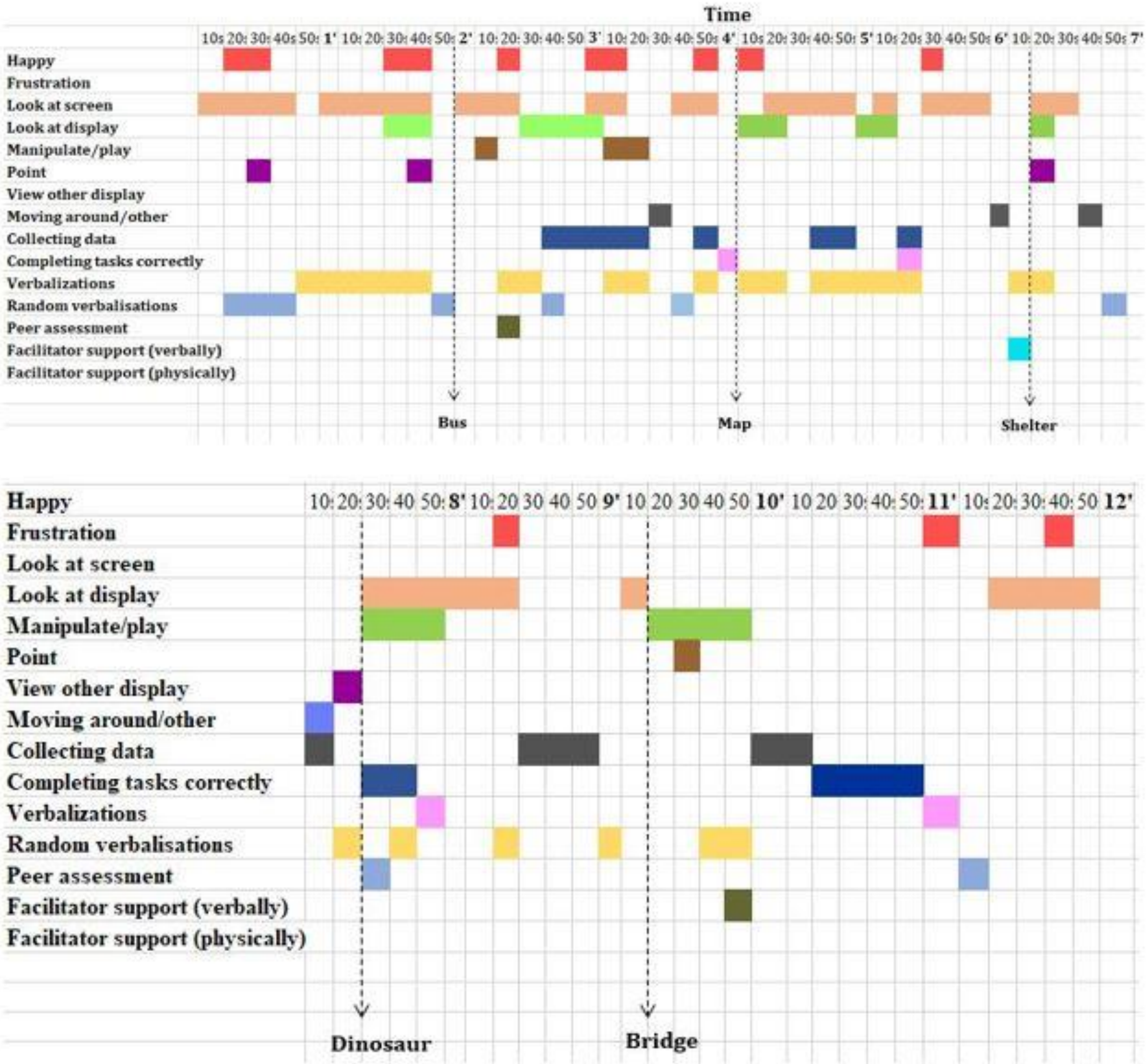
Group 2 timeline for Tina during the museum visit.



Group 2 timeline for Bruce during the museum visit.



Group 2 timeline for Rob during the museum visit.



Group 2 timeline for Samira during the museum visit.