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Abstract

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Evaluation of Pilot Exercises

For policy makers, the deliverable is in three parts: a glossary, a policy briefing and key performance indicators. For practitioners, academics and people who use inclusive technologies, we have added an annexe. This annexe has an unabridged version of the policy briefing, and delves into each part of the deliverable, highlighting the findings in detail and providing examples of supporting evidence.

1 GLOSSARY

Advocacy - The ability to support the voice of disabled people, to make sure their rights are considered or what they say is heard.

Augmentation / Virtual Reality – Technologies that imitate real life situations or exhibitions by providing real-time, coordinated multi-sensory images, sounds, touch etc.

Cross-Modal Perception – The cognitive process that allows an object perceived through one sense to be recognized through a different sense. For example, an object that has previously been touched is recognized by sight, or vice versa.

Cultural Institutions – Institutions whose primary purpose is to preserve, promote or teach about cultural objects, environments, periods or practices. Cultural institutions can include museums, national parks, monuments or art centres.

Epistemological Model – The way a topic or subject is understood by studying the development of knowledge about the topic. For example, an epistemological model of disability is developed by understanding what people have previously written about disability at different points in time, and for what reason this writing was done.

Inclusive Technical Capital: The skills and knowledge learnt by disabled people to use and manipulate technologies for education, support, entertainment or accessing information.

Inclusive Technology – Mainstream technology that can be adapted or used easily by people with various access preferences.

Key Performance Indicators – A set of points that provide advise on how to develop, design or use technologies in cultural institutions.

Access Preferences – Participants in ARCHES did not wish to be defined by their impairment labels, but in the context of Cultural Heritage felt it was more appropriate and useful to be defined by their access preferences – NB it was understood that most if not all people have some form of access preference, even if they do not identify themselves as disabled or having an impairment. Examples of access preferences include: larger text, higher resolution sounds or easy read texts.

Technologies – In ARCHES, this usually referred to digital hardware, software or firm ware, but it could also refer to mechanical devices such as wheelchairs or sensory back-packs.

2 POLICY BRIEFING

This report is an evaluation of the design, testing and use of technologies and tools used throughout ARCHES's group practice and tests. The aims of the evaluation are to develop recommendations in the form of Key Performance Indicators; to discuss the practice of the design and use of technologies; to inform policies on inclusive technologies.

As per the original aims of ARCHES, the development and use of technologies was based on three over-riding principles: a non-classificatory-approach to disabilities (Rix, 2007); the philosophical development of inclusive technologies rather than traditional assistive technologies (Hayhoe, 2014, 2019a); augmented and cross-modal forms of learning and communication (Sheehy, Ferguson & Clough, 2014).

2.1 Methodologies and Data Collection Methods

The methodology used to analyse the evaluation of the pilot studies, group activities and tests was a form of Grounded Methodology used in previous museum studies. It consisted of three phases: Phase 1- categories of process, behavior, identity, practice and environments were

identified; Phase 2 - links between variables in individual categories were connected and developed into a unified epistemological model, and an initial hypothesis was developed; Phase 3 - testable evidence was used to interrogate the initial hypothesis.

Unfortunately, much of the technology was not developed during the course of the study, therefore our strategy of data collection was adapted to reflect this lack of testing. This adaptation included:

1. Systematic literature reviews leading to the development of an analytical framework.
2. Interviews with participants, museum professionals and technology partners
3. Observations of inclusive technologies and tools used during participant sessions
4. The remaining pilot tests and consultations with participants
5. A formal consultation exercise with participants in London and Vienna

The following is a discussion of the results of the data analysis.

2.2 Phase One Analysis

Four literature searches focusing on the practice, design and use of technologies for people with sensory impairments and intellectual impairments in cultural institutions were prepared during the early stages of this work package. These reviews were on:

- Augmented Reality (AR) in cultural heritage environments (Sheehy et al, in press)
- the design of technologies for people with learning disabilities and sensory impairments in cultural heritage environments (this was comprised of two reviews) (Seale et al, 2018, in press)
- learning with networked technologies in cultural heritage environments (in development for publication)

The researchers learnt two significant lessons from these reviews, which were taken forward to the second phase of research. The first lesson was, there is no single understanding of design for disability by engineers, educators and app developers. The second lesson was, there is a significant difference in the understanding of disability by educators, designers and engineers; although these professionals share a need to develop and use technologies that provide agency for disabled people.

Although there is no overall understanding of the design or use of technologies, it was felt that this literature agreed on four important elements that made technologies inclusive. These elements formed the basis of an Analytical Framework, used to evaluate the data from the participatory groups (Seale, et. al., 2018, in press):

- Design for usability in a defined environment and for a defined practice
- Design to provide accessibility for its intended users
- Design for agency, and to empower its intended users through its practice
- Design for Learning Support, to develop users' inclusive technical capital

2.3 Phase Two Analysis

The observations, interviews and tests were analysed using the Analytical Framework and the following findings were made:

- Usability - Usability was the most significant issue for participants involved in ARCHES. It was also the issue that caused most frustration, particularly when technologies were either not usable, took too long to work or were not compatible with the platforms they were loaded onto. At their best, however, the most usable technologies appeared to give the participants confidence during visits to galleries and provoked discussions and a feeling of community. Two sub-issues were also noted for their importance and needing further research: network use and compatibility; the size and shape of the hardware.
- Accessibility - Many of the participants came to the project with considerable knowledge of how to access their mobile devices and had inclusive technical capital that allowed them to navigate their environments, learn or simply gather information using apps. Their existing practice emphasised Web searches and using customized apps for information. Many participants also suggested examining accessible art apps they used on a regular basis and had skills that allowed them to evaluate theirs' and others' use of apps. Two sub-issues were identified for their importance and needing further research: the paradoxes between different access preferences – e.g. interfaces with signed information being inaccessible to people with visual impairments; the ambiguity of language, signs and symbols used in interfaces.

- Agency - This was difficult to observe, as there were few observable acts of Agency during testing – this seemed to be a longer-term goal. During ARCHES, the most observable element of agency was the recognition that feedback from participants led to changes. However, there are two issues of Agency needing further research: cultural appropriateness and the representation of access preferences, disabilities and the ethnicity of users; the miss-use of language preventing full engagement with participation.
- Learning Support - As with Agency, it was difficult to gauge the extent to which technologies developed Learning Support in the form of new knowledge or skills. However, it was observed that the casual use of technologies taught participants how to search for information, enabled and developed further self-directed skills and knowledge, and formed personal inclusion.

Building on these findings, the following hypothesis was formulated that could be taken forward to the third phase of analysis and triangulate the early findings.

> *The technologies that were tested or used during ARCHES were largely successful in developing elements of the four stages of the Analytical Framework produced in phase one of analysis - i.e. they were largely Usable and Accessible, and developed some elements of Agency and Learning Support. However, other issues arose that related to technologies and a range of access preferences. In particular, some access preferences were not based on the physical, sensory or cognitive needs of the participants, but on their social or cultural needs. In addition, there were other practical issues and issues of well-being that needed further consideration.*

2.4 Phase Three Analysis

The results of the exercise supported the hypothesis in large part, and participants agreed that the issues in the Analytical Framework were important to a greater extent. Thus, the Analytical Framework was largely seen as a basis for developing a number of Key Performance Indicators.

However, there were some differences in what was thought of as more or less important within the framework. In particular, the Usability and Accessibility categories of the Analytical Framework were seen as much more important than Agency and Learning Support.

However, as the second phase of analysis found, there were further observations that did not appear in the literature and subsequently were not included in the Analytical Framework or analysis. These are summarized as follows:

- Usability - Unlike phases one and two, networks were not felt to be greatly important, however, physical durability; size and portability of devices were seen as highly important.
- Accessibility - By far the most discussed topic during the exercises was the nature of accessibility, and on this topic the issue of an emotional connection to technologies arose a number of times. In addition, the following sub-issues were also identified by participants: the ability to choose the amount and type of information and the emotional connection with information; the simplicity and familiarity of technological interfaces.
- Agency & Learning Support - Agency was linked to issues of hearing impairment and deafness and, where learning support was mentioned, it was often linked to the amount and type of information available. Although, as in the second phase of analysis, issues of agency and learning support were occasionally correlated.
- In addition to the issues identified by the Analytical Framework, the following issues were also identified by participants during the exercises:
- Support and Advocacy – The need to consider third-parties acting as supporters or advocate, as well as providing agency.
- Well-Being – The need to consider the stress and threat to well-being that technologies can cause.
- Awareness of Technologies – As one participant stated, “The first thing I would like to know is what is the availability of the apps when I first enter the museum. Who tells me we have an app. The availability and who or what tells me that this app is available for this museum is the first issue I conjure.”

2.5 Discussion

Traditional assistive technologies have, despite their best intentions, largely reinforced the exclusion of disabled people. This is largely due to stereotypical ideas about disabled people, and because these technologies have often only catered for single impairments.

Furthermore, and largely because of the youth of inclusive technologies, literature has failed to challenge its culture meaningfully or develop frameworks by which these technologies can be measured. ARCHES has attempted to change this culture.

So, what is the next stage in this process?

Importantly, further research needs to be conducted into the issue of inclusive technologies for use in cultural institutions. Although ARCHES has started this process, it is unable to account for all contexts and all access needs.

In addition, cultural institutions need to develop further strategies and policies that lead to cultural and political change in their institutions. Without this political will, the development of inclusive technological solutions will not evolve, users will not develop confidence in their use, and participation will not lead to fundamental changes.

3 KEY PERFORMANCE INDICATORS

3.1 Designing for Usability

- Technologies should ensure disabled users can use the technologies with their preferred operating system or platform
- If technologies require creative work to be saved, then data should be saved locally and devices should not rely on wireless networks being available
- Wherever possible, backing up and saving on technologies should be automatic, and the user should be informed the work has been saved to reduce stress
- If technologies are tactile or require images to be enlarged, they should be large enough to be understood by users relying on their sense of touch
- Users should not have to hold a devise too close to their face, particularly for long periods of time
- If technologies do not have to rely on zooming into images or touch, they should be small and light enough to be carried and held easily, by whatever means, for long periods of time
- Where it is possible, technologies and apps should aim to use an equivalent amount of power and have an equivalent power source to mainstream technologies
- Technologies should be designed to be transported, lifted and installed easily by people with a whole range of access preferences – this can include appropriate handles or grips
- Technologies should have appropriate packaging, and this packaging should not make lifting or installation difficult
- Technologies should be designed to be used in different lighting and sound conditions – this is to increase visibility in low and bright light, and where possible to reduce background noise if they have a sound output
- Technologies should be designed to be safe and stable, particularly if they are to be placed onto a surface and touched regularly
- It should be ensured that technologies are designed to work with the native accessible functions in the operating system and on the device that is being used

3.2 Designing for Accessibility

- Technologies should be designed for different language groups, and allow for an easy transition between languages
- Technologies should allow for evolving access preferences and different access needs for the same user at different times – e.g. the user should be able to jump between being able to sign, lip read or have captions at different times depending on where they are and who they are with
- Technologies should be designed to allow for Easy Read texts where needed, or allow switching to fuller forms and more detailed text where required

- Technologies should be able to provide for the broadest possible choice of access preferences (such as sensory, mobility, cognitive, communication, learning or memory) for individual users rather than perceived physical, cognitive or sensory abilities or levels of need
- Technologies should use simple, familiar icons and navigational conventions (e.g. folder and disk icons and nested folder structures for saving) wherever possible and appropriate
- Technologies should be multi-modal, and use elements of multi-modal augmentation where possible and appropriate
- Technologies should allow for changes of colour, brightness, contrast, reverse colours, stereo and mono-sound and allow for the reduction of background noise and physical stability wherever possible
- Technologies should allow for zooming into text or images on screen that does not need to be held in a particular position for too long
- Technologies for use in cultural institutions should include practical information about accessing day-to-day facilities, such as where accessible toilets and cafés are, or how to travel easily to the site

3.3 Designing for Agency

- Technologies should allow users to provide feedback and have a say in the development of the designs they use
- Technologies should be designed to make users reflect on their own access preferences and those of others
- Technologies should be designed to allow users to promote their own needs confidently, confidentially and anonymously through communication functions wherever possible

3.4 Designing for Learning Support

- Technologies should be designed to allow users to learn through creative activities wherever possible and allow them to develop a sense of identity
- Exercises that facilitate learning through technologies should be provided for multiple levels of learner and through multiple-forms of media through the same interface, device or app wherever possible or feasible
- All learning through technologies in cultural institutions should have defined learning goals and a learning outcome
- Learning with technologies should allow for cultural and social interactions within the user's community and between users' communities
- Technologies should allow learners to learn about others' access preferences and to be aware of different forms of access setting
- Technologies should enable users to learn about the nature of the cultural institution they are visiting

3.5 Designing for Support and Advocacy

- Technologies should, under certain circumstances, allow users have others speak for them, translate for them or advocate for them
- Technologies should allow supporters or translators to communicate to people they are supporting
- Technologies should allow for social communication and the quick availability of communication to get support
- Technologies should provide tutorials, information, guidance and training for supporters as well as end users
- Technologies should provide information and settings for translators, such as signers

3.6 Designing for Well Being

- Technologies should not overload users with information
- Technologies should give users the choice not to physically or cognitively engage with processes or information for long periods

- Technologies should give users the choice of taking frequent breaks in instruction
- Technologies should not allow a single voice to over-power others during communication wherever possible
- Technologies should ensure e-safety and do all it can to reduce the stress of users by taking into account their access preferences
- Technological design should support confidence in their use, and give the user a slow step-by-step development of their use of the technology

3.7 Developing an Awareness of Inclusive Technologies

- Technology designers and cultural institutions should ensure that the use of inclusive technologies is advertised before and during visits
- Technologies should be designed to engage advocates or cultural institutions in the awareness of the technology wherever possible

ANNEXE

A - INTRODUCTION

This report is the full evaluation of the design, testing and use of technologies and tools used in ARCHES's tests and activities. The aim of the evaluation is to develop recommendations in the form of Key Performance Indicators at the top of this report; to discuss the practice of design and use of technologies in cultural heritage environments; to inform policies on inclusive technologies in cultural institutions – these aims were formulated with particular reference to heritage environments such as museums, monuments and national parks.

As per the original aims of ARCHES, the development of participant practice using technologies was based on three over-riding principles.

The first principle is that access preferences are not a like-for-like replacement for impairment names or disability categories. No one in ARCHES was defined by their sensory and intellectual impairments or labels of that sort. Access preferences were what someone would choose from a long list of access options - see Deliverable 6.2. This was previously referred to as "Labels of Opportunity" (Rix 2007: p. 28)

For instance, people with what was traditionally referred to as "Down syndrome" often had access preferences associated with physical, sensory and learning needs. It was also observed that people that have many access preferences often refer to themselves by their most important, strongest or socially most recognizable impairment category, such as deafness (Hayhoe, 2019b).

In reality, it was observed that many people may have other complex needs that need to be considered as well. Thus, the negative outcome of traditional assistive technologies is that they are often designed by assuming that the user has one access need; for example, a Brailler is designed on the assumption its user only has visual impairment, a hearing aid is designed on the principle that the wearer may only have a hearing impairment. The outcome is the same for many accessible modern apps, which make the same basic assumption.

The outcome of the non-classificatory approach was an encouragement of technologies that are now designed to be flexible and able to suit many access preferences. Another outcome is that technologies can often be customizable, adhering to the principle of Universal Design and adjust to changing access preferences (Thomson, et. al. 2015).

The second principle was the philosophical development of inclusive technologies rather than traditional forms of assistive technologies (Hayhoe, 2014). This principle was based on the observation that traditional assistive technologies represented some of the last barriers to inclusion for disabled people, as their use was different from that of non-disabled users.

For example, traditional zoom devices and cameras distinguish people with visual impairments from those without. Inclusive technology is defined as:

> "[A] mainstream technology that can be used with either no or minimal adaption by a person with a disability as an accessible technology. It is also seen as technology that provides social inclusion, such as communication and interaction, for [disabled people.]" (Hayhoe, 2019a)

The important distinction between inclusive technologies and traditional assistive technologies is that they do not distinguish between participants. Given their inclusive nature, these technologies require the same technical skills and habits –what is described as technical capital (Yardi, 2009) – as other technology users. However, the development of these specialist skills is re-defined through the use of inclusive technologies as inclusive technical capital (Hayhoe, 2019a, 2014).

Given these guiding principles, trends in technology usage and their size and lightness, mobile technologies such as smartphones and tablet computers were identified as the devices most likely to achieve inclusion during ARCHES. This is not possible in all situations, however, as it is currently not possible to make tactile technologies mobile. Therefore, engineers are working to develop new augmented technologies to translate the needs of inclusive technologies, with many paradoxes still existing.

The third principle of this project was augmented and cross-modal forms of learning. In particular, ARCHES used the principle that augmented reality used multiple forms of media to

develop alternative environments and ways of perceiving and learning about the outside world (Sheehy, Ferguson, & Clough, 2014). These different and alternative views are most commonly delivered through approximations to virtual-reality (VR) technologies.

Similarly, cross-modal cognition can be seen as the way that cultural heritage visitors interpret and integrate sensory information to develop a single "image" of the outside world (Spence, 2010) or through a cross-modal understanding of the outside world in combination with language (Hayhoe, Cohen & Garcia-Carrisoza, 2019).

This is particularly important for those with perceptual and learning disabilities, as substituting or enhancing touch, sound or sight for those with such preferences can enhance learning. In practice, ARCHES worked on the principle that this idea of developing augmented reality by tailoring sensory input for those with a variety of access preferences enhances the capacity to understand museum environments and exhibits (Neumüller & Reichinger, 2013).

What now follows in this report is split into the following sections:

1. Methodology and Methods – this section describes the grounded methodology used in the study, and the methods of collecting data
2. Findings: Phase One – this section analyses the results of a series of systematic literature searches, used as a foundation for the participatory research
3. Findings: Phase Two – this section analyses the results of interviews with participants about their experiences of ARCHES
4. Findings: Phase Three – this section discusses the finding of observations and final exercises during the pilot exercises
5. Conclusions – this section concludes our findings

B - METHODOLOGY AND DATA COLLECTION METHODS

B(i) Grounded Methodology

The methodology used to analyse the evaluation of the pilot studies and participant group activities was a form of Grounded Methodology (GM) used in previous museum and heritage studies (Hayhoe, 2012, 2019b). GM is an adapted form of Grounded Theory (GT) (Glaser & Strauss, 1967), which is specifically designed without inducing testable theories. Instead, GM encourages the evolution of interpretive deduced theories that evolve through discourse, such as course or workshop designs or the design or unique use of technologies. As it is more flexible, GM can also be applied to forms of investigation that are not normally associated with GT, such as literature searches.

As with GT, GM has three phases of study, with data analyzed differently during these three phases. During the first phase, categories of observable processes, behaviours, identities, practices or environments are identified, and theories of analysis begin to be developed. This provides a focus for the research. For example, in previous research using this methodology, learning environments and practice were classified according to access preferences to examine appropriate technologies for learning support.

During the second phase, links between variables in individual categories are connected together and developed into a unified epistemological model or paradigm that can be tested. If it is for a study of a test or exercise, this linkage is done for practical purposes and provides a direction for evaluation. Between the second and third phases, an initial, testable hypothesis is developed. During the third phase, testable evidence is used to interrogate the initial hypothesis; this data can include a workshop, course evaluations, structured exercise or further phases of observation.

As with GT, GM also constantly compares data, refines its methodology and regards all forms of data collected during the project as equally important, valuable and useable. This flexible approach to data collection suited the ARCHES' reflexive, problem solving approach to new contexts, topics and settings, which were largely un-scrutinized and under-investigated. Data and theoretical approaches can also be stored for later research, where they can be applicable in a different context.

There are practical differences between GT and GM. Most notably, GM relies less on formal coding, which has evolved to become a significant element of GT. Instead, GM relies on narratives developed by the researcher in order to state an original problem, and these narratives

are presented either as a thematic analysis, case studies or a combination of both. GM is also applicable to non-traditional research studies, such as the design and evaluation of learning or a structured literature search.

Where mixed forms of data collection are used or the study occurs over a long period of time, it is usual for categories to be developed and to increase in focus as the study continues. This focus is largely due to earlier phases of analyses using broader, looser categories, and also because the nature of these categories - and the subsequent findings - also become more apparent over the course of the study. These categories and findings subsequently need greater analysis and increasingly robust evidence to support these claims.

As this study used mixed forms of qualitative data and its fieldwork was conducted over the course of two and a half years, it was decided to use a form of data analysis that increased as the study progressed. These methods of data collection are now discussed below.

B(ii) Data Collection Methods

Unfortunately, much of the technology was not developed in time to present three distinct phases of the research; some technologies such as the avatar were not developed enough by June 2019 to test and Our Story was not available at all. Therefore, the strategy of the researchers was adapted to reflect this lack of testing.

The subsequent research therefore examined the broader picture of technological development and multi-sensory activities in situ. This included examining the use of our host technologies, such as the tablet computers, projectors and mobile telephones, the hands-on activities undertaken within the groups and an examination of the academic literature in this field. Eventually, after adapting the research study, the data collection methods were ordered into logical strands of data development and analysis that could be used in its three phased grounded methodology. These three phases were:

- Systematic literature reviews of academic literature on participation, design, e-learning, the use of augmented reality in museums, and m-learning in museums. This exercise also identified an Analytical Framework that could focus the following phases of analysis in phases two and three.
- The results of interviews with participants (these were translated by professional translators in Austria and Spain), observations of partner and mainstream inclusive technologies and tools used during participant sessions – these two methods will be discussed in fuller detail in Deliverable 2.4 – the results of pilot tests and consultations with participants. At the end of this section, an initial hypothesis was formulated and taken forward to be tested in the third phase.
- A formal consultation exercise with participants in London and Vienna: the first part of the exercise asked the participants what they thought about the different parts of the Analytical Framework, which was broken down into approachable language; the second part of the exercise was to ask the participants to design or describe what their ultimate technology would be, based on their experiences in the groups. The exercises in Vienna were interpreted by a professional translator as the participant running the exercises was a native English speaker.

The following is a discussion of the results of this data analysis.

C - PHASE ONE ANALYSIS

Four literature searches focusing on the design and use of technologies for people with access preferences in cultural institutions were prepared during the early stages of this work package. These reviews were:

- A review of literature on Augmented Reality (AR) in cultural heritage environments
- Two reviews of literature on the design of technologies for people with learning disabilities and sensory impairments in cultural heritage environments
- A review of the practice and development of learning through the use of networked technologies in cultural heritage environments

The reviews in points 1 & 2 have been published or are in press (Seale, et. al., 2018, in press; Sheehy, et. al., in press), whilst the review in point 3 is being prepared for publication. The following is a summary of this work.

C(i) Review of the Literature on Augmented Reality (AR)

It was observed that AR technologies are discussed in multiple formats in the literature, but that a single paradigm or over-riding model of use was yet to evolve. Importantly, it was found that AR was mainly used for mobile data connections, for multi-sensory media, text to speech applications and, less commonly, for haptic telepresence (i.e. having a touch representation of an object in a different location). Literature also suggests that museum visitors are able to share AR experiences in real time through social networks, through their own choice of personal technology and social media.

In addition, the majority of inclusive AR technologies discussed in the literature are designed to support visitors with visual impairments, with other access preferences supported to a lesser extent through separate technologies. For instance, there is mention of devices that aid navigation within the museums and support people with learning disabilities to get to the site itself or provide support through robotics. This would seem to suggest that many AR devices currently still support traditional models of assistive technologies, and design for individual access preferences.

Moreover, it is also found that there is a lack of focus on the needs of Deaf, deaf and hearing-impaired people in the literature. It was felt this was because text technologies are commercially available, live translation systems are well established and signing avatars are founds in apps, so few are developed as “standalone technologies.” Problems with usefully deploying and integrating these technologies into museum experiences are also found in the literature.

During an analysis of the uneven development of AR, eight affordances were identified as being important to the use of AR and measured against a scale of ability. These affordances were: Collaboration, Connectivity, Authenticity, Multi-Sensory Media, Student-Centred Technologies, Shared Knowledge, Community and Exploration. In a literature survey, it was observed that Connectivity and Authenticity impair the development of augmented learning at present more than other affordances., with Community and Student-Centred Technologies and Shared Knowledge found to be most important to the design of successful technologies.

C(ii) Reviews of Literature on the Design Process for Learning and Sensory Access Preferences

It was observed that the literature in these two reviews tended to use generic (i.e. standardised) design techniques, principles of Universal Design (i.e. designs and tools that suited a majority of user needs), minimised specialist tools, and their designers did not explicitly address a need to ensure accessibility.

Unfortunately, the absence of detailed justifications in this literature also made it difficult to draw firm conclusions that could demonstrate an epistemological trend and a paradigm of design that was evaluable. Subsequently, it was observed that many technologies favoured generic designs and users with sensory impairments over users with learning disabilities – it was also observed that where these issues were considered, designers preferred specialist designs for users with learning disabilities.

These reviews also observed that generic design techniques tended to be employed by disabled designers and stakeholders, who also involved disabled people in their design process. Thus, it was concluded that using significant amounts of participation and hybridised approaches to working with users with access preferences led to significant engagement and commitment to inclusion.

Much of the literature mentioning the experience of working with participatory design also found that designers working with users with learning disabilities learn a lot about the needs of these users, users with sensory impairments and themselves. However, this advocacy aside, as with the review of literature on AR, this survey could not identify a clear overall picture of paradigms or models of design and development, perhaps because this is a young topic of investigation.

Significantly, following this survey it was felt that more evidence to support the initial analysis and the tentative conclusions made by this literature was needed. Furthermore, this field needs to consider developing robust paradigms that can further research, and allow future literature reviews to examine clear frameworks as per a range of access preferences. Areas it was

thought that could benefit from this form of evaluation are the design of technologies favouring participatory design practices with users with sensory impairments and the explicit and detailed decision-making processes that technology designers currently make.

In order to try and formalise these future directions of research, a model of analysis was developed during the course of study that could be used to evaluate design practices and literature. This model was composed of the four broad elements, and turned into Table 1, which shows suggested user groups these elements these should be applied to:

- Designing for usability in a defined environment and for a defined practice - ensuring people with access preference can easily use the technology and this use is unimpeded.
- Designing for accessibility to the audience for which it is intended - ensuring people with access preferences can easily find the content or experience being offered by the technology and reducing barriers to meaningful engagement with the content or experience
- Designing for agency, to empower its intended users through its practice - ensuring people with access preferences can exert some control over the content or experience being offered by the technology
- Designing for learning support, to develop participation in the development of the technology - ensuring people with access preferences can learn something from the content or experience being offered by the technology and in doing so participate in an active way in the arts, rather than being passive consumers of heritage and cultural sites.

Table 1: A comprehensive framework for the design of technologies for people with learning difficulties

Diversity & Difference/Digital Inclusion	USE	ACCESS	EMPOWERMENT	PARTICIPATION
Designing for anyone – disabled or non-disabled	Usability design principles			
Designing for anyone who is disabled	Usability design principles	Accessibility Design principles		
Designing for anyone who is disempowered or excluded	Usability design principles	Accessibility Design principles	Agency design principles	
Designing for anyone with a learning difficulty	Usability design principles	Accessibility Design principles	Agency design principles	Learning Support Design Principles

C(iii) Review of the Literature on Learning Practices Using Technologies

As per the three surveys above, the review observed that teaching and learning strategies for disabled learners in cultural heritage environments was a greatly under-researched field. In addition, the literature as a whole failed to develop its own research models that could be tested by a robust evaluation at the point the survey was conducted.

This said, it was found that the literature that does exist supports the inclusion agenda of cultural institutions through the use of three forms of technology: the pedagogical use of fixed technologies, which allow for cross-modal interaction with exhibits; the redesign of exhibits to make them more interactive and academically stimulating through augmented technologies; the development of discourses on museum exhibits using social networks.

However, the review subsequently observed that early evaluations identified three significant weaknesses in current teaching and learning strategies and their use of technologies. Firstly, it was found that the design of teaching and learning lacks agency for those involved in the

education, design or use of technology. In particular, there was a lack of involvement of people with access preferences in the development of their own education.

Secondly, it was felt that there was little coherence in the management of inclusive learning, and there seems to be a lack of standardisation or holistic understanding of the use of technologies in the education of people with access preferences. Thirdly, it was found that although the literature has moved forward in its understanding of access, teaching and learning through the use of technologies, literature still focusses on individual impairments and still favours a deficit model of users with access preferences

C(iv) Conclusions Taken Forward

The researchers learnt two significant lessons from these reviews, which were subsequently taken forward to the second phase of research. The first and most significant lesson was that there is no overall understanding of design for access preferences by engineers, educators and app developers. Secondly, there was also a significant difference between different professions, such as educators, designers and engineers, although they share a significant need to develop technologies that provide agency for people with access preferences.

D - PHASE TWO ANALYSIS

As stated in the section above, the data collected for this phase was analysed according to the model from the two literature searches on the design of technologies. The elements of this model are presented in following sub-sections of the evaluation.

D(i) Usability of Technologies

Usability was amongst the most significant issue for participants involved in ARCHES. It was also the issue that caused most frustration, particularly when technologies were either not usable, took too long to work or were not compatible with the platforms they were loaded onto. At their best, however, the most usable technologies appeared to give the participants confidence during visits to galleries and provoked discussions and a community feel amongst the group.

For instance, notes on the exercises from the latter Coprix game showed the creative process stimulated significant social interaction between participants. However, it was observed that the inability to save images in Our Story, despite the presence of Wi-Fi, left participants lacking trust in the app. The following is one such case of a participant's inability to save their work, which meant the story they created was lost:

"I sent a story by email and this got to my computer and I sent the story back to the iPad as an attachment but I could not discover a way to get it put into the app."

Of all the usability issues that occurred, two particular sub-issues appear to need further investigation in future to improve accessibility: networking and the compatibility of apps; the size and shape of the tool.

D(i,a) Networking and Compatibility

The reliance of mobile technologies on connectivity to either mobile or Wi-Fi networks to save work, access data or simply contact supporters when sessions were finishing could be problematic. It seemed this was more important to participants who sometimes found performing backups or locating themselves harder than others. Thus, lack of network or connectivity should be seen as an access issue in modern technologies and can cause frustrations and tensions when not available.

For example, in almost all the ARCHES partner museums it was noted that free Wi-Fi and mobile telephone signals were available, and Wi-Fi was easy to connect with in the rooms used for participant sessions. This allowed access to social media to illustrate points to the participants during conversations, a point which was noted on several occasions. These networks also allowed participants to connect with supporters who brought them to groups or to arrange transportation home.

However, although Wi-Fi was normally reliable in the sessions' rooms, it was less reliable in the galleries or other, older parts of the buildings themselves. The inability to connect to a network restricted the use of technologies, which relied on backing-up through some form of Cloud – in

addition, it was found that a lack of Wi-Fi in Oviedo stifled the work being done in the first six months.

This restriction was largely caused by the historical nature of the partner museums and the inability of the museums to make structural changes or install routers on thick stone walls. This was also an issue guided by the legal restrictions the museums worked within, with many buildings having preservation controls, such as UNESCO World Heritage status.

Conversely, the introduction of connectivity was also noted by participants as an important outcome of their contribution to ARCHES. For instance, an interview with a participant from the Oviedo group indicated that the group's feedback had led to the installation of Wi-Fi in the museum:

> "And I think we might get some small changes within the institution. I think so … And they're putting Wi-Fi all around the museum so people could use apps and other things around the museum."

D(i,b) The Size and Shape of the Tools

It is particularly difficult to judge what the ideal shape or size of an inclusive technology should be, as it depends so much on the function of the tool and its user. For instance, it was noted that people with visual impairments often preferred larger access technologies if they were to try to see an image but smaller pocket-sized devices if they relied on sound functions.

It was also observed that participants would hold screens close to their faces if the image was too small and imperceptible, paradoxically making it necessary to have a large image but a light device. This position was also often physically awkward and uncomfortable for participants' arms and subsequently this position could not be sustained for long periods – this meant that text had to be significantly enlarged by only be a word or two at a time.

Inappropriately small sizes and shapes of screens would also mean that participants were likely to be more dependent on supporters in groups to change the settings for them.

A large device was particularly important to those participants who relied on tactile perception. For instance, the reliefs had to be of a large enough size to allow for sufficient details to be shown, but not too large as to make the whole image's narrative imperceptible. It was also observed that large technologies could also be hazardous to participants in gallery environments.

For example, instances where technologies got in the way of participants in wheelchairs were frequent. Furthermore, in London it was found that placing a large screen in an unfamiliar position caused a minor accident during a lunch period when there was a great deal of movement around the room:

> "During lunch I break off to talk to the scribe who I haven't seen for a long while. As I talk, [a participant] comes in and as the television isn't in its normal place in the teaching room, [the participant] walks into the side of the screen. He hits his head and is momentarily stunned. He points out there is a need for a barrier around the television on its stand, as it reaches beyond the width of the stand."

The physical size and shape of static devices in their packaging also had an effect on accessibility, and made sessions more reliant on physically stronger and more mobile participants. As was noted in one session, for example, the setup of the Sprout took four people some time to setup carefully. If participant groups had not had such support, testing such delicate, large devices would have been difficult:

> "The Sprout is in a large box, and when we open it up to examine it we discuss the best method to take it out safely. The participants take it out between the three of them, and set it up with the individual pieces on its nearest table. As it is awkward and heavy, they have to be very careful as they lift and manoeuvre. They then plug in the technology under the table – the position of the plug is awkward and under the table"

Subsequently, considerable efforts went into engineering hardware to make the Sprout more usable, with items being added to make the technologies safer and to provide physical stability for users with access preferences. For example, after significant testing the Sprout had a frame added to hold it and its relief in a fixed position, making the relief easier to install and use during touch sessions – although the issue of packaging also needs further research. As VRVis described of this device:

> "The Sprout is on a higher platform (24mm) than the relief to widen the projection area, so the projection will fit all reliefs … The Sprout is prevented from tipping over. (We found out otherwise it could easily tip over if people lean on the top part of the projector). The power

cable is fixed and protected from random unplugging … The openings of the Sprout are protected from all kind of vandalism [in the gallery]."

D(ii) Accessibility

Many participants came to the project with considerable knowledge of how to use their mobile devices and the skills that allowed them to navigate their environments, learn or simply gather information using apps – either through Web searches or using customized apps for information. Although, where they had little knowledge, this often hampered their inclusion in the groups. For instance, the following was recorded in the observational notes from Madrid:

"At the end [of the session], many members check their mobile phones for their rides or the supporter, person or family members who come to pick them up."

Furthermore, many participants in the early group sessions in London in particular suggested examining art apps they used on a regular basis and had skills that allowed them to evaluate theirs's and others' use of apps. For instance, on a number of occasions they suggested apps as models of good practice, amongst the most popular of which was Smartify and Google Arts and Culture.

Many of the participants were also familiar with the use of social media and communication apps, such as WhatsApp and email platforms, before ARCHES. Subsequently, many of the groups joined and followed eachother and other ARCHES groups on social media during the course of the sessions. And, even after the London group finished in May 2019, messages from the group were still sent and photographs of the final session were shared and liked. Consequently, many of the users needed little training in the use of mobile technologies at the beginning of the project – although notably, it was often supporters or museum professionals needed more training than the other participants.

During the project, it was also noted that the most significant accessible settings used were those that zoomed to observe graphics and text on-screen and voice-over to allow access to icons and tagged graphics. Other features that had significant use included the automatic adjustment of brightness and alternative forms of gesture. For instance, in Oviedo the following preferences were recorded in a survey for Coprix:

"[Participant 1]: VoiceOver (female images)
[Participant 2]: Display Accommodation-Auto Brightness
[Participant 3]: Zoom, Zoom hand gestures; VoiceOver (female voice; see image for speed regulation);
[Participant 4]: Black and white contrast; VoiceOver (female see images)"

Similarly, a London participant described their mobile access preference as follows:

"For accessibility on my iPhone I use voice-over. Which allow[s] me to navigate around, such as Apps, website, calls, etc … I use voice-over because I am not able to see screen[s], so voice over reads for me what's on screen, while I touch the screen."

Eventually, the use of mainstream technologies for day-to-day use were so ubiquitous that their functions became the most significant use of technologies by the participant groups. For instance, in all the groups it was recorded that participants would leave their smartphones in-front of them at the beginning of each session, and would largely rely on the tablet computers in the group for almost all their non-spoken communication.

Furthermore, the projector and screen and large screen television used to present the work at hand, both of which were used during presentations to the group, were found to be amongst the most inclusive technologies. Although these technologies were only lightly discussed during the project, it was mentioned how important they were for showing details of artworks in a way that was not normally accessible.

For example, in the latter stages of the London group the participants designed a sensory back-pack for the museums – this back-pack is a bag of items that could be taken in front of an exhibit and allows its user to experience elements of the artworks they could not normally touch or smell.

During the session, one of the items featured was a large oriental rug, whose pattern was displayed on the large screen television at the front of the room for the group to see. As they discussed the rug, one participant - who prior to this session had not talked about this access

preference - told the group this was the first time she had been able to see the pattern of the rug, as her low vision hampered her full view of it in the dimly lit gallery.

Of the many accessibility issues recorded during the sessions, the following two sub-issues were identified as needing further research: the paradoxes between different forms of access preferences; and the language or alternative forms of communication used in interfaces.

D(ii,a) Paradoxes Between Access Preferences

An issue that arose on several occasions was sign language users and their need for a highly visual interface clashing with the ability to design alternative forms of image for people without vision.

The issue was not a problem for the static technologies, such as the Sprout, as the avatar and text can be projected on screen, and the relief is accessible to touch. However, the mobile technologies have no animated or refreshable tactile graphics – these are not yet available. This meant, for instance, that when designing the Coprix game, it was noted that its interface had to be mainly visual in order to accommodate the avatars or human signers. In this instance, the artwork descriptions were available elsewhere, however the visual elements of creating a new image from components of other paintings was not available to those with no vision at all.

It was also observed that people who are less used to tactile artworks could find reliefs confusing. For example, during the evaluation of the Sprout it was found that developing an understanding of three-dimensional representations of two-and-a-half-dimensional images was not immediately understood by participants with sight - this seems to support the findings of an earlier topical review on tactile perception conducted as part of ARCHES (Hayhoe, 2018). As VRVis recorded on their testing:

> "[The] relief on its own is of too complex nature for a wide range of people to enjoy. Though participants liked the texture and material when it came to analyse the conversion of the object from 3D to 2.5D, it became noticeable that the size and depth of the figures confused the participants' concept of distance. In addition, the two scenes at the top of each corner were too small and detailed to get a proper understanding of what is being illustrated."

In addition, by involving participants who would not normally use a relief, other issues emerged. For example, issues were also raised about the quality and nature of text which benefited all users.

D(ii,b) Language and Alternative Forms of Communication

Where communication with technology was familiar, it made the participants more confident and provided a feeling of attainment from using the hardware and software. However, it was also observed that during a number of sessions participants often found the meaning of instructions ambiguous, and this could lead to a lack of confidence in the technologies in the following sessions.

Importantly, it was observed that understanding or lack of understanding was not always correlated to the access preferences of the participants but to their general experience of technologies and the nature of the designs being tested. For instance, where designers used words or phrases from "professional" software, such as those used in presentation software, many of the participants found the terms confusing.

In these circumstances, the simplest and most easily understood interfaces appeared to be those that used readily comprehended symbols used in the most common consumer apps. For example, when Our Story used the term 'headings' to describe a function that would produce a title for their piece of work, participants found this highly ambiguous and suggested more common alternatives.

> "The instruction 'make this as a heading' was a bit mysterious to me before using. An alternative heading might work better such as 'centre the text' or even an icon with the text in the middle."

In addition, during this test it was also observed that familiar symbols used in similar technologies and learning settings were preferable to their corresponding words, which could differ in meaning. For example, participants recorded the following comments on this issue:

> "[Participant 1]: taking the photos, it would be good to have the text and an icon about saving or retaking - perhaps a simple tick or save icon and a cross … Perhaps even a tick over the save icon. … [Participant 2]: In general, it might be good to have a tick with the messages such as e.g. story X saved correctly. This would help children/people who are not too good at reading."

D(iii) Agency

In general, agency was difficult to observe during testing or observations on the use of technologies in situ. However, during ARCHES' the most observable element of agency was the recognition of feedback from participants leading to changes.

For instance, agency was observable when discussing the contents of artworks during sessions that examined the ability of artworks to "tell a story." The participants particularly appreciated being involved in the process of choosing artworks and the language that was used to describe each piece in the apps, as it made the importance of their voice apparent. In addition, there were other examples of mobile technologies developing agency and knowledge amongst the participants during the broader work in the sessions.

Furthermore, it was noted that participants liked to use technology to record their own participation in the group, to make notes and to develop their own understanding of the process that was occurring – in some instances, participants had been encouraged to do so prior to attending the groups. It was felt that this allowed the participants the opportunity to develop their own "participatory voice." For example, it was observed during one session:

> "[A Participant] takes the iPad from the table in its case, and starts going around the table unobtrusively taking pictures of the group. She puts the iPad back away from the table on a table to the side."

However, as with Usability and Accessibility, there are two issues that need further research to improve Agency: cultural appropriateness of the representation of access preferences, disability and the ethnicity of participants; the use of language preventing full engagement with participation.

D(iii,a) Cultural Appropriateness and Representation

One of the main issues mentioned during discussions on the use of avatars and other forms of animated characters was the cultural stereotyping of the characters. This issue seemed particularly acute in London, where participants were representative of numerous ethnicities. For instance, as one participant observed of characters in the storyboard of an animation:

> "[Everyone] is a lovely shade of "white". I appreciate the story-board is short but surely some diversity could be included.
>
> Likewise, in respect to the representation of disabled people I assume that the blond man in the dark glasses … is supposed to represent a blind person? I appreciate that it would be impossible to represent every disability or impairment within the story-board, so why not represent us with the universal symbol."

Similar concerns were mooted in Madrid during a discussion on numerous symbols used to represent disabled people on instruction sheets. As was noted during one observation:

> "Some of the symbols on the sheet are criticised for being offensive, particularly to "blind and deaf people.""

D(iii,b) The Use of Language and Images Preventing Participation in Design

Conversely, it was also observed that inappropriate forms of language or the use of images led to participants feeling excluded from participatory conversations on the design of technologies.

For example, in the London participatory sessions there were comments made on some of the texts produced to be used in conjunction with the technologies; during several sessions, some participants found the text too complex. In addition, during discussions on the exhibits it was observed that the use of text in conjunction with images made it difficult for some participants to contribute to the design of the technology. This was recorded in observational notes as follows:

> "[There are comments about the text] on screen being too long and not "easy read" and the typeface being too small. At one point, [a participant] also has to go to [another participant with visual impairments] that have not been described to him as the talk is given to provide a verbal description … [Presenter] is talking, [participant with visual impairments] sits still and quiet. [Presenter] has a great number of images, and she gestures over them to show the features. [Participant with visual impairments] remains quiet and does not engage with the group."

D(iv) Learning Support

As with Agency, it was difficult to gauge the extent to which technologies developed Learning Support in the form of new knowledge and skills, as no instruments of measuring learning

were used during ARCHES. However, it became apparent that the casual use of technologies in particular taught participants to search for information that enabled and developed further self-directed skills and knowledge and form personal inclusion - these skills and knowledge were termed inclusive capitals during an earlier topical review for ARCHES (Hayhoe, 2019b).

For instance, during numerous participant sessions it was noted that search functions were used casually to search for information and research and discuss different elements of access and inclusion. In this way, there appeared to be a correlation between Learning Support and Agency within participatory settings, with inclusive capitals being largely premised on finding mainstream forms of information. The following excerpt, for example, illustrates a session from Madrid where a number of participants were asked to comment on images that were to be used for a project app.

> "During our conversation we use the iPad as a reference point for finding [images to be used in technologies]. We use a regular Google search engine to identify the correct image, which has to be very precise. [We find a sign for deafness, which has been discussed previously] …
>
> The tablet computer is passed between the participants, which allows for quick comparisons. It also causes a talking point between us, and allows us to compare information quickly."

One significant design element that facilitated Learning Support was the ability of technologies to transform information for participants. In particular, many participants felt it was important to integrate alternative forms of communication according to menu preference, which could subsequently provide different ways and a greater depth of learning – an issue that was found to reduce stress for some participants.

For example, in a message to TreeLogic early in the development of ARCHES, and acting on feedback from participants, different interfaces including different forms of knowledge and information were felt to be necessary for some:

> "[Question] for TreeLogic:
>
> Would it be possible to develop two interfaces attending to participant´s preferences: one simpler (with all the information in the same page and the link of more info at the end) and a different one that includes different sections/icons next to short description where you can click into to know more?"

During participatory exercises, there was also evidence that technologies helped to develop empathy and an understanding of others' access preferences during the course of using the partner technologies. However, despite this increased knowledge there still appeared to be a bar between the use of these technologies and the feeling that certain forms of access settings were "for someone else."

It seemed therefore that the traditional culture of separate assistive technologies for separate impairments – what can be referred to as a culture of separation - may form a cultural block that may take time to over-come. For example, in an interview with a participant from London it appeared that one participant felt it difficult to use technologies for participants with visual impairments.

> "I don't like using the eye things because it was horrible, but it made me think of the fact of if you're blind that's what your vision would be and so just to touch the object for that few minutes I would use them, but not for the whole time and that was good for me because I haven't really understood my cousin, who is blind."

D(v) Initial hypothesis

Building on these findings, the following hypothesis was formulated that could be taken forward to the third phase of analysis and triangulate the early findings.

> *The technologies that were tested or used during ARCHES were largely successful in developing elements of the four stages of the Analytical Framework produced in phase one of analysis - i.e. they were largely Usable and Accessible, and developed some elements of Agency and Learning Support. However, other issues arose that related to technologies and a range of access preferences. In particular, some access preferences were not based on the physical, sensory or cognitive needs of the participants, but on their social or cultural needs. In addition, there were other practical issues and issues of well-being that needed further consideration.*

E - PHASE THREE FINDINGS

To reiterate, the two-part exercise that resulted in the findings of phase three:

- Part 1: Participants from groups in London and Vienna were asked what they thought of the Analytical Framework identified in phase one of the research - the exercise in Vienna was supported by an English/German speaking translator. Their comments were based on their experiences of testing the technologies that were developed as part of ARCHES and their use of other technologies in the museum(s).
- Part 2: The groups were also asked to design or describe their ultimate technology for use in their host museum, and again this technology and its features were based on their experience of using and evaluating technologies over the course of ARCHES. Many of the participants decided to describe rather than draw designs.

The results of this exercise support the hypothesis in large part. Furthermore, the model Analytical Framework was partially useful for developing Key Performance Indicators; although there was some difference in what was thought of as more or less important, with usability and accessibility the most important and agency and learning support thought of as less important.

However, as the second phase of analysis did, there were further observations that did not appear in the literature and subsequently had not been integrated into the Analytical Framework. In addition, different correlations between the elements of the Analytical Framework were noted by the participants. These observations are discussed below.

E(i) Usability

Unlike phases one and two, issues such as networking was felt to be of a lesser importance than they were in phase two. However, during the exercises two other issues were seen as being of particular importance. The first issue was the physical durability of hardware, such as whether telephones and tablets were water-proof or hard-wearing. This issue was important as mobile technologies would have a great deal of use, and were fragile when dropped – given the nature of mobility issues in particular, this was thought to make inclusive technologies particularly vulnerable.

The second usability issue raised was the size and portability of devices. For instance, it was observed that people who were reliant on zooming into images or who were signers preferred tablet computers rather than mobile telephones, as the image on screen was larger. However, it was also observed that making these devices larger would paradoxically make them less usable to many.

Thus, many participants felt that smaller devices were important when touring galleries or moving around town. For instance, one participant felt that a smart-watch was a good example of a useable technology, as it was small enough to be useful to people with most mobility access preferences. Similarly, another participant pointed out:

> "I like it when the technology is small, I like to put it in my pocket. A big screen is not very useful for me as often I have a cane."

It was also observed that participants found a significant correlation between usability and accessibility, with some appearing to feel they were the same issue. For example, many of the participants stated that they liked to have their access needs pre-programmed so they didn't have to change them themselves – it was pointed out during the exercises that changing settings often led to mistakes that were difficult to rectify.

Conversely, others participants liked to have personalized settings that could change or evolve with their access preferences over time, or simple enough to be able to change or adapt settings to their current needs – it was observable access preferences may change over time according to several variables, such as worsening eye sight, hearing or mobility. If the technology is borrowed, then it was felt to be difficult to have to change too many settings, and if it was their own device many participants took time to personalize their settings.

A number of participants felt there was a significant overlap between usability and accessibility – almost as if they are the same issue. In particular, some participants preferred a simpler looking interface, which was more usable in terms of its shape, familiarity and size, with

accessible raised buttons that were modest – and tactile – rather than complex or stylish. Thus, it was felt that not only software should be fully adjustable but hardware too. As one participant put it:

> "Whether it is new technology or old technology, it should not matter. The main thing is it enables access."

Furthermore, and in common with the observations made in phase two, some participants thought that small devices could be used to project enlarged images onto a wall, as the projector used during sessions did. The projector was again pointed out as a device that was particularly accessible, as it not only zooms but leaves people "hands free" – thus, it is seen as a useful, ubiquitous inclusive technology.

E(ii) Accessibility

By far and away the most discussed topic during the exercises was the nature of accessibility, and on this topic the issue of an emotional connection to the technologies arose a number of times; and within this broader issue, two sub-issues were also identified by participants.

The first sub-issue participants identified was the ability to choose the amount and type of information, and the emotional connection they had with information through the interface. For instance, on a practical level one participant mentioned that when they listened to audio descriptions they liked to make their own decisions about how much text they would like, what the information they received was and the type of "ambient noise" they preferred.

Others felt that the type of voices used in voice-to-text also needed to be more "personally" accessible. For instance, their understanding of the sounds they preferred was not simply based on hearing levels, but also on the empathy this voice engendered and how comfortable they made the participants feel. For example, one participant mentioned the need for a person with a soft voice and simple wording in a text-to-speech function, as this was less threatening to her as a user.

However, as with all the other issues discussed, some participants preferred a "tougher approach" and to develop resilience through inclusive technologies. In particular, some participants felt the harder they tried to become accustomed to unfamiliar technologies, the greater sense of achievement they felt. Subsequently, it was observable that there was a strong correlation between the tougher approach to accessibility and the learning support elements of the analytical framework that were discussed afterwards. As one participant recalled:

> "when we started the multi-media project, how hard was it for people. Because, it was really hard … but when we started to do the project, we had so much fun with it, didn't we. We had pictures, we had something to write. And so, we could send something to [Other Participant]. That was the whole exercise."

The second sub-issue that was raised by the participants in Vienna and London was the simplicity and familiarity of the interfaces of technologies. In particular, there was felt to be a strong need for inclusive technologies to bear a similarity to old-fashioned technologies they had used.

For example, in descriptions of interfaces for the "ultimate technology," participants mentioned a preference for buttons instead of touch screen technologies – again this was un-related to their access preference, it just seemed more familiar. Furthermore, several participants also preferred to have familiar sounds such as those you would hear on many contemporary technologies or media devices – such as a familiar person or the sound of typing or the sound of a photography "click." As one participant commented:

> "I would rather hear someone. But, I would do it a different way, and I think other people would as well"

In addition, some participants described an inclination towards tactile elements of interfaces to make them feel comforting. As one participant stated, "[It needs to feel] reassuring, comforting, soothing." In a further example, one participant's design integrated several colorful, tactile and multi-media elements as a welcoming device for the entrance of the museum:

> "This could go at the front entrance of the museum, so that's what this picture is about … So, for example, it should have three pages, a book a picture and a green button. The green button people can actually press and words will come up … If someone could feel it, it would be furry, so people could feel it and see the text … And there could be patterns, and less writing – it should be in easy read."

E(iii) Agency & Learning Support

As previously stated, agency and learning support were thought to be the least recognizable issues associated with inclusive technologies by the participants during the exercise. Where agency was mentioned it was often linked to issues of hearing access preferences, and where learning support was mentioned, it was often linked to issues of the amount and type of information that was available; although, as in the second phase of analysis, issues of agency and learning support were occasionally correlated.

For instance, a number of participants felt that having sign-language empowered signers, who sometimes preferred to see themselves as a distinct community. Conversely other participants felt that technology that provided too much emphasis on signing or de-emphasized the needs of non-signers with hearing impairments removed agency. For instance, during the exercises one participant raised the point that signing was often seen as the only need people with hearing impairments were thought to have in technologies. As she stated on this issue:

> "The main point is, I don't think that any aspect of deafness is still being looked into. I mean, yes, it's OK to have [the signer] but if you come here [to a museum] on your own, you would need help to know where to go to look at a certain thing."

With respect to learning support, there were differences between participants about how much information should be made available. Some participants liked all the information to be shown, and then being able to sift teaching materials available in apps themselves and decide what they wanted. Conversely, a number of participants preferred information and teaching materials to be introduced either slowly or bit-by-bit. As one participant stated:

> "A little bit is good, but too much is too much. It's sometimes too much for you to develop and formulate your own thoughts … they want to see the art, they want to have a bit of information, but they want it to be short and concise."

Similarly, there were different access preferences about the practice of learning in the museum, with participants correlating the style of learning support with elements of agency. For instance, some participants preferred to be provided with concepts and ideas about artworks, where their ideas could be taken further and they could decide how to use the information themselves. This provided a sense of empowerment and allowed them a say in their own learning objectives. As one participant stated:

> "Discovering new things is important, and facilitating things you have done before is important."

However, other participants preferred to "have fun in the museum," and did not want to worry about having to deal with too much information, finding there was value in having choice and agency in their purpose. Some participants also stated they would like information before they get to cultural institutions, so they could decide what they would like when they got there.

> "You go to a museum in your free time, when you want to have fun for example. And, it's nice to have some information."

E(iv) Support and Advocacy, Well-Being and Awareness of Technologies

The first of the additional issues discussed by participants was the need to consider third-parties acting as supporters or advocates (advocacy in this instance was the ability to communicate for others, to make sure their rights were considered or what they said was heard).

For example, one participant identified an app she had on her smartphone that allowed multiple conversations for signers or for those who found verbal communication difficult. The signer featured on the app was a human interface that could both communicate and advocate for the user if needed:

> "I'm OK, but there are people who can't speak. There's an app here, and it's basically an interpreter and you can get a three-way conversation. There will be an interpreter who takes what is typed in to say what a person wants. So, there are lots of bits and pieces to allow people to get what they need."

The other issue mooted was the stress and threat to well-being that technologies can cause. For example, one participant explained how she found the ownership of technologies threatening for a long time, an issue that was exasperated by media coverage of threats to personal security, personal finances and inappropriate material.

It was only when she had an incident that caused extreme stress that she decided to get a smartphone, and from there a computer. From this point, it was a supporter that helped her to learn how to use mainstream technologies, building her confidence in technology as she did so.

> "Because for a very, very long time I refused to have a computer … But, I had someone come in with me once a week, helping me with stuff. And, it's been really, really good. But, it was very difficult for me in the first place. I was worried about getting lots of things that I didn't want to get into. You know, about all that stuff you get on the dark Web, and stuff like that. And, I didn't want to do anything like that, that's why I refused to have a computer."

Another participant expressed a similar fear, but found that attending ARCHES to learn about museums had increased her confidence in the use of technologies. Furthermore, she found that using technologies and developing soft skills also gave her the confidence to develop further skills such as electronic communication, and subsequently undertake solo projects and exercises.

> "I used to have a fear of technology. Not understanding how to use emails. And, not understanding how to use anything. But, I've taught myself. And I still do get it [a fear of technology], but I don't get it as much as I used to.
> It is this project that's got me out of my fear. Because I had a fear of the iPad and looking in the museums and no knowing how to use an iPad. But I had a fear of going around the museum with it [an iPad], and writing notes on it and things, and looking up a presentation on it."

The third issue raised was one of an awareness of technology. This issue was first mooted in the design of the ultimate technologies, where it was felt that technologies should be advertised to potential users. Other participants described how they wanted the technologies they designed to be put on front desks or by entrances to museums, so they would be the first thing visitors saw when they entered the building.

The most explicit description of raising a general awareness of inclusive technology in museums, however, came out of discussions that occurred in groups of participants. As one stated:

> "The first thing I would like to know is what is the availability of the apps when I first enter the museum. Who tells me we have an app. The availability and who or what tells me that this app is available for this museum is the first issue I conjure."

F - CONCLUSION

Many traditional assistive technologies have, despite their best intentions, predominantly reinforced the exclusion of disabled people. Largely stereotyping disability, these technologies often only focused on single impairments and fell short of providing wide-ranging inclusion.

Historically, these separate technologies caused numerous problems, not least of which was a culture of technical separation. This meant that many disabled people either shunned these separate technologies or were caught-up in a separate culture of only being able to use such devices. Subsequently, many users only developed skills related to these assistive technologies, and found it difficult to adapt to technologies in a mainstream environment.

Contemporary technologies, with accessible and inclusive settings built into their operating systems, particularly mobile wireless technologies such as smartphones and tablets, have disrupted this exclusion. Moreover, they have changed the philosophy of such technologies, from a notion of assistance to those considered to be incapable of using mainstream technologies, to one of technological inclusion.

Subsequently, over the past decade, new and inclusive mainstream devices have become almost ubiquitous for those who previously shunned technologies.

And yet, largely because of the youth of the philosophies of new technologies, literature has failed to change its culture meaningfully and develop frameworks or instruments by which inclusive technologies can be measured. ARCHES has attempted to change this culture.

In particular, two ARCHES' systematic literature reviews distilled an overall Analytical Framework from the field of technological design, one that could be used as an initial instrument in the development of Key Performance Indicators. This framework was made up of four elements: usability, accessibility, agency and learning support.

This Framework was subsequently examined against data from tests, observations of participatory sessions and a structured exercise in two further stages of analysis. The testing of the Analytical Framework has importantly validated the four core issues that it was based on, finding these issues featured in the following two phases of research.

However, these phases also identified further issues that do not appear in previous literature and also find that the importance of the factors making up the analytical framework differ; with usability and accessibility being seen as disproportionately more important to participants in this study than agency and learning support. Therefore, the Analytical Framework has had to evolve in order to reflect this feedback and to develop its Key Performance Indicators.

So, what is the next stage in this process?

Importantly, further research needs to be conducted into the issue of inclusive technologies for use in cultural institutions. Although ARCHES has started this process, it is unable to account for all contexts and all access needs, and therefore its Key Performance Indicators and Analytical Framework need further development.

In addition, cultural institutions, NGOs and governments need to develop further strategies and policies that lead to cultural and political change in their institutions. This is most important, as without this political will, the development of inclusive technological solutions will not evolve, users will not develop confidence in their use, and participation will not lead to fundamental changes.

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