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USABILITY OF MOBILE AUGMENTED REALITY AUTHORING TOOLS

FOR THE CREATION OF ACCESSIBLE CONTENT

BY

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Approval Page

The future of learning.

Approval of Thesis

The undersigned certify that they have read the thesis entitled

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Submitted by

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Dedication

This thesis is dedicated to my family: my spouse, Bill Ziehler, who encouraged me to "just write it up", believed in me, and helped me believe in myself; my wonderful Sophie Marie and Claire Diane who encouraged me even when they didn't know why; and finally my parents, Sandy and Dino Tesolin, for always being proud of me.

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Abstract

Mobile Augmented Reality (MAR) has been touted as a transformative technology in distance education. Studies have shown that students with disabilities achieve success through MAR applications, but that distance educators lack the resources to create accessible MAR content. This case study examined the usability of four selected MAR authoring tools based on their ability to create accessible content. During the creation of the content, I assessed the extent to which relevant success criteria outlined in the Authoring Tool Accessibility Guidelines (ATAG 2.0) were met and analyzed my Research Journal through this process. The results of this study showed that none of the selected MAR authoring met any of the ATAG 2.0 success criteria. Analysis of the Research Journal revealed a more contextualized understanding of the assessment and a supplemental proposed framework that may potentially assist in the future creation of accessible MAR.

Keywords: mobile augmented reality (MAR), authoring tools (AT), distance education, students with disabilities, accessibility, Authoring Tool Accessibility Guidelines (ATAG) 2.0

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Chapter 1. Introduction

People with disabilities represent a growing and important population for distance educators. Approximately 15% of the global population is considered disabled (World Health Organization, 2014). World-wide, people limited by physical barriers and stigmatization are the least likely to start school in k-12 and post-secondary and if they do, the most likely to drop-out (Global Partnership for Education, 2012). Consequently, the completion rates for post-secondary education are significantly lower for people who are disabled than for the general population (WHO and World Bank, 2011). This situation can lead to lifelong socio-economic disadvantage as an estimated 20% of the world's poorest people are said to have disabilities (WHO and World Bank, 2011). Around the world, patterns of higher unemployment, higher frequency of working poor, and low-paying employment with poor career prospects are found for people with disabilities (ILO, 2015).

Distance education has long been considered to hold a greater capacity for inclusion and accessibility for all learners by not being bounded by the barriers of time and place. A long-standing feature of distance education has been to provide students with greater access to educational opportunities (Bates, 2005). Unfortunately, other systemic barriers have emerged over time to reduce this accessibility. A review of the literature reveals a plethora of barriers including negative stereotypes or attitudinal barriers, inaccessible educational technologies, and lack of qualified educators as major factors preventing learners with disabilities from succeeding in distance education (Acosta & Luján-Mora, 2016; Kent, 2015; Lambert & Dryer, 2018; McManus, Dryer & Henning, 2017; Mikolajewska & Mikolajewska, 2011; Moorefield-Lang, Copehan, & Haynes, 2016; Seale, 2014; Tandy & Meacham, 2009).

One technology that has the potential to enhance the distance education experience for all learners is mobile-augmented reality (MAR). Mobile Augmented Reality is the intersection of two interface technologies: augmented reality and mobile computing (Nincarean, Alia, Halim & Rahman, 2013). Augmented reality (AR) is the interplay between the real world and a virtual component such as informational text, graphics, video, sound, animations, or GPS coordinates that enhance the user's perception of reality. There are two kinds of augmented reality: location-based and marker-based. Marker-based AR uses recognizable images or symbols in the real world, such as Quick Response Codes (QR Codes), whereas Location-based AR uses the location of the user through systems such as the Global Positioning System (GPS) to augment the physical world.

Small and portable computing devices (e.g., smartphones and tablet computers), linked by wireless networks, contain elements such as a camera and Microelectromechanical systems sensors such as accelerometer, GPS, and solid state compass that make them suitable for MAR platforms (Nincarean, Alia, Halim, & Rahman, 2013). Unlike augmented reality (AR), mobile augmented reality (MAR) provides students with worldwide access AR through omnipresent mobile devices and mobile learning (Kipper & Rompolla, 2012; Uther, 2019).

As illustrated in Figure 1, a mobile device can provide a range of augmented or virtual reality objects like videos that augment a concept found in a real object like a textbook. This ARTutor augmentation depicts the still frame of a virtual video of a landmark above a trigger image of that same landmark in a textbook.

Figure 1

ARTutor Video Augmentation Superimposed on Trigger Image

Note. This figure shows the still of a video augmentation from a textbook. From "ARTutor- An Augmented Reality Platform for Interactive Distance Learning." by C. Lydtridis, A. Tsinakos, I. Kazanidis, (2018). *Education Sciences, 8*(1):6. Copyright 2018 by C. Lydtridis, A. Tsinakos, I. Kazanidis. Reprinted with permission.

Distance education can incorporate MAR technology through the use of interactive textbooks, virtual laboratories, and a variety of other learning resources that optimize real-world experiences through mobile devices. Studies, overviews, and meta-analyses have shown promising results through the addition of authentic explorations, interactions, and collaborations to distance learning using mobile augmented reality technology (Akçayır & Akçayır, 2017; Bacca, Baldiris, Fabregat, Graf & Kinshuk, 2014; Bacca, Baldiris, Fabregat, & Graf, 2015; Ibanez, Delgado-Kloos, 2018; Ozdemir, Sahin, Arcagok, & Demir, 2018).

Negative stereotypes or stigmas can be mitigated through the increased interactions and collaborations that MAR can provide between learners and educators who have disabilities and those who do not. This is supported by the intergroup contact theory referenced in the meta-analytic research of Pettigrew, Tropp, Wagner, and Christ (2011). MAR accessed through mobile devices and acting as an assistive technology for learners with various sensory or mobility disabilities, as well as those learners on the autism spectrum, could also begin to address and minimize inaccessible technologies and resources in DE (Baker, Bakar, & Zulkifli, 2017; Bau & Poupyrev, 2012; Campigotto, McEwen, & Epp, 2013; Deb & Bhattacharya, 2018; de Oliveira et al, 2017, February; Escobedo, et al., 2014; Ribeiro, Florêncio, Chou, & Zhang, 2012; Squires, 2017). Additionally, MAR can help students with intellectual disabilities, learning disabilities, ADHD, or autism to grasp concepts through authentic learning and consequently increase their confidence in their abilities and enhance their motivation to learn (Avila-Pesantez et al, 2018, April; Heath, McDaniel & Panchanathan 2018; Lumbreras, de Lourdes, & Ariel, 2018**;** McMahon, Cihak, Wright & Bell 2016).

Research Problem

Despite its potential, few educators are using MAR technology (Project Tomorrow, 2017) and consequently mobile augmented reality (MAR) resources are not often incorporated in educational settings (Da Silva et al., 2018; O'Shea & Elliott, 2016). Further, as with most emerging technologies, the lack of research about MAR in distance education generally and specifically in the context of students with disabilities, also limits its use. Other factors that restrict the use of MAR include the cost of development, inadequate technical support, and the lack of flexibility and customization of content (Muraina et al., 2016). On the other hand, easy-

to-use MAR authoring software has started to result in increased use of MAR by educators (Coffman & Klinger, 2019), but its impact is so far limited as few educators currently possess the training, expertise, or resources to effectively integrate technology in education (Mao, Ifenthaler, Garavaglio, Fujimoto, & Rossi, 2019), including MAR technology (Wang, Callaghan, Bernhardt, White, K., & Peña-Rios, 2018). No research appears to exist that examines educators' ability to use MAR in distance education for students with disabilities; however, research does show that, globally, educators continue to possess little to no expertise in incorporating information and communication technology (ICT) in education for students with disabilities (Aksal & Gazi, 2015; Arhipova & Sergeeva, 2015; Fernández-Batanero, Cabero, & López, 2018).

One recommendation to increase MAR use in education has been to provide easy-to-use authoring tools for educators so they can create flexible and accessible MAR learning scenarios relevant to all their students (Akçayır & Akçayır, 2017; Bacca, Baldiris, Fabregat, & Graf, 2015; Wang, Callaghan, Bernhardt, White, K., & Peña-Rios, 2018). Current studies have examined the potential educational benefits of using authoring tools to create mobile augmented reality content and factors such as ease-of-use that might prevent educators from adopting them in their practice (Coffman & Klinger, 2019; Da Silva et. al, 2018;**,** Maia et al, 2017**;** Mota, Ruiz-Rube, Dodero, & Arnedillo-Sánchez, 2018; Rodrigues et al, 2017; Vidal et al, 2018). However, despite these studies, an important gap in the literature remains, that is, a lack of research that examines how distance educators might identify authoring tools that can create accessible mobile augmented reality for learners with disabilities. The thesis research reported herein helps to fill this gap.

Significance of Study

The results of this study may provide distance educators and instructional designers with concrete considerations for using MAR to create accessible educational resources for students with disabilities. The findings may also influence educational administrators in their attempts to incorporate effective educational technologies.

Vetting or evaluating the accessibility of educational technologies before incorporating them in distance education is vital. Accommodating or modifying learning activities that have been created using inaccessible technologies, after the fact, can lead to problems such as inequity of learning opportunities, and increased effort, time, and cost (Hashey & Stahl, 2014).

MAR developers may also benefit by using the findings of this study to inform the design features of MAR platforms to ensure greater accessibility for all users. Finally, learners with disabilities could ultimately benefit as MAR use can potentially reduce or remove systemic physical and attitudinal barriers and create a fully accessible experience.

Purpose of the Study

The purpose of this case study evaluation was to examine the usability of mobile augmented reality (MAR) authoring tools to create accessible educational resources by educators in distance education for learners with disabilities. Specifically selected augmented reality authoring tools were assessed using internationally recognized criteria in order to determine how accessible these platforms were for creating accessible content for students with disabilities in distance education. Simultaneously with these assessments, Research Journal data were collected as I recorded my experiences throughout the process in the form of notes in a Research Journal. The results of the assessments were determined using the Authoring Tool Accessibility Guidelines (ATAG 2.0) developed by theWorld Wide Web Consortium (W3C, 2015). The

subsequent Research Journal results were determined using thematic analysis with steps outlined by Braun, Clarke, Hayfield & Terry (2019). This approach attempted to provide added insight and expand the comprehension of the results. Supplemental to this case study evaluation, and resulting from the process, I suggested a more robust framework in which to evaluate the usability of authoring tools used to create accessible MAR applications by distance educators.

Research Questions

The study examined the following research questions:

1. What MAR authoring tools, available to the widest audience of distance educator users, can be used to create resources for distance education that meet internationally-recognized accessibility guidelines?

    Sub-question:

    - What criteria can be used to evaluate the authoring tools, and are there any limitations to these criteria?

2. How do the recorded notes of the researcher enhance the understanding of assessing the usability of MAR authoring tools to create accessible distance education content for students with disabilities?

3. How can the MAR authoring tool platforms be improved to ensure accessible MAR content in DE?

Limitations

A limitation is a restriction or influence on the study that cannot be controlled by the researcher. The following are the limitations for the proposed study:

a) Authoring Tool Accessibility Guidelines (ATAG) are for authoring tools that design web content. A MAR application is not simply web content but the interaction of web content with physical reality. This limits the criteria of ATAG to fully evaluate the accessibility of the MAR authoring tool. These limitations will be discussed in the methodology, analysis and conclusion of this study.

b) ATAG do not consider holistic principles, inclusive design, and/or considerations for people who have psychiatric impairments. Therefore, this evaluation is limited in terms of evaluating the accessibility for all learners and its use in inclusive or universal design in distance education. These limitations are discussed in the analysis and conclusion of this study.

c) Evaluation of the ATAG success criteria was only determined by the author and the selected WCAG 2.0 automatic evaluators.

d) The results of the study are not generizable to all authoring tools and are only specific to the authoring tools that were evaluated.

e) The results of the study are not generizable to all MAR content and are only specific to the content outlined in the study.

f) The results of the study are not generizable to all educators creating distance education MAR applications and are only specific to the experience of this author.

Delimitations

A delimitation is a restriction or boundary that the researcher deliberately chooses. The research was delimited by the following:

a) Only authoring tools that could create marker-based augmented reality (AR) applications for distance education were evaluated. Marker-based augmented reality is better-suited to distance education than location-based augmented reality because it is not tied to a specific location. A key advantage and component in distance education is not being limited by location.

b) Only authoring tools that were free, compatible with both iOS and android operating systems, and developed for non-programmers were evaluated. This delimitation ensured that only authoring tools that addressed the barriers of cost, technological compatibility, and skills for distance educators were evaluated in order to provide the widest range of applicability in distance education.

c) Only authoring tools that existed between September 2018 and April 2019 were examined. No software updates or new authoring tools that were developed after April 2019 were examined. This was necessary because of the rapidly changing MAR technology.

d) A delimitation that relates to the limitations of the researcher was that only selected guidelines from ATAG 2.0 were assessed. These guidelines were chosen based on both the researcher as a novice evaluator of accessibility and distance educators general lack of expertise in the creation of accessible MAR content for students with disabilities.

e) The researcher journal analysis was delimited to the experience of the author and her written observations throughout the process of this study.

Definition of Terms

Authoring Tool

Authoring tools are any application which helps “authors” or users (web developers, designers, writers, educators, etc.) edit markup and language presentation documents (W3C, 2015). Authoring tools generally require less technical knowledge and are used for applications that present a mixture of textual, graphical, and audio data. In this study, authoring tools are software applications that are used to create mobile augmented reality content.

Cognitive Disability (CD)

Many disabilities fall under this broad category of disability. They are distinguished by the following affected cognitive functions: memory, executive function, reasoning, attention, literacy, behaviour. Cognitive disabilities include aphasia, memory loss, ADHD, anxiety, depression, autism spectrum disorders, and learning disabilities (W3C, 2018).

Disability

There is no clear definition for disability (UN, 2015a). For the purposes of this thesis, the term disability is used to describe functional limitations of major life activities including but not limited to learning (National Center on Disability and Journalism, 2018). These include limitations in environment physically, sensorial, cognitively, and/or psychosocially. "People with disabilities" or “learners with disabilities” or "students with disabilities" could include people who have low vision, are Deaf or hard of hearing, use a wheelchair or have other physical or mobility or dexterity disabilities, who have an autistic spectrum disorder or are autistic, have Attention Deficit Hyperactive Disorder (ADHD) or have one or more learning disabilities,

people who are developmentally disabled and also people who have anxiety, depression and/or are otherwise psychosocially disabled.

Summary and Organization of the Thesis

Chapter I introduced the topic of examining the usability of MAR authoring tools to create accessible resources for learners with disabilities in distance education and provided the purpose of the study and the research questions. The chapter briefly outlined the problem, the research questions, and the importance of the study. It also indicated the limitations and delimitations of the study and defined various terms used in the study.

The next chapter, the Literature Review, examines key areas of the study. It examined the critical disability theory and transformative framework that underscored this study. A definition of accessibility is presented with further reflection on accessibility in technology, standards, and evaluation. Major themes included not only accessibility, but also authoring tools and Research Journals.

The third chapter for this thesis, Methodology, outlined the research design and the steps that were taken to complete the research as a case study, as well as the data analysis procedures. The mobile augmented reality content for this study, the ATAG 2.0 Implementation Guide and the Researcher's Notes were all found in the appendices.

Chapter 4, Results and Discussion, explored the results of both the examination of usability of MAR authoring tools and the Research Journal. The examination results were presented in detail in the appendices and summarized in tables and text in the chapter. The presentation of the Research Journal results followed with each theme specifically outlined.

The next chapter, Chapter 5, Conceptual Framework, provided the details of the proposed conceptual framework for the use of MAR benefiting students with disabilities in distance education including the theoretical foundation, principles and guidelines.

Chapter 6, the Conclusion, finalized the topic of examining the usability of authoring tools in creating accessible MAR content for distance education. The major findings were explored and contextualized in the literature. The possibilities in future research were recommended.

Chapter 2. Literature Review

Introduction

This review contextualizes this study in the existing body of research by discussing theoretical frameworks, and synthesizing the state of knowledge through the exploration of major themes that relate to the topic of examining the usability of authoring tools to create accessible mobile augmented reality open educational resources by distance educators for learners with disabilities. It begins with the consideration of this study within the transformative framework and critical disability theory. This review analyzes research on the definitions of accessibility with specific attention to technologies used in distance education and their standards of accessibility and the evaluation of these standards. Studies that highlight the relevance of authoring tools in the creation of accessible distance education are also discussed along with an examination of methodologies for evaluating the accessibility of authoring tools. Finally, the qualitative methodology of the Research Journal is examined as it pertains to the development of a framework for evaluating the usability of authoring tools to create accessible MAR by distance educators.

Theoretical Foundation

Transformative Framework

The overall context for this study is a transformative framework that assumes the challenge of systemic oppression, attempts to build trust in oppressed communities, and encourages the use of the findings to fight for social justice (Mertens, 2010). Specifically, the purpose of this study is to examine the usability of mobile augmented reality authoring tools to create accessible educational resources by distance educators for students with disabilities. The

findings could be used by distance educators and developers to help reduce systemic distance educational barriers for learners with disabilities.

IMS Global Learning Consortium (2004) defines disability "as a mismatch between the needs of the learner and the education offered" and systemic barriers are a product of that mismatch (Section 2). This definition is an evolving concept based on the social model of disability, which recognizes that people with long-term impairments are hindered from full participation through specific socially-constructed barriers of attitude and environment (UN, 2006). This view of disability contrasts sharply with the medical model of disability that focuses on a clinical diagnosis and views the individual as someone in need of treatment or correction. The medical model of disability and the ensuing diagnosis often negatively stigmatizes the person with the impairment as a victim (Brisenden, 1986). A more comprehensive model is the model of interaction provided by the World Health Organization (2018) that reflects the interaction between the disabling factors in society and the disabling factors of an individual's body. Transformationally, this model addresses the removal of both societal and environmental barriers (WHO, 2018).

Critical Disability Theory

This study was guided by the critical disability theory that seeks to transform society so that people with disabilities can fully participate (Hosking, 2008). Critical disability theory recognizes a power structure that benefits and normalizes individuals without disabilities while simultaneously stigmatizes people with disabilities and severely limits them through inaccessible environments. While examining the concept of Universal Design, Hamraie (2016) recognizes that we are not living in a post-disability world and notes that the critical disability theory defines

accessibility to specifically address the needs of people with disabilities who have been marginalized in our society. The thesis research study reported herein, by focusing on evaluating the usability of authoring tools to create accessible educational resources specifically for people with disabilities, is illustrative of this critical disability theory. Following this theoretical context, the study looked to transform society by creating distance education environments that accommodate the full participation of learners with disabilities.

Accessibility

The concept of accessibility is important to examine in the context of this study in order to create an understanding for evaluation. Persson, Åhman, Yngling, and Gulliksen (2015) conclude that an international consensus has yet to be achieved, but suggest a definition built on the concept that accessibility provides opportunities to the population with the widest range of characteristics regardless of their challenges. This definition, however, does not focus specifically on people with disabilities and the inequities of the societal power structure; therefore, it was considered inadequate for this study, which was underpinned by the transformative framework and critical disability theory. More in line is the definition offered by Rosen (2017) as a "design philosophy that centers the needs and experiences of people with disabilities" (para. 26).

Accessibility in Distance Education

An important accepted component of distance education is the use of information and communication technologies (ICT) to facilitate the interaction between learners and content, learners and educators, and learners and each other (Simonson, Smaldino, Albright & Zvacek, 2013). Thus, accessibility in distance education must consider the accessibility of the ICT used

in the interaction. Much research has focused on how technology can promote (Dobranski & Hargittai, 2012; Söderström, 2009; Stendal, 2012) and limit accessibility (Blanck, 2014; Chadwick & Wesson, 2016; Dobransky & Hargittai, 2012). A more comprehensive view is offered by Wentz, Jaeger, and Lazar (2011) who conclude that those barriers are not inherent in the technology, but exist due to choices made in the design highlighting the inefficiency of retro-fitting technologies. A more recent view is offered by Seale (2014), who states that accessibility involves two processes: designing and accessing.

The design of accessible mobile augmented educational resources by distance educators is the process that was examined in this thesis research study. Accessible technology, in this case, should not be described as low-cost and easily-found or "usable for all end-users" as it was by Kline, Flynn and Keogh (2017), but instead as a technology which "aims to remove barriers for people with disabilities by allowing them to perceive, navigate and interact with web applications, tools and mobile devices" (Lew et al., 2015, p. 1). Accessible technology is characterized by the design of distance education technology that centers on the interaction of learners with disabilities with that technology.

Evaluating Accessibility in Distance Education Technology

"Standards provide a useful place to start" (Kimura, 2018, p. 5). A standard is something established by authority as a model or example to measure a criterion. The internationally prominent Web Content Accessibility Guidelines (WCAG) 2.0 developed through the World Wide Consortium and Web Accessibility Initiative (W3C, 2008) is recognized as an international guideline and "gold standard" (Kimura, 2018). Kimura is not alone in this thinking as evidenced by the fact that the International Organization for Standardization has adopted WCAG 2.0 as

their ISO/IEC 40500:2012, information technology standard. While WCAG 2.0 is accepted as an international standard, there remains problems or concerns "with the evaluation of WCAG relate to the level-of-success criteria (A, AA, AAA), the high standard, unnecessary focus on criteria, and/or conversely, the neglect of other criteria on many of the automated WCAG evaluators that exist (Vigo, Brown & Conway, 2013). The most recent studies show that WCAG 2.0 continues to be used globally as the standard to evaluate the accessibility of educational web content (Acosta-Vargas, Acosta, & Luján-Mora,2018; Aracid et al., 2018; Nir & Rimmerman, 2018**)**.

Authoring Tools in the Creation of MAR

Inherent in authoring tools is their ability to create specific content for specific educational scenarios; this ability provides options for matching the learning environment to the needs of all students and specifically for students with disabilities. A significant facilitating factor for encouraging educators to incorporate accessible mobile augmented reality into their teaching practice is to ensure that easy-to-use authoring tools are available. A recent qualitative study by da Silva et al. (2018) looked at practicing educators and their use of authoring tools to create augmented reality. The authors' conclusions reinforced the need for authoring tools that do not require a computer programming background and recommended HP Reveal (previously Aurasma) as the authoring tool of choice. Based on this recommendation, the easy-to-use HP Reveal authoring software was included as one of the authoring tools examined in this study. Unfortunately, while the da Silva et al. (2018) study suggests that future work on a guideline for the creation of authoring tools be based on teachers' needs, there was no consideration of accessibility of the authoring tool for educators and students with disabilities. In contrast, this

thesis research study focused specifically on ensuring that authoring tools could create accessible mobile augmented reality learning experiences for students with disabilities.

Evaluation of Authoring Tools

As a subset of Web Content Accessibility Guidelines, the Authoring Tool Accessibility Guidelines (ATAG) 2.0 evaluate the accessibility of authoring tools in terms of their accessibility for the author as well as in the creation of content (ATAG, 2015); the latter being the most applicable in the context of this thesis research study. Particularly relevant to this research was the methodology used by Acosta, Acosta-Vargas, Salvador-Ullauri, and Luján-Mora (2018) in their study looking specifically at methodology to assess the accessibility of online editors. The researchers divided the methodology into three phases, with the first phase configuring the content editors or authoring tools, the second phase assessing the accessibility considering ATAG 2.0 and WCAG 2.0 criteria, and finally the third phase recording the results of these assessments. The second phase subdivided into several steps was most valid for this thesis research and informed its methodology. Crucial to the credibility of the research, step 1 of phase 2 selected only the ATAG compliance criteria or standards most pertinent to the usability of the authoring tool in creating accessible content.

Mixed methodology has become a common way to increase the validity of the evaluation of accessibility by supplementing the automated accessibility tools with manual evaluations by experts and/or users with or without disabilities. The study by Vigo, Brown, and Conway (2013) provides a benchmark for accessibility evaluation tools (or automated accessibility tools) and consequently a validation for the methodology and their use. They concluded that for improved effectiveness, researchers should use multiple tools and choose each based on the tool's ability to

catch specific errors. In keeping with this recommendation, the findings of this thesis research study identify the specific benefits and limitations of the four automated accessibility tools studied (AChecker, Total Validator, TAW, and Deque). Rounding out the literature on automatic evaluation tools, Silva, Eler and Fraser's (2018) research identifies accessibility properties that can be evaluated using specific mobile automatic evaluators. The influence of these findings provides still another dimension to the accessibility examination process in that the MAR platforms can be evaluated in their intended mobile format.

To supplement these automated tools, Rebelo, Barcia, Merino, and daLuz (2004) introduced the concept of evaluating usability of an authoring tool through a developer/target user. They advised that the target user did not have to be a usability specialist or an accessibility expert in order to provide valid results if a checklist was used that assured stable results, identified problems easily, and reduced subjectivity. Similarly, Feiner, Krianz, and Andrews (2018) proposed that a single developer/target-user accessibility checklist can be an effective method to get an overview of the most significant accessibility problems. Based on these studies, the methodology used to evaluate the usability of authoring tools to create accessible mobile augmented reality content incorporated multiple automated tools and was supplemented by the researcher/target end-user's manual evaluation of selected relevant criteria from ATAG 2.0.

Summary

In this literature review, the research was first contextualized through the transformative framework and critical theory lens. Major topics of accessibility, evaluating accessibility, authoring tools, and evaluating accessibility for authoring tools were explored. Several studies

informed the basis for the methodology for this study, with regard to the format (Acosta et al., 2018) and the evaluation techniques used (Vigo, Brown & Conway, 2013; Feiner, Krianz & Andrews, 2018), as well as the selection of specific authoring tools to be examined (da Silva et al., 2018) . However, none of the studies examined if mobile augmented reality authoring tools could create accessible learning resources for students with disabilities.

Chapter 3. Methodology

Research Design

Case study evaluation research is a form of applied research that assesses value but also seeks to contextualize that assessment (Russell, Greenhalgh, & Kushnes, 2015). It is a form of applied research in that it attempts to solve a practical problem to benefit and empower the stakeholders in the field of study (Clark & Dawson, 1999). Further defining this as a case study incorporates the key point that this study provided an in depth and holistic investigation within a real world context (Yin, 2017). This case study not only assessed the usability of selected mobile augmented reality (MAR) authoring tools to create accessible distance education content using Authoring Tool Accessibility Guidelines (ATAG) but further data from the Research Journal also grounded and contextualized this assessment. While the usability of the MAR authoring tools was being assessed, I recorded my thoughts and first-hand observations in my Research Journal. This Research Journal was thematically analyzed and the results were presented in conjunction with the usability assessments for an in depth examination. The findings of this thesis research case study could be used by educators, administrators, and instructional designers in distance education to help them select the most appropriate tools for creating an inclusive educational experience.

Selection of Authoring Tools

The authoring tools chosen for this study were selected based on four criteria: function (i.e., authored Marker-based MAR applications); low (IT) skill level of user (i.e., designed for non-programmers); software (i.e., compatible with iOS and android operating systems) and cost (i,e., free). Based on these criteria, the following four authoring platforms were examined:

HP Reveal (https://www.hpreveal.com); Blippar (https://web.blippar.com/blipp-builder#Blippbuilder); ARTutor (Lytridis C., Tsinakos A., and Kazanidis I. 2018); and Metaverse (https://gometa.io)

Several additional MAR authoring platforms were examined throughout the study period but were not included in the final study because they did not meet eventual delimitations determined by the researcher. The following authoring platforms were excluded because high IT skill were needed: ARCore (https://developers.google.com/ar/) ARToolkit (Billinghurst, Kato, Weghorst, & Furness, 1999), Easy AR (https://www.easyar.com), MIT App Inventor 2 (Pokress & Veiga, 2013), and VEDILS (Mota, Ruiz-Rube, Dodero, & Molina, 2016). Additionally, ARIS (Holden, 2014) was excluded for only using location-based MAR, Glimpse AR (http://glimpsear.io) for its eventual cost, and you augment (https://youaugment.com) because it was only in an alpha version.

The Evaluator

I am student researcher completing the thesis route of the Masters of Education in Distance Education program at Athabasca University. I had no previous experience with any of the authoring tool platforms and was considered a novice in accessibility and usability testing. As a K-12 educator, I was considered a target-user. Examining the existing systemic barriers for students in current education institutions has been a strong interest for me as a former high school biology teacher. Despite having a father who is deaf as well as a familial and personal history of anxiety and depression, I was largely uninformed about creating learning experiences for a wide-range of students with many specific disabilities. I took notes throughout the process of examining the usability of MAR authoring tools to create accessible distance education

content. I acknowledged my preconceived ideas about limitations of "accessible for all" and "universally-designed" educational experiences along with criticism of WCAG 2.0 and ATAG 2.0 as addressing barriers for people with learning and psychiatric disabilities. These preconceived ideas and biases were managed and bracketed through the reflexive journaling and memoing simultaneously collected in this research.

Setting

A distance learning scenario involving an osmosis experiment was used to provide the content for the MAR applications created by the four platforms . This learning scenario was chosen based on the researcher's background as a high school biology teacher, the relevance of this topic as a major biological concept, its compatibility with marker-based MAR, and the global availability of experiment materials. Specifically, the experiment demonstrated osmosis across the cell membrane of chicken eggs (Appendix 1).

Instrumentation

Authoring Tool Accessibility Guidelines (ATAG) was chosen as a tool to evaluate accessibility of the four identified authoring tool platforms. ATAG 2.0 was recommended by World Wide Web Consortium (W3C) on September 24, 2015 as part of a series of guidelines developed through W3C's Web Accessibility Initiative (WAI).

The authoring tools were evaluated based on the success criteria or accessibility requirements identified through the guidelines and principles of ATAG 2.0. There are two main parts to ATAG: Part A evaluates the accessibility for authors with disabilities; Part B evaluates the accessibility of the content or the MAR learning opportunity produced by the authoring tool. Each of Parts A and B has four principles and guidelines, and each guideline has testable criteria.

While the entirety of ATAG 2.0 is important to consider for a fully accessible authoring tool platform, I prioritized the guidelines that were considered most effective for a novice to evaluate and most relevant to a distance educator interested in creating an easy, but accessible, MAR educational resource. I had not directly experienced ableism barriers and was therefore not inherently qualified to assess the accessibility of the authoring tool user interface manually (Part A). As such, the comparative evaluation for this research was focused on ATAG 2.0 Part B, that is, how the authoring platform supported the production of accessible content (WC3, 2014).

Data Collection Procedures

The assessment data were collected in three phases and the research journal data were collected concurrent to phase three, step 3 of the assessment data collection.

Assessment Data Collection

Phase 1. Acquiring the MAR Authoring Tools. The four authoring platforms were acquired for this study by visiting the respective websites (https://www.hpreveal.com, www.blippar.com, http://aetma.teiemt.gr/aetma/artutor/ and https://gometa.io) and signing-up for their free augmented reality platform product. Signing up required using an existing email address of the researcher and creating new passwords for each platform. . The researcher approached each organization with the provided email contact or Facebook messenger to request permission to use the platforms in the study and all organizations agreed to their inclusion.

The four authoring platforms were downloaded to the researcher's laptop computer, an OS X El Capitan MacBook (Version 10.11.6). Subsequently, the four MAR authoring tool apps were installed on the researcher's iPhone SE (Version iOS 12.1.4) in order to test the MAR applications.

Phase 2. Creating the MAR Content. For each of the authoring tools, the researcher created a target image or a QR code for the mobile device to recognize and link to an overlay that would augment the learner's perception of reality. This augmented reality content was defined as marker-based augmented reality because a target image was used instead of a GPS location. The target image was created by the author as a stylized black-and-white image of an egg in an osmotic solution with water molecules highlighted. This image was created as an independent portable network graphic (png); it also included a pdf and hardcopy of the written description of the experiment (Appendix 1) that the distance education learners would have in their possession. This target image triggered the overlay of an author-created video that introduced the concept of osmosis specific to this experiment with one animated image and voice-over narration. This video was saved as a moving pictures expert group 4 (mp4) and uploaded as a YouTube video (https://www.youtube.com/watch?v=q959lXYqurQ).

The platform-specific instructions and tutorials were followed for each authoring platform, creating four separate instances of MAR content for the osmosis experiment.

Phase 3. Evaluating the MAR Authoring Platforms. Phase 3 of the assessment data collection involved three steps as described below.

Step 1. Relevant Success Criteria. The initial step for this comparative evaluation phase determined the most relevant ATAG 2.0 success criteria and compliance levels for creating accessible MAR educational resources in distance education. After considering the expected MAR outcome using authoring tools and the lack of expertise of the author to both create accessible MAR and evaluate the accessibility of software programs, the most relevant success criteria in the ATAG 2.0 were chosen. More specifically, the chosen success criteria focused on

the authoring tool's ability to provide authors with assistance in creating accessible MAR. Additionally, only success criteria that conformed to level A were examined so that the authoring tools only had to meet the minimum level of accessibility for ATAG 2.0. These selected success criteria are listed in Table 1 and this table outlined the success criteria and respective descriptions along with the level of compliance needed to be successful.

Table 1

The selected ATAG 2.0 criteria and their descriptions.

ATAG 2.0 Success Criterion	Description of guideline	Level of compliance
B.1.1.2 Content Auto-generation During Authoring Sessions	If the AT provides the functionality for automatically generating web content during an authoring session, then content is accessible, authors are prompted for any required accessibility information, accessibility checking is automatically performed or AT prompts authors to perform accessibility checking	A- WCAG A
B.2.2.1 Accessible Option Prominence	If authors are provided with a choice of authoring actions then options that will result in accessible content are at least as prominent as options that will not.	A- WCAG A
B.3.1.1 Checking Assistance	If the AT provides authors with the ability to add or modify web content in such a way that WCAG 2.0 success criterion can be violated, then accessibility checking for that success criterion is provided.	A- WCAG A
B.3.1.2 Helps Authors Decide	If AT provides accessibility checking that relies authors to decide whether potential web content accessibility problems are correctly identified, then the accessibility checking process provides instruction that describe how to decide.	A
B.3.1.3 Helps Authors Locate	If AT provides checks that require authors to decide whether a potential web content accessibility program is correctly identified, then the relevant content identified to the authors.	A
B.3.2.1 Repair Assistance	If checking can detect that a WCAG 2.0 success criterion is not met, then repair suggestion(s) are provided.	A- WCAG A
B.4.1.1 Features Active by Default	All accessible content support features are turned-on by default	A

ATAG 2.0 Success Criterion	Description of guideline	Level of compliance
B.4.1.2 Option to Reactivate Features	The AT does not include the option to turn off its accessible content support features or features which have been turned off can be turned back on.	A
B.4.2.1 Model Practice	A range of examples in the documentation demonstrate accessible authoring practices	A- WCAG A
B.4.2.2 Feature Instructions	Instructions for using any accessible content support features appear in documentation	A

Step 2. Techniques Used to Evaluate the Authoring Software. In the second step, the decision to use specific techniques such as an automatic evaluator tool or the manual evaluation by the researcher/target-user was based on the effectiveness of these respective methods for evaluating the aforementioned success criteria. The automatic evaluator tools were chosen for the success criteria that required that the authoring tool meet WCAG level A success criteria for conformance. The conclusions from the formative research by Vigo, Brown and Conway (2013) provided evidence supporting the use of automatic evaluators as capable of determining minimum accessibility guidelines and further reported that using more than one automatic evaluator increased the validity of the method.

Three automatic evaluator tools were ultimately chosen. Two of the automatic evaluators from the Vigo, Brown, and Conway (2013) study, AChecker and TAW, were used to evaluate WCAG 2.0 success criteria relevant to ATAG 2.0. AChecker was chosen for its higher score in correctness (true positives) and TAW was chosen for its higher scores in coverage and completeness. In addition, based on a recent study by Silva, Eler and Fraser (2018) that looked specifically at automated evaluator tools for mobile accessibility, the following iOS compatible evaluator was chosen: Mobile Accessibility Checker. Therefore, using AChecker, TAW, and

Mobile Accessibility Checker in conjunction covered more success criteria accurately and increased the validity of the assessment.

There were six ATAG 2.0 success criteria: B.1.1.2; B.2.2.1; B.2.4.1; B.3.1.1; B.3.2.1; and B.4.2.1.

To evaluate the ATAG 2.0 success criteria that did not require that the authoring tools meet the WCAG success criteria, the researcher performed a manual evaluation as the end-user target. The five success criteria manually evaluated by the author were B.3.1.2, B.3.1.3, B.4.1.1, B.4.1.2, and B.4.2.2. These success criteria were determined through simple yes or no answers, as there was little or no room for subjective interpretation as each criterion was either present or not present.

Step 3. Examining Usability. The final step in Phase III examined the usability of the MAR authoring tool to create accessible educational resources based on previously determined success criteria and compliance levels. The reports from all three automatic evaluator tools for all four authoring tools were synthesized and used to determine if the success criteria dependent on WCAG 2.0 level A conformance were met. The remaining success criteria were assessed by the researcher manually by using the ATAG 2.0 implementation guidelines and specific examples.

Research Journal Data Collection

Contemporaneously to the Phase III, step 3 of the evaluation data collection, I took notes and kept a Research Journal to record my thoughts and reactions while evaluating the usability of the authoring tools in the creation of accessible MAR content. Ortlipp (2008) describes the Research Journal as a recording of thoughts and ideas during an investigation that creates

transparency and contributes to the rigour of the research. The thick descriptions that I recorded not only described what was happening but also contextualized the data with subjective explanations. Additionally, Ortlipp demonstrates how a Research Journal can shape the outcome of the study as this specific Research Journal and research will reveal. Notes were typed directly in the iOS word processor Pages and were not edited.

Data Analysis

Data analysis involved analyzing the assessment data, the Research Journal Data and a supplementary analysis of the Research Journal as it connects with the assessment data.

Assessment Data Analysis

The assessment data were collected from the examination of authoring tools ARTutor, Blippar, HP Reveal, and Metaverse through the specific testing of selected success criteria of ATAG 2.0 established in Phase III, Step 1, and by specific methods shown in Phase III, Step 2. Appendix 3 and 4, respectively and in addition to the results, show the methodology of the manual evaluations and automatic tool evaluations.

Research Journal Data Analysis

The journal data were collected in an iOS word processor Pages with a tool that allowed commenting on specific parts of the text (Appendix 5). The text were analyzed thematically. As a novice researcher, thematic analysis was chosen as the method for data analysis due to its inherent usability for people new to qualitative research (Braun, Clarke, Hayfield & Terry, 2019). It only provides a method and not an approach for systematically analyzing data that can tie into theoretical issues. The purpose of the thematic analysis was to answer the complementary qualitative research question "How do the recorded notes of the researcher enhance the

understanding of assessing the usability of MAR authoring tools to create accessible distance education content for students with disabilities?". This thematic analysis was guided primarily by an inductive approach driven by what was actually in the data, but also deductively by drawing on the critical disability theory that informed this research. This analysis followed the six phases outlined by Braun et al. (2019) acknowledging that these phases are not always completely distinct.

Phase 1. Familiarize Yourself With the Data. As with all qualitative data analysis, my first step was to immerse myself in the data by reading and re-reading the text and reading it closely to focus on significant details and patterns. This was followed by using the comment tool in the word processor to actively explore what the data might mean.

Phase 2. Generating Initial Codes. I used the comments in the word processor and re-read the text to develop a mix of interpretive and descriptive codes. Each data item was initially coded by first identifying it and marking the associated text. Subsequent codes were identified by reading the subsequent text and determining if a new code was needed or not. The coding was modified throughout to incorporate new ideas as needed. After a thorough review of all the codes and associated text, everything was transferred to the iOS spreadsheet Numbers to help with the next phase.

Phase 3. Searching for Themes. As outlined by Braun, Clarke, Hayfield and Terry (2019), I reviewed the coded data and began to identify areas of similarities and links between the codes. Themes were then constructed by re-reading all the codes as they were grouped in the iOS spreadsheet Numbers found in Appendix 6. I made several passes through all the data, re-arranging the codes to find more links or new interpretations ubiquitously through the lens of the

research question: "How do the recorded notes of the researcher enhance the understanding of assessing the usability of MAR authoring tools to create accessible distance education content for students with disabilities?" Eventually, I determined 5 themes through which to interpret the data in a meaningful way. These included: "framework foundation";" defining disability"; "uses of MAR"; "current testing"; and guidelines" .

Phase 4. Reviewing Potential Themes. In order to ensure the quality of the themes analyzed, this phase was essential. The process by which the quality of each theme was ensured was based on my response the following questions suggested by Braun and Clarke (p. 65, 2019):

* Is this a theme (it could be just a code)?

* If it is a theme, what is the quality of this theme (does it tell me something useful about the data set and my research question)?

* What are the boundaries of this theme (what does it include and exclude)?

* Are there enough (meaningful) data to support this theme (is the theme thin or thick)?

* Are the data too diverse ad wide ranging (does the theme lack coherence)?

Finally, the whole data set was re-read and themes were re-examined and re-organized in the context of their importance as meaningful insights into the data as they relate to each other and the research question.

Phase 5. Defining and Naming Themes.

Each theme was then defined by its clear focus, scope and purpose. A few examples from the data were used to illustrate each theme and to develop an analytic narrative. Importantly, the themes were also connected to each other, the research question and any related scholarly works through this analysis.

Phase 6. Producing the Report. The final phase of the analysis merges the Research Journal analysis with the assessments of the four MAR authoring tools in their usability to create accessible distance education content for learner with disabilities to both assess and contextualize.

Supplemental Journal Data Analysis

Supplemental analysis of the Research Journal themes involved closely reading this thematic analysis or report to better perceive the connections and relationships between these themes. The close reading involved pulling out significant connections and recognizing patterns. This supplemental analysis was presented visually and formed a foundation for the proposed conceptual framework to assist in the creation of accessible MAR content for students with disabilities.

Ethical Considerations

There were no ethical issues as the study did not involve any human subjects except for the researcher. Written notification was sent to specific organizations that owned the authoring tool platforms that were evaluated and permission was given. The Research Journal contained quotes from published research papers and written concepts and ideas inspired by the research from the author. No personal information was shared.

Rigour of the Study

To ensure the rigour of this case study, I used a variety of strategies to increase the credibility, transferability, dependability and confirmability of the findings. For credibility, I tried to mitigate the effects of updated ATAG guidelines and/or updated or new authoring tools that could invalidate the results by defining the time period for the comparative evaluation and

subsequent researcher journal findings. Using a mixed method of both manual evaluations and three diverse automatic evaluator tools for assessing the accessibility of the authoring tools, validated the results found. Additionally, the use of the YouTube Uniform Resource Locator (URL) as a stand-in for the MAR content for all four of the authoring tools when some of the URLs available for the selected authoring tools were not sufficiently accurate affirmed the results from the automatic evaluators.

The thick descriptions that I provided in the methodology and the Research Journal for acquiring the data and determining the analyses helped ensure transferability because the details provided a step-by-step process for other researchers to follow. The thematic analysis that I used to analyze the results of the Researcher Journal contained several steps that pushed me to re-examine my themes and codes multiple times over an extended period. This process enhanced the dependability of the findings. Finally, confirmability was promoted through the use of the Research Journal which also acted as a reflexive journal to illuminate my thought-processes throughout this case study.

Summary

This chapter began with a description of the research design as case study evaluation research and then outlined how the objects or MAR authoring tools were selected for testing, followed by a description of the evaluator and the setting or distance education learning experience used to test the authoring tools. The focus of the chapter then proceeded to the instrumentation or tools used to carry out this research. As the instrumentation, Authoring Tool Accessibility Guidelines 2.0 were explained for validity and parsed for relevance. Finally, step-

by-step procedures were described for both the assessment and Research Journal portions of the study.

Chapter 4. Results and Discussion

This section presents the results and discussion of the assessment data analysis followed by the results and discussion of the Research Journal data analysis. The assessment results show the comparative examination of four authoring tools in their usability to create accessible mobile augmented reality content for distance education. As the data were collected for the evaluation, the Research Journal data were also produced. The Research Journal data were then thematically analyzed after the data analysis of the comparative authoring tool evaluations using thematic analysis. A supplemental and further analysis of the Research Journal themes, described the relationships and formed the basis for a proposed conceptual framework, found in Chapter V, for creating accessible MAR to benefit distance education students with disabilities.

Assessment Results

Each authoring tool (ARTutor, Blippar, HP Reveal, and Metaverse) was examined based on the same selected success criteria of ATAG 2.0. Results of satisfied or not satisfied were determined manually by the researcher (see Appendix 3) through the guidelines and examples provided by ATAG 2.0 and supplemented where necessary by the results from the three automatic evaluator tool reports (see Appendix 4). As displayed in Table 2, and explained further in Appendix 3, none of the authoring tools satisfied any of the selected ATAG 2.0 success criteria.

Table 2

Results of Evaluation of MAR Authoring Tools

Criteria	ARTutor	Blippar	HP Reveal	Metaverse
B.1.1.2: Content Auto-Generation	Automatic tools results: 241 WCAG 2.0 problems with content Manual results: • no prompts • no auto checks • no prompts for manual checking; NOT SATISFIED	Automatic tools results: 53 WCAG 2.0 problems with content Manual results: • no prompts • no auto checks • no prompts for manual checking; NOT SATISFIED	Automatic tools results: 71 WCAG 2.0 problems with content Manual results: • no prompts • no auto checks • no prompts for manual checking; NOT SATISFIED	Automatic tools results: 121 WCAG 2.0 problems with content Manual results: • no prompts • no auto checks • no prompts for manual checking; NOT SATISFIED
B.2.2.1 Option prominence	Manual results: • no accessible options were as prominent NOT SATISFIED	Manual results: • no accessible options were as prominent NOT SATISFIED	Manual results: • no accessible options were as prominent NOT SATISFIED	Manual results: • no accessible options were as prominent NOT SATISFIED
B.3.1.1 Checking Assistance	Manual results: • no automated checks • no semi-automated • no manual checks NOT SATISFIED	Manual results: • no automated checks • no semi-automated • no manual checks NOT SATISFIED	Manual results: • no automated checks • no semi-automated • no manual checks NOT SATISFIED	Manual results: • no automated checks • no semi-automated • no manual checks NOT SATISFIED

Criteria	ARTutor	Blippar	HP Reveal	Metaverse
B.3.1.2 Help Authors Decide	Manual results: • no instructions to ID accessibility problems were provided NOT SATISFIED	Manual results: • no instructions to ID accessibility problems were provided NOT SATISFIED	Manual results: • no instructions to ID accessibility problems were provided NOT SATISFIED	Manual results: • no instructions to ID accessibility problems were provided NOT SATISFIED
B.3.1.3 Help Authors Locate	Manual results: • no help given for locating accessibility problems NOT SATISFIED	Manual results: • no help given for locating accessibility problems NOT SATISFIED	Manual results: • no help given for locating accessibility problems NOT SATISFIED	Manual results: • no help given for locating accessibility problems NOT SATISFIED
B.3.2.1 Repair Assistance	Manual results: • no repair assistance NOT SATISFIED	Manual results: • no repair assistance NOT SATISFIED	Manual results: • no repair assistance NOT SATISFIED	Manual results: • no repair assistance NOT SATISFIED
B.4.1.1 Features Active by Default	Manual results: • no accessible features available NOT SATISFIED	Manual results: • no accessible features available NOT SATISFIED	Manual results: • no accessible features available NOT SATISFIED	Manual results: • no accessible features available NOT SATISFIED
B.4.1.2 Option to Reactivate Features	Manual results: • no reactivation of features possible NOT SATISFIED	Manual results: • no reactivation of features possible NOT SATISFIED	Manual results: • no reactivation of features possible NOT SATISFIED	Manual results: • no reactivation of features possible NOT SATISFIED

Criteria	ARTutor	Blippar	HP Reveal	Metaverse
B.4.2.1 Model Practice	Manual results: • no modelling of accessible practices given NOT SATISFIED	Manual results: • no modelling of accessible practices given NOT SATISFIED	Manual results: • no modelling of accessible practices given NOT SATISFIED	Manual results: • no modelling of accessible practices given NOT SATISFIED
B.4.2.2 Feature Instructions	Manual results: • no instructions on using accessible features NOT SATISFIED	Manual results: • no instructions on using accessible features NOT SATISFIED	Manual results: • no instructions on using accessible features NOT SATISFIED	Manual results: • no instructions on using accessible features NOT SATISFIED

Standards B.1.1.2, B.2.2.1, B.3.1.1, B.3.2.1, and B.4.2.1 criteria all relied on the MAR content created by each of the authoring tools to meet the minimum WCAG 2.0 requirements. This assessment was done using the three automatic evaluator tools (AChecker, TAW, and Mobile Accessibility Checkers). For example, success criteria B.1.1.2 Content Auto-Generation During Authoring Session results were analyzed through the examination of the three reports by the automatic evaluators. Problems with WCAG 2.0 success criteria were found under sections "perceivable," "understandable," and "robust" with the MAR authoring tool ARTutor by the three automatic evaluators. Therefore, the auto-generation by this authoring tool, ARTutor, did not meet WCAG 2.0 success criteria nor did it provide prompts, automatically check for accessibility nor provide prompts for author to check manually for accessibility. The conclusion

was that the success criteria B.1.1.2 Content Auto-Generation during Authoring Sessions was not met by the ARTutor authoring tool.

It was not possible to perform statistical analyses with any merit due to the floor effect and resulting lack of variance in the results. There is no nuance in terms of meeting the success criteria, the authoring tool either satisfies the criteria or does not. In the manual determination, the criteria is either present or not. While no authoring tool met the criteria for B.1.1.2, in terms of creating accessible MAR content based on WCAG 2.0, there were differences in the number of problems identified using the three automatic evaluators AChecker, TAW and Mobile Accessibility Checker (see Appendix 4). In this respect, Blippar had the lowest number of identified problems, with a total of 53, followed by Metaverse at 71, HP Reveal at 121, and finally ARTutor with the highest number of identified problems.

Assessment Discussion

The main finding in the examination of the assessment results is that none of the MAR authoring tools satisfied the selected ATAG 2.0 success criteria for accessibility for people with disabilities. Therefore, according to this study, the four authoring tools did not comply with ATAG 2.0 level A and would not necessarily provide accessible MAR content for distance educators. There are many possible explanations for this shortcoming, but predominant is that many mobile software programs are developed without deliberate thought to ensuring accessibility for people with disabilities (Krainz, Miesenberger & Freiner, 2018). This despite the fact that accessible information technology has been mandated by the U.S. government since 1998 and the international organization World Wide Web (W3C) produced its web content accessibility guidelines (WCAG) in 1999.

Unfortunately, the overall negative results of the evaluation does not allow any determination beyond the fact that none of the authoring tools would be useful in creating accessible MAR content. No authoring tool can be determined to be more useful than another in this study because the criteria were too stringent for the selected authoring tools to meet. As shown in Appendix 4, Blippar had the least identified problems meeting the WCAG 2.0 criteria using the three automatic evaluators, followed by Metaverse, HP Reveal, and finally ARTutor. However, despite these differences, no one authoring tool was ultimately more or less accessible according to the selected criteria. None of them met the minimum WCAG 2.0 level A criteria and consequently did not satisfy B.1.1.2 to auto-generate accessible content or any of the other criteria relying on the WCAG 2.0 minimum accessibility criteria.

Instrumental to this study is the choice I made to focus on the ATAG 2.0 guidelines that guided and supported authors in making accessible content. Authors prefer to be guided to resolve accessibility issues (Elias, James, Lohmann, Auer & Wald, 2018). The selected guidelines were based on my preferences as a target user with little experience, to be assisted in the creation of accessible MAR content for distance education students. In other words, the authoring tool supported and guided the authors in generating expert-level accessible content. It was in these guidelines, that the authoring tools were found to be lacking.

Part of the assessment for several of the success criteria were based on whether the web content created met WCAG 2.0 level A. This was true for the following success criteria: B.1.1.2, B.2.2.1, B.3.1.1, B.3.1.2, B.3.1.3, and B.3.2.1. Each subsequent success criterion built on the previous criteria, so that if the WCAG 2.0 level A was not met in the actual MAR content created, and the author did not deliberately ignore the AT guidance, then I had to conclude that

these aforementioned guiding success criteria (B.1.1.2, B.2.2.1, B.3.1.2, B.3.1.3, and B.3.2.1) were also not met. Otherwise, accessible MAR content would have resulted as the final product.

Therefore, it is important to investigate how the three automatic tools (AChecker, TAW and MACS) only evaluated the specific URLs to determine if the authoring tool satisfied WCAG 2.0 level A criteria. For example, in the case of the authoring tool HP Reveal, only the URL of the home page was able to be evaluated and no portion of the authoring tool's editing mode. This limitation calls into question the validity of the accessibility assessment: How could an authoring tool's URL be evaluated as "not satisfying" the WCAG 2. level A if the correct URL was not available to the researcher? To remedy this potential issue, the three automatic tool WCAG 2.0 level A assessments of the YouTube URL could be used in substitution as each scenario for each authoring tool included an overlay of the animation found at the YouTube URL. This assessment process is explained in detail in Appendix 4. Additionally, I did not specifically include closed captioning or an audio description while making the video augmentation, therefore, none of the AR content met the success criteria of 1.2.1 Audio-only and Video only, 1.2.2 Captions (Prerecorded), and 1.2.3 Audio Description or Media Alternative. This constraint was also detailed in Appendix 4.

Throughout the examination of the four authoring tools, I realized the limitations of the ATAG 2.0 guidelines. Since 2015 when ATAG 2.0 was published (W3C), mobile technology has advanced and become even more ubiquitous **(**Robinson, Pearson & Jones, 2018**).** Additionally, certain disabilities were not addressed in WCAG 2.0 that ATAG 2.0 references. A Cognitive and Learning Disabilities Accessibility Task Force has since been created by W3C to address these unrecognized disabilities and guidelines are currently being proposed and explored. Thus, I

considered emerging guidelines for mobile devices, cognitive and learning disabilities, and mobile augmented reality **(**Silva, Eler & Fraser, 2018) while examining the four authoring tools.

Based on these emerging guidelines and emphasis on user control and error-tolerance for MAR, Blippar offers the most user options and is the most error-tolerant and most accessible, followed by ARTutor, then Metaverse, and finally HP Reveal. The latter offers the least user control and is the least error-tolerant and least accessible for students with disabilities. These emergent guidelines and emphasis on user control and error-tolerance were further explored in the analysis of the Researcher Journal. Important to note is that while this study was taking place in April 2019, the HP Reveal Studio became unavailable with promises of a new mobile augmented reality authoring tool to be revealed in August 2019. It is possible that HP Reveal may address these accessibility shortcomings in their future software.

Research Journal Results

The Researcher Journal was examined to contextualize data to enhance the understanding of the usability of the selected MAR authoring tools in the creation of accessible content for students with disabilities in distance education. Notes were taken throughout the process of the assessments to illustrate both the steps taken and the thoughts, criticisms and questions that the researcher had during this time of examining MAR authoring tools using ATAG 2.0.

The analysis followed the five phases of Braun and Clarke (2019) for thematic analysis as outlined in the previous methodology chapter. Twenty-six codes were identified and then further grouped and constructed into five themes: current; framework foundation; defining disability; uses of MAR; and principles. Appendix 6 provides a spreadsheet showing the data points, codes

and themes, and how they interrelate. Table 3 shows the 26 codes as they relate to the five overall themes.

Table 3

Results of Thematic Analysis of the Research Journal

Theme	Description	Codes
Current Testing	What the researcher did to evaluate the MAR authoring platforms	1. Creation of MAR 2. Operating MAR 3. results of test- automatic tool 4. results of test-manually 5. ways to test- accessibility experts 6. ways to test- automatic tool 7. ways to test- critique 8. ways to test- novice end-user
Framework Foundation	The researcher's guiding research paradigm	1. accessibility for all/UDL critique 2. Critical Disability Theory 3. Exploring Conceptual Framework
Defining Disability	The researcher's thoughts on how to define disability in the context of MAR	1. Defining barriers 2. Defining disability 3. Disability not in WCAG 2.0 4. Function Impairments= Cognitive Disability
Uses of MAR	The researcher's thoughts on how MAR can be used effectively in DE	1. MAR as a tool 2. MAR for learning 3. MAR in evaluation 4. MAR match to disability

Principles	The potential principles for a framework that would help distance educators create accessible MAR content.	1. Accessibility check 2. Ideas for Guidelines-impairments 3. Ideas for Guidelines-mobile devices 4. Ideas for Guidelines-MAR 5. user control

The following is an elaboration on Table 3 as well as a synopsis of that comprehensive spreadsheet that highlights specific codes and data points to show how they related to the five themes.

Theme 1: "Current Testing": How and What Was Found

The Research Journal had several passages relating to this theme because this activity was the primary action of the researcher throughout the time of the journaling. Nine codes were linked to this theme and included how the testing was done "creating MAR" or "operating MAR," the specific methods such as "ways to test: automatic tool" or "ways to test: novice end-user," and finally the results of the evaluation, which included codes like "results of test: automatic tests" and "results of test: manually". Throughout these data points and specifically within this theme, I wrote specific criticisms of the evaluation process, which are captured under the code "ways to test: critique." This theme contained the main process of the research and illuminated my thoughts and more specifically the criticisms on the process. Codes in this theme were divided into three sub-themes: creating/operating; ways to test; and results.

Creating/Operating. As part of this sub-theme, I included step-by-step instructions of how each of the MAR contents were created by each of the respective authoring tools. Sample entries included "I was able to do a screen capture and copy and paste the QR code into the

document about the experiment…. therefore it functions in a very similar way…" Most of these passages were simply a recording of what I did to create the scenario for the evaluation.

Ways to test. I examined the ways in which the MAR authoring tools could be evaluated. I named, contextualized, and criticized the various methods, such as is shown in the following passage:

What about the total user experience? The guidelines don't consider that AR is the relationship between online or virtual and real-life…. it is not one or the other so ATAG is inherently inadequate… nothing currently exists to provide a framework or guide to help developers and/or educators.

Critiques of the process are noted as I began to analyze the methodology and results.

Results. Not all of the results or even the majority of the results of the usability assessments were listed in the Research Journal, but the results determined manually were. These noted manual results highlights the inadequacy of the assessment process. An example of such a note was "Hard to read video…and text…… you can connect with the target at a different orientation though… no closed captioning…" This note illustrates that I felt that certain aspects of the MAR content needed to be evaluated despite not being included in ATAG 2.0

Theme 2: "Framework Foundation": Theories and Structural Concepts

While the notes were not as frequent as in the previous theme, and only contained three codes, this theme was significant as it outlined the guiding research paradigm and a framework for this research.

"**Accessibility for All"/UDL- Critique and "Critical Disability" Theory.** These were two interrelated and repeated codes within this theme. An excerpt from my Research Journal

that provided insight into the interrelationship of the two identified codes was "the push to create something that helps everyone is a great marketing tool as in Universal Design and also Universal Design for Learning but the focus should be for people with disabilities because they are the ones limited in education- in this context." It demonstrated my specific focus and goals in the development of this framework.

Exploring Conceptual Framework. This was the most frequent code in this theme and it revealed my thought process on how a framework could be constructed. The following passage was included in this code: "I think a framework that looks at AR currently and the real-benefits for people with certain impairments… matched with the characteristics of the technology that benefit in certain areas of learning… is a good place to start… with follow-up in areas that should be further explored." While there were varying notes that fell within this code, all referenced the potential construction and basis of the framework.

Theme 3: "Defining Disability": What Does This Mean in the Context of MAR?

There were four codes that coalesced under the theme of defining disability. This theme had the fewest number of research notes, but they provided insight into my thoughts on how to define disability in the context of mobile augmented reality. To illustrate this theme, the following codes were highlighted: defining barriers, disability not in WCAG and function impairments=cognitive disability.

Defining barriers. This code was repeated only a few times, but it showed my interest in addressing not only physical barriers, but societal or "invisible" barriers in distance education as it related to evaluating the usability of authoring tools to create accessible MAR content. It is exemplified in the following passage:

BUT the cognitive, learning and psychiatric disabilities are disabilities that also have stigmas … as people who are weak or "less-then" or not even believed…. they are the "invisible" disabilities and many students do not advocate for themselves or even communicate their disabilities to others in a education situation.

Disability not in WCAG 2.0. This code captured my search for meaning in the definition of disability as it relates to creating accessible MAR content using authoring tools and notably that the international guidelines of WCAG 2.0 were not comprehensive enough. Several data points demonstrate this concern including this one: "Certain aspects of learning/cognitive disabilities are not included in ATAG… and no psychiatric disabilities."

Function Impairments = Cognitive Disability. I wrote a lot about the concept of functional impairments as it related to cognitive disability and how to define disability within that context. In this theme, this code was the most frequent in the Researcher Journal. The following is an example of this code:"The research describes challenges in the areas of attention, executive function, knowledge, language, literacy, memory, perception, and reasoning." I grappled with how to define disability in the context of MAR and explored the idea that it is the function of the person that is limited, not the person.

Theme 4: "Uses of MAR": When and How to Use MAR Effectively?

This theme contained only four codes with the most repeated code being "MAR for learning." This code along with the other codes "MAR as a tool," "MAR in evaluation," and "MAR match to disability" explored my thought processes in terms of how MAR can be used effectively in distance education based primarily on studies and research that I had read.

MAR for learning. As illustrated by this quote, "Best ways to use AR in distance education for accessibility—— multi-modal learning, authentic situations and theoretical concepts," I discovered and determined how to construct a framework that would be effective in terms of the characteristics of MAR technology, the learning scenarios in distance education, and the students with disabilities who would most benefit from accessible MAR.

MAR Match to Disability. I noted this topic specifically as a way to ensure that MAR was used effectively. A sample passage was "Some disabilities are more compatible with augmented reality such as hearing impairment….. autism, cognitive disability and learning disability…."

Theme 5: "Principles": How to Enhance MAR Accessibility for DE

This theme contained the second largest number of notes in the Research Journal and was the culminating theme. It explored the potential principles for a framework that distance educators could use to create accessible MAR for students with disabilities. There were five codes found in this theme and all centered on directions to create more accessible MAR for distance education.

Accessibility Check. This frequently repeated code drew attention to the existing guidelines in ATAG 2.0 that recommended having accessibility features and prompts. I noted this topic and referenced that many distance educators did not have the expertise to create accessible MAR content on their own. This idea was reflected in the following passage:

Many educators aren't familiar with accessibility considerations- or don't automatically consider them. Training is useful but a program/tool/platform that allowed you to produce products as an expert in accessibility issues would be ideal.

Ideas for Guidelines. Three codes were associated with this particular code and they are *impairments, mobile devices* and *MAR*. All three explored ideas for guidelines that could lead to more accessible MAR, but each code focused on a specific aspect.

"*Impairments*" covered a wide-variety of notes that referenced various impairments and guidelines that could potentially remove barriers for these impairments. The following note suggested guidelines that could help remove barriers for people with cognitive disabilities: "cognitive disabilities (tutorial, playground mode, level difficulty, intuitive menus, perspective, customization, context guidance)"

"*Mobile devices*" did not reference any impairments, but instead was directed at the technical aspects of a mobile device and guidelines for that technology. "Accessibility practices were used in development of mobile devices— aspect ratios, awkward keyboards, font, colors, simplifying pages… mobile phones and assistive devices…" is a note that reflected potential mobile device guidelines.

Similarly, "*MAR*" keyed into the unique characteristics of mobile augmented reality for accessibility as found in the following passage:

Interaction and Input controls: voice control and recognition, motion and gesture recognition, eye and head tracking, keyboard/controller, sensor, mobile device as input for other devices… IE. motion control and motion through space…. maybe you don't need to move the mobile.

This note demonstrated the specific MAR characteristics that linked reality and virtual reality.

User Control. While not frequent, this code was unique because it represented my discovery that user control was determinative in the accessibility of MAR.

"The more control you had over the MAR, the better this seems for accessibility" is an example of a note in this code. It did not fall under any other code topic, but was important to highlight because of its perceived usefulness in the creation of a framework for distance educators interested in creating accessible MAR content.

Research Journal Discussion

The goal of the research journal was to use the recorded thoughts of the researcher to enhance the understanding of the assessment process of the MAR authoring tools for their usability in creating accessible distance education resources. This exhaustive exploration took place while the four selected authoring tools were being examined. It deepened my understanding of accessibility as it related to MAR in distance education. The simple act of recording my thoughts was helpful, but this intense and comprehensive thematic analysis forced me to examine aspects that I might not have otherwise registered at a conscious level. In addition to the actual process of examination, the Research Journal reflected my comprehensive readings, research, discussions, and ideas with respect to this topic. All of the research notes were generated by me so the analysis is inherently subjective. However, this subjectivity does not preclude the validity of this thematic analysis (Kiernan & Hill, 2018).

Summary

This chapter provided the results and a discussion of both the authoring system assessment and research journal analysis in this case study. The comprehensive analysis of the guidelines and the results of the automatic evaluator tools are provided in the appendices. Specific aspects are highlighted to help illustrate the results. Subsequently, the thematic analysis of the researcher journal revealed five themes. For each theme there is a synopsis of the theme

and codes and data are used to highlight and reinforce the information. The comprehensive themes, codes and data points are all found in the appendices for reference purposes.

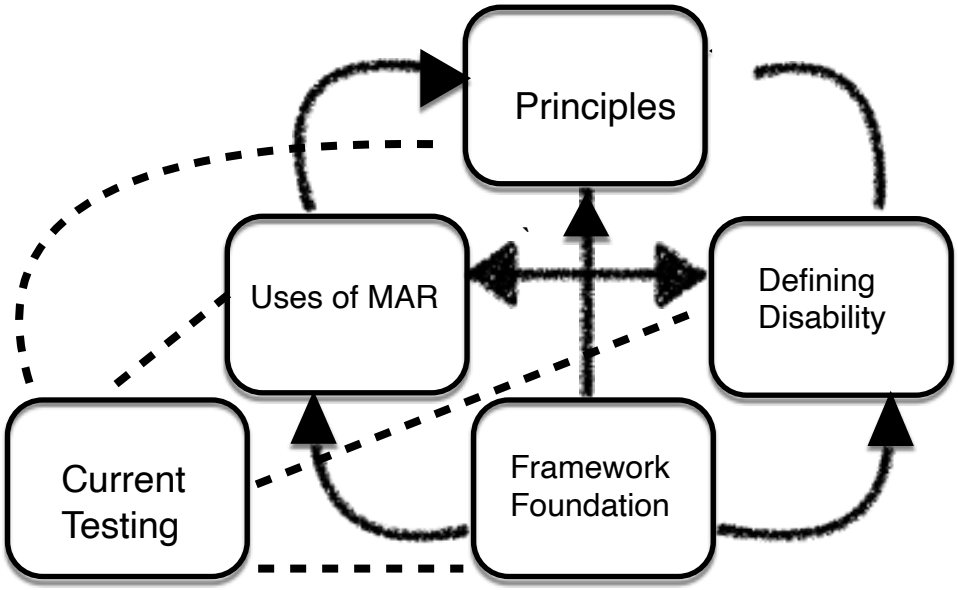
Chapter 5. Conceptual Framework for MAR to Benefit Students with Disabilities in DE

After exploring the comparative assessment results and the research journal results, a conceptual framework for using accessible MAR in distance education evolved. This conceptual framework includes the foundational critical disability theory, the definition of disability in the context of MAR, the most effective uses of MAR, and the specific guidelines to help distance educators create accessible MAR.

After analyzing the five themes and exploring the results of the Research Journal thematic analysis, a natural progression and relationship developed between and among the themes. Figure 2 illustrates these relationships. The first theme, *current testing,* and the data from this theme influenced all the other themes; *framework foundation*, *defining disability*, *uses of MAR* and *principles* and these themes reciprocally affected *current testing*. Its location at the bottom of the figure shows this influence. There was a back and forth of effect between this theme and the others that is depicted by the broken line connecting this theme to the four others.

Figure 2

The Relationships Between the Themes Found in the Research Journal Analysis.



Framework foundation was the next theme identified and it is also found at the bottom of the figure to emphasize its foundational determination on the three subsequent themes. Strong arrows also show how this theme directs the remaining themes and reciprocal arrows are absent to show the absence of influence on the *framework foundation*.

The themes of *defining disability* and *uses of MAR* are lined up together above *current testing* and *framework foundation* themes. As previously mentioned, these two themes (*defining disability* and *uses of MAR*) were heavily influenced by *framework foundation*, and additionally, they leveraged each other and together both carried weight with the final theme of *principles*. All the arrows show the influence of the previous level and as each level reinterprets the previous level of themes, the final level is influenced by all the previous levels. The results of each of these themes and their relationships to each other are discussed below, leading to the final product of this analysis: a conceptual framework for MAR benefiting students with disabilities in DE.

Current Testing

The *current testing* theme informs the other themes in that the process and especially the critique of that process was reflected in the subsequent themes: *framework foundation, defining disability, uses of MAR* and *principles*. The contents of the Research Journal show my thought process in terms of creating MAR content, the ways in which the authoring tools were evaluated, and the results of that evaluation.

My notes revealed my criticism of the ATAG 2.0 guidelines and its inability to accurately capture the interplay between reality and virtual reality that is characteristic of mobile augmented reality. Also found in my notes, were my criticism of its inability to reflect the characteristics of

mobile devices and specifically cognitive disabilities. These criticisms were also reflected in the *defining disability* theme and importantly in the *principles* theme. Throughout the conceptual framework, the *current testing* theme was not reflected specifically, but as a starting point to examine MAR content accessibility for students with disabilities in DE.

Framework Foundation

The *framework foundation* theme, as reflected in its title, is the foundation for all the remaining themes. The entries found within this theme reflect both the guiding research paradigm and ideas about how to construct the conceptual framework. The extensive data surrounding the exploration of conceptual frameworks helped me to define, delimit, and structure this conceptual framework for MAR to benefit students with disabilities. Ideas about theoretical foundations, definitions, and guiding principles all provided the structure for this conceptual framework.

Within this theme, many passages also demonstrated a critique of the "universal design for all" approach that is found in other frameworks and guidelines, in that it does not always recognize the societal barriers by which many with disabilities are marginalized. A concern is that once the issue is depicted as everyone being on the spectrum of disablement then the rights of people with disabilities could be diluted (Goodley, 2019). An alternative to these approaches is found in the Critical Disability Theory reviewed in Chapter 2 and referenced numerous times in the Researcher Journal. This theory served as an organizing construct for the research by recognizing that a societal transformation was necessary to create equity for students with disabilities in distance education. As a foundational influence, Critical Disability Theory serves as the first point of the conceptual framework for MAR to benefit students with disabilities in DE.

Defining Disability

An important aspect of the conceptual framework for MAR benefiting students with disabilities in DE is the definition of disability in this context. My notes revealed that I found both the physical and societal barriers important to recognize as disabling. Illustrated in Figure 2, the *defining disability* theme was guided by the *framework foundation* theme and its underpinning of the Critical Disability Theory. The *defining disability* theme critiqued the lack of reference to learning and cognitive disabilities in WCAG 2.0 and ATAG 2.0 that I used to examine MAR accessibility. I concluded that disability in the context of MAR for students with disabilities must include physical, sensorial and also cognitive disabilities. Importantly, these cognitive disabilities are explored as function impairments which served to broaden the number of students with disabilities that might benefit from MAR in distance education. The synthesized results from this theme, *defining disability*, worked together to form the definition of disability for this conceptual framework. This theme, *defining disability*, and the following theme of *uses of MAR*, strongly affected each other and consequently the guiding principles.

Uses of MAR

The final influence on the guiding principles of the conceptual framework of MAR benefiting students with disabilities in DE is the penultimate theme- *uses of MAR*. This theme directly impacted the guiding *principles* theme but also the *defining disability* and it was itself impacted by the *framework foundation* theme. In order to benefit students with disabilities, the most effective uses had to be identified. Throughout the Research Journal there are MAR references to benefits in learning, matched to disability, as a tool and in evaluation. All four of these codes provided information regarding how MAR could be used and evaluated in its use.

The focus of the conceptual framework pinpointed the ways that MAR assisted students with disabilities in learning through multimode presentations of information, interactions, authentic and conceptual learning. Further to this point, specific disabilities were identified that were best able to take advantage of these learning opportunities based on the opportunities and limitations of the current mobile augmented reality technology. While useful, the ways that MAR was used for evaluation, and as a tool for therapy was not addressed in this conceptual framework because of the limitations and lack of research in distance education applications.

Principles

Concluding this discussion of the results of this study, was the theme *principles* which encompassed notes relating to accessibility checks, ideas for guidelines relating to impairments, mobile devices, MAR, and user control. All of the aforementioned four themes have had direct or indirect impacts on this final theme. A repeated note is the importance of having an accessibility check that can help create accessible MAR content worthy of an expert in the field. Similarly, various ideas for guidelines were mentioned that are well-matched to address specific impairments or barriers to distance education for students with disabilities. MAR differs from augmented reality in that it works through a mobile device. Guidelines that help reduce barriers inherent in mobile devices and MAR technology were also identified. The synthesis of this data provided the guiding principles for the conceptual framework of MAR benefiting students with disabilities in DE.

The following proposed conceptual framework was the result of a supplemental analysis of the thematic analysis from the Research Journal described in the above text.

Conceptual Framework for MAR to Benefit Students with Disabilities in DE

Critical Disability Theory

Critical disability theory provided the foundation for this conceptual framework. A key component of this theory was that people with disabilities are acknowledged very specifically. There was a recognition of the systemic power dynamic between people who have disabilities and people who do not. Historically and throughout the world, people with disabilities have been marginalized. Actual biological disabilities, personal experiences of students with disabilities, and socially constructed disadvantages all play a role in the disabling of certain students in distance education. Students with disabilities in a distance education setting were intentionally considered along with the specific barriers to their education in the context of this framework.

Definition of Disability

Continuing from the foundational Critical Disability Theory, the definition of disability in this conceptual framework reflected the student's disability to perform functions related to MAR in a distance education environment that acknowledges physical, institutional, and attitudinal barriers. In addition to physical and sensory impairments such as sight, hearing, mobility, and dexterity, as addressed in WCAG 2.0 (W3C, 2012), this definition also includes cognitive impairments related to the functions of attention, executive function, knowledge, language, literacy, memory, perception, and reasoning. A variety of disabilities may affect these cognitive functions including age-related cognitive decline, aphasia, ADHD, autism spectrum disorders, intellectual disabilities, dyscalculia, dyslexia, depression, anxiety and other psychosocial disabilities currently discussed in the Cognitive and Learning Disabilities Accessibility Task

Force (W3C, 2019). How the students with disabilities performed the various functions of MAR in a distance education environment was considered key based on the International Classification of Functioning, Disability, and Health by the World Health Organization (2018) examined in the Research Journal. However, it is important to note that this thesis research study did not address students' performance of MAR functions, but was limited to the usability of selected authoring system to create accessible MAR.

Effective Uses of MAR

The need to identify the most effective ways that MAR can be used in distance education for students with disabilities was essential to this conceptual framework. While there are many studies that outline the beneficial uses of MAR in an educational setting (e.g., Ozdemir, Sahin, Arcagok, & Demir, 2018), this framework looked at the specific benefits to students with disabilities in a distance education. The following MAR uses have been identified in terms of addressing disabling barriers according to notes appearing in the Research Journal: multi-modal presentations and assessments, interactions, authentic and conceptual learning. These notes referenced the research of Tesolin and Tsinakos (2018), which identified these strategies for using MAR to address barriers that students with disabilities face in distance education. Certain disabilities and their related barriers to specific functions were better matched to these uses than other disabilities and functions. For example, barriers to the function of hearing were well-matched to MAR content as mobile devices act as an assistive tool to provide closed captioning and written audio descriptions along with providing alternative ways of receiving and relating conceptual information such as videos or animation. Similarly, attention, memory, and perception are functions stemming from cognitive disabilities that were well-matched to MAR

content. MAR content can draw attention to a concept in a unique and realistic way and repeat information in a variety of forms that would key into attention and memory issues. Finally, in the current form of MAR content, limitations of functions related to dexterity and vision, were not well-matched. MAR currently relies extensively on visual stimulus to link virtual reality to reality in a very specific way. Eventually, this technology may evolve to be better matched to address more forms of disabilities.

Principles

Three principles were synthesized from a variety of sources in the Research Journal to establish a standard on which to create accessible MAR content for students with disabilities in distance education. These principles were informed by the critical disability theory, definition of disability, and the identification of the most effective uses of MAR content. Examples of guidelines are found throughout the three listed principles.

Principle 1. Provide Accessibility Features, Prompts, and Suggestions.

This principle is essential for distance educators interested in creating accessible MAR content. Few distance educators have the expertise to automatically create accessible MAR content so authoring tools should all emphasize accessibility features, prompts and suggestions. This would include prominent accessibility features, prompts, questions or checks on accessibility issues and finally suggestions to repair accessibility issues that matched sensorial, physical and cognitive impairments. These aspects would ensure that content was always developed with accessibility in mind and would result in expert-level accessible MAR content.

Principle 2. Increase User Control.

Students with disabilities must have the ability to control MAR in terms of presentation, but not content. This control would include changing the orientation of mobile device, and the ability to scale (zoom), change colours/brightness, slow down, repeat, pause, rewind, or fast forward MAR content. Related to this user control is built-in delay and error tolerance in terms of interactive elements so that results are what the user wanted. Error-tolerant interactive elements are preserved by ensuring that required gestures are easy to carry out and interactive elements are large enough and surrounded by an inactive space. Other aspects of user control include being able to adjust the level of difficulty or offer multiple levels of mastery and provide appropriate and relevant feedback as needed in a MAR activity. Anything that is out of the user's control limits accessibility

Principle 3. Simplify Design.

By providing a clear and consistent design, MAR content becomes accessible to a greater number of distance education students. Navigation on a mobile device where different pages are uniquely identifiable should be easy to understand for all students. All important information should be perceivable without scrolling, and text and images should be limited so that confusion is minimized. Finally, any actionable elements (including touch targets) should be highlighted and clearly distinguishable in the design and show change when used.

Table 4 provides examples of specific guidelines that could help distance educators create accessible MAR content related to three principles.

Table 4

Principles and Guidelines for Creating MAR Content

Principle	Guidelines
Provide accessibility features, prompts, and suggestions	1. Provide prominent accessibility features that conform to WCAG 2.1 at a minimum and address physical, sensorial and cognitive disabilities. 2. Provide accessibility prompts that conform to WCAG 2.1 at a minimum and address physical, sensorial and cognitive disabilities. 3. Provide suggestions to repair accessibility problems so that content conforms to WCAG 2.1 at a minimum and address physical, sensorial and cognitive disabilities.
Increase user control	1. Provide user control over mobile device orientation and content such as sizing/zoom, brightness, colours, and MAR products such as videos/animations and 3-D images 2. Provide user control to ensure that results are what the user wants. This includes error-tolerance and time-delay mechanisms. 3. Provide user control over level of difficulty and feedback
Simplify design	1. Provide a clear and consistent design that leads to easy navigation for all learners. 2. Limit scrolling, text and images to only what is important and necessary. 3. Provide distinguishable change when actionable items are used.

Summary

This chapter provided a description of the supplemental analysis of the Research Journal that synthesized the themes to form the basis of the conceptual framework to assist distance educators in creating accessible MAR content. Initially the critical disability theory was examined as the foundation for this framework, followed by definitions of disability and an examination of the most effective uses of mobile augmented reality for people with disability. Finally, the principles for this framework were described culminating in a table with the principles and associated guidelines.

Chapter 6. Conclusions and Recommendations

There is much to be gained by this case study evaluation that examined authoring tools and their potential to create accessible MAR content for students with disabilities in distance education. The diverse data collected and analyzed in this case study provided guidance as to the accessibility of selected authoring software, and showed deficiencies in the standards used to assess the ability to create accessible content. The research journal data gathered contemporaneously to the assessment of the MAR authoring tools revealed a thematic analysis that subjectively considered this assessment. Supplemental to this thematic analysis of the Research Journal, a conceptual framework for guiding MAR creation benefiting students with disabilities in distance education was proposed based on a further analysis and synthesis of thematic connections. The case study revealed that no existing authoring tools within the limitations and delimitations of the study were equipped to create fully accessible MAR content by distance educators. Among the four authoring tools, none provided prominent accessibility features, checks, prompts or suggestions for repairs that could have assisted novice users like myself in the creation of expert-level accessible MAR content. This is an important consideration as many distance educators lack the training and expertise in this area and institutions have not or cannot invest in this training.

There were differences in performance within the four examinations of the authoring tools: ARTutor, Blippar, HP Reveal and Metaverse, While each authoring tool was evaluated using the ATAG 2.0 criteria, other characteristics were commented on in the Research Journal that related to new and emerging guidelines for mobile devices, cognitive and learning disabilities, and even mobile augmented reality specifically. These new guidelines were

ultimately reflected in the following three guiding principles for creating accessible MAR: 1) provide accessibility features, checks and suggestions; 2) increase user control; and 3) simplify design found in the proposed conceptual framework. Distance educators, administrators and software developers can use these results when making choices for accessibility in MAR technologies for distance education.

Additionally, the case study also drew upon my thoughts on the examination of the authoring tools and the subsequent analysis of the Research Journal, which might prove to be even more valuable. The unedited Research Journal was thematically analyzed through comprehensive study that eventually led to five main themes on which to focus. The thematic analysis along with the analysis of the authoring tools were then synthesized into a proposed conceptual framework for MAR creation benefiting students with disabilities in distance education. This case study evaluation and supplemental conceptual framework may serve as tools for educators, administrators, software developers, and even students with disabilities themselves in order to reduce stigma and physical barriers in distance education.

Recommendation for Further and Future Research

One potential avenue for further research could involve improving this case study evaluation. Assessments that incorporated different or more Authoring Tool Accessibility Guidelines that better reflected the overall accessibility of the authoring tools could provide more insightful and useful results. I was limited by my lack of experience in terms of both heretics or usability assessment experience, accessibility assessment experience and technical experience. Additionally, new guidelines that reference other functional disabilities will soon be incorporated into the Web Content Accessibility Guidelines and subsequently Authoring Tool Accessibility

Guidelines. It is also possible that new automatic evaluators will be more effective and incorporate these new guidelines. All of these updated considerations could greatly improve the applicability and usefulness of the results.

Future research with respect to distance educators and their use of MAR technology in general but specifically as it applies to students with disabilities could also prove enlightening. Mobile Augmented Reality could be studied as it relates to students with specific disabilities both for students with disabilities who have historically benefited from distance education and for students with disabilities who have historically been marginalized in distance education. Studies that could also be insightful in addressing barriers for students with disabilities would comprise the role of software developers in their creation of accessible MAR technology. The supplemental proposed framework could be explored with research examining one or more of the proposed principles. Ultimately, accessibility as it relates to mobile augmented reality in distance education is definitely lacking and any research on this topic would contribute to the literature.

Tools and resources are needed for distance educators to assist them in using mobile augmented reality to benefit all students but specifically students with disabilities. New technologies can be exciting and motivating for all learners in distance education but most educators lack the expertise to implement these new technologies so that students with disabilities are not restricted in their participation. The results of the study and the supplemental proposed conceptual framework begin to address this problem.

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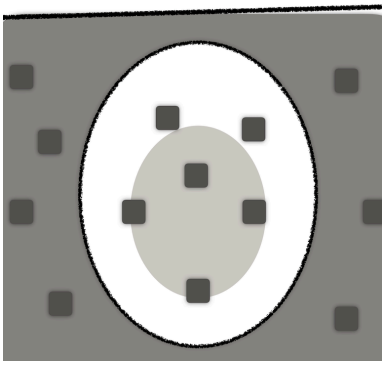


Appendix A: Osmosis Egg Experiment

Purpose:
To determine the effects of osmosis on cells with semi-permeable membranes submerged in two different osmotic environments (**hypertonic** solution and **hypotonic** solution).

Materials:
* 2 eggs
* 2 glasses (must fit egg plus liquid)
* household vinegar (2 cups)
* distilled water (2 cups)
* light corn syrup (1 1/4 cups)
* Sticky notes/masking tape and pencil

Procedure:
1. Place one egg in each glass. Pour in enough vinegar to cover each egg.
2.Allow the two glasses to sit for 24 hours.
3. Gently holding the egg in the glass, pour out the old vinegar.
4. Replace with fresh vinegar, and let sit for another 24 hours.
5. Repeat this process until the shells are fully dissolved (2-3 days)
6. Gently remove the eggs using the slotted spoon.
7. Rinse with tap water in the sink. Rinse out the empty glasses as well.
8. Gently put the shell-less eggs aside on a plate.
9. Prepare first glass with one cup of light corn syrup.
10. Label first glass “**Hypertonic**”
11. Prepare the second glass with one cup of distilled water.
12. Label 2nd glass “**Hypotonic**”
13. Gently put a shell-less egg in each of the glasses, and let sit for 24 hrs.
11. Gently put the eggs on a plate. Observe and record the differences.

Table 1.0 The results of the osmosis egg experiment

Solution	Before submerging	After Submerging
Hypertonic		
Hypotonic		

Appendix B: ATAG 2.0 Part B

Implementing Principle B.2: Authors are supported in producing accessible content

Implementing Guideline B.2.1: Ensure that accessible content production is possible. [Return to Guideline]

Rationale: To support accessible web content (WCAG) production, at minimum, it is possible to produce web content that conforms with WCAG 2.0 using the authoring tool.

Implementing Success Criterion B.2.1.1 Accessible Content Possible (WCAG):

The authoring tool does not place restrictions on the web content that authors can specify or those restrictions do not prevent WCAG 2.0 success criteria from being met. (**Level A** to meet WCAG 2.0 Level A success criteria; **Level AA** to meet WCAG 2.0 Level A and AA success criteria; **Level AAA** to meet all WCAG 2.0 success criteria)

Return to B.2.1.1 in Guidelines

Intent of Success Criterion B.2.1.1:

The intent of this success criterion is to ensure that authors who have the motivation and knowledge to create more accessible web content using an authoring tool are not prevented from doing so by restrictions in the actions that the authoring tool allows them to perform. The subsequent success criteria in Part B will build on this minimal requirement.

Note that the term "restricted" is not intended to have any negative connotation. Authoring tools usually restrict web content authoring in order to simplify the production of content that is in fact complex and technical. The accessibility implications of the restrictions may be positive or negative and need to be considered case by case:

Examples of unrestricted authoring:

1. source code editor: authors can type whatever they like (e.g.)
2. WYSIWYG editor for HTML4: the "Insert Image" dialog includes all of the HTML4 attributes for <img>.

Examples of restricted authoring that does not prevent WCAG 2.0 success criteria from being met:

1. WYSIWYG editor for HTML4: the "Insert Image" dialog includes just some of the HTML4 attributes for <img>, but alt and longdesc are included in the subset.
2. CMS: authors can only add images that they have previously uploaded to their "Asset Manager". While alternate text and long description do not appear as options when they choose images from the "Asset Manager" to include on a page, they can add/edit these values at any time within the "Asset Manager".

Examples of restricted authoring that prevents WCAG 2.0 success criteria from being met:

1. WYSIWYG editor for HTML4: the "Insert Image" dialog has only one field "source". There is no possible way to add other attribute values, including for the alt and longdesc attributes.
2. CMS: to be saved, each page of content must have a main title, but when the author provides text for the title it is marked up with presentation markup rather than appropriate header markup.

Unrestricted authoring tools entail less author guidance and therefore may allow the introduction of more accessibility problems than authoring tools with restrictions that encourage accessibility. ATAG 2.0 addresses this issue with other success criteria, including B.3.1.1 Checking Assistance (WCAG), which requires an accessibility checking feature.

Restrictions on authors may also be related to automatically-generated content. ATAG 2.0 addresses the accessibility of automatically-generated content in Guideline B.1.1: Ensure that automatically-specified content is accessible.

WCAG 2.0 is referenced because it provides testable success criteria to measure web content accessibility.

Examples of Success Criterion B.2.1.1:

- **No restrictions (source content editing-view):** An authoring tool is designed around a source editing-view, allowing motivated and knowledgeable authors to control every detail of the content produced, including following accessible authoring practices.
- **Accessible workflow exists:** An authoring tool is designed such that accessible web content (in this case conforming to WCAG 2.0 Level A) will result if authors do all of the following:
    - turn on all features that support the production of accessible content;
    - correctly follow all prompts by features that support the production of accessible content;
    - uses the accessibility checker, including a final check prior to publishing;
    - correctly perform any manual checks suggested by the accessibility checker; and
    - correctly repair all of the automatically, semi-automatically, or manually identified web content accessibility problems using the automated, semi-automated, and manual repair assistance that the authoring tool provides.

Related Resources for Success Criterion B.2.1.1:

- WCAG 2.0 (including Understanding WCAG 2.0 and How to Meet WCAG 2.0)

Implementing Guideline B.2.2: Guide authors to produce accessible content. [Return to Guideline]

Rationale: By guiding authors from the outset toward the creation and maintenance of accessible web content (WCAG), web content accessibility problems (WCAG) are mitigated and less repair effort is required.

Implementing Success Criterion B.2.2.1 Accessible Option Prominence (WCAG):

If authors are provided with a choice of authoring actions for achieving the same authoring outcome (e.g. styling text), then options that will result in accessible web content (WCAG) are at least as prominent as options that will not. (**Level A** to meet WCAG 2.0 Level A success criteria; **Level AA** to meet WCAG 2.0 Level A and AA success criteria; **Level AAA** to meet all WCAG 2.0 success criteria)

Return to B.2.2.1 in Guidelines

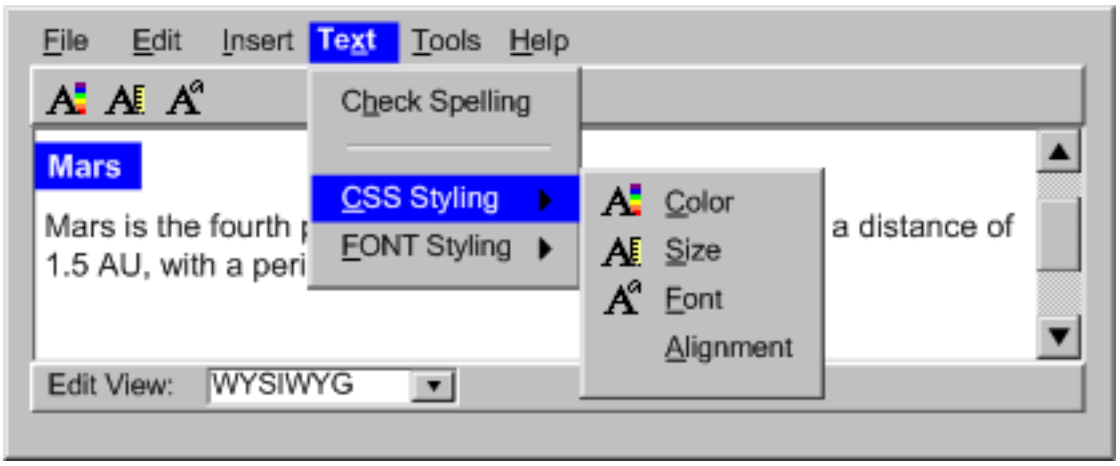
Intent of Success Criterion B.2.2.1:

The intent of this success criterion is to help ensure that accessible authoring practices are part of the default workflow of authoring tools. This requirement applies when the authoring outcome is predictable by the authoring tool. For example, a generic "insert table" command would not be applicable, despite the fact that an author might misuse it for layout, because the author might be seeking the outcome of adding tabular information. In contrast, a page layout editor is covered by the requirement because the purpose of the feature is to edit the page layout.

WCAG 2.0 is referenced because it provides testable success criteria to measure web content accessibility.

Examples of Success Criterion B.2.2.1:

- **Structural markup:** A WYSIWYG HTML editor does not include any authoring action options that will necessarily result in web content that will not meet the WCAG 2.0 Level A success criteria. For example:
  - a toolbar button that allows text to be marked as bold does so by adding a element rather than a element with a bold style.
  - a the toolbar button for placing text into a bulleted list does so with list markup (e.g. and <li> elements) rather than a element-based implementation.
  - a page layout view makes use of CSS positioning rather than table markup.
- **De-emphasizing problematic options:** A WYSIWYG editing-view emphasizes more accessible choices with a higher position in the menus and a position in user interface shortcuts, such as toolbars. Choices that always lead to less accessible web content are de-emphasized with lower menu positions.
- **Figure:** An authoring tool that supports two methods for setting text color: using CSS and using font. Since using CSS is the more accessible option, it is given a higher prominence within the authoring interface by: (1) the "CSS Styling" option appearing above the "FONT Styling" option in the drop down Text menu, and (2) the CSS styling option being used to implement the one-click text color formatting button in the tool bar. The association is made clear because the toolbar button has the same icon (an "A" beside a color spectrum) as the "Color" sub-menu item under the "CSS Styling" menu option.). (Source: mock up by AUWG)

- 

Related Resources for Success Criterion B.2.2.1:

- WCAG 2.0 (including Understanding WCAG 2.0 and How to Meet WCAG 2.0)

Implementing Success Criterion B.2.2.2 Setting Accessibility Properties (WCAG):

If the authoring tool provides mechanisms to set web content properties (e.g. attribute values), then mechanisms are also provided to set web content properties related to accessibility information (WCAG). (**Level A** to meet WCAG 2.0 Level A success criteria; **Level AA** to meet WCAG 2.0 Level A and AA success criteria; **Level AAA** to meet all WCAG 2.0 success criteria)

Note: For the prominence of the mechanisms, see Success Criterion B.4.1.4.

Return to B.2.2.2 in Guidelines

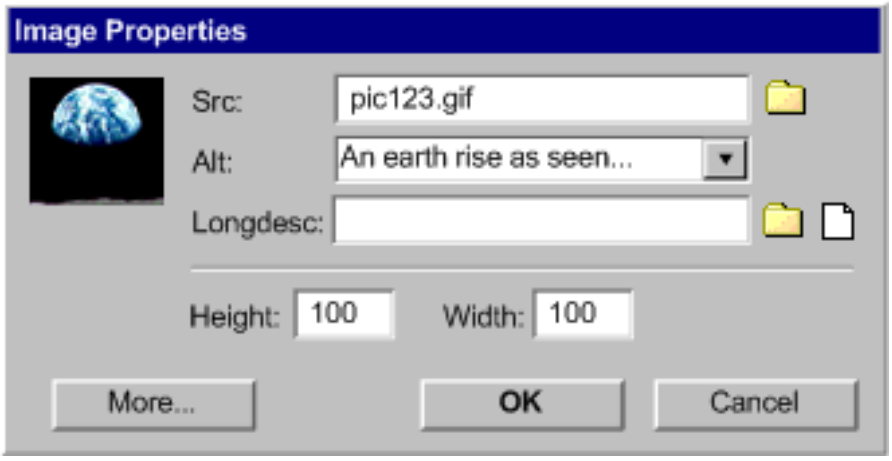
Intent of Success Criterion B.2.2.2:

The intent of this success criterion is to ensure that if authoring tools provide authors with content authoring support that goes beyond source editing (e.g. property dialogs) then accessibility information that is required for the content are similarly supported. In many cases, authoring tools support a subset of all of the possible properties that technologies might offer. This success criterion requires that the subset of supported properties must include properties required for conformance to WCAG 2.0.

The note is a reminder that the mechanisms for adding accessibility information properties must have prominence that is at least comparable with the other mechanisms for other properties.

Examples of Success Criterion B.2.2.2:

- **Context sensitive properties:** A markup authoring tool includes a context sensitive properties pane that displays property fields for the most common subset of attributes associated with the markup element that currently has focus in the editing-view. The attributes that are required for WCAG 2.0 are included in the subset.
- **Figure:** An "Image Properties" dialog box in which the input fields are ordered (from top to bottom, left to right): source ("src"), short label ("alt"), long description ("longdesc"), height, and width. The buttons at the bottom are "More...", "OK", and "Cancel". (Source: mock up by AUWG)

- 

- **Time-based media alternatives:** A SMIL authoring tool lets authors create multimedia presentations by pulling together video, audio, and timed text objects on to a timeline, even though the tool has no built-in ability to edit these objects. When authors specify information about video to be inserted, they are also provided with the opportunity to associate a timed text object (for captions), an audio object (for audio description), and a secondary video (for sign language interpretation). When authors specify information about audio to be inserted, they are also provided with the opportunity to associate a timed text object (for captions) and a video (for sign language interpretation).
- **Data table for a bar graph:** A learning content management system has a feature that lets authors insert figures. The feature accepts images, even though the authoring tool has no built-in ability to edit images, but as part of the "figure properties" the authors can identify the figure as a graph. If they choose this option, then the system assists them in creating an accompanying data table using the values used to create the graph.

Related Resources for Success Criterion B.2.2.2:

- Appendix A: Gathering Accessibility Information from Authors
- WCAG 2.0 (including Understanding WCAG 2.0 and How to Meet WCAG 2.0)

Implementing Guideline B.2.3: Assist authors with managing alternative content for non-text content. [Return to Guideline]

Rationale: Improperly generated alternative content can create web content accessibility problems (WCAG) and interfere with accessibility checking.
Note: This guideline only applies when non-text content is specified by authors (e.g. inserting an image). When non-text content is automatically added by the authoring tool, see Guideline B.1.1.

Implementing Success Criterion B.2.3.1 Alternative Content is Editable (WCAG):

If the authoring tool provides functionality for adding non-text content, then authorsare able to modify programmatically associated text alternatives for non-text content. (**Level A** to meet WCAG 2.0 Level A success criteria; **Level AA** to meet WCAG 2.0 Level A and AA success criteria; **Level AAA** to meet all WCAG 2.0 success criteria)

Note: An exception can be made when the non-text content is known to be decoration, formatting, invisible or a CAPTCHA.

Return to B.2.3.1 in Guidelines

Intent of Success Criterion B.2.3.1:

The intent of this success criterion is to ensure that authors can add alternative content for non-text content and modify that alternative content in the future.

If the type of alternative content (e.g. alternative text) is not typically displayed on screen by user agents, then WYSIWYG editing-views may not display it. This is acceptable as long as another mechanism is provided for modifying that alternative content (e.g. an "Image Properties" dialog).

Examples of Success Criterion B.2.3.1:

- **Source content editing-view:** In a source editing-view, alternative content within the source is always available, regardless of what user agents might render. If alternative content is referenced from an external location (e.g. HTML4 longdesc), then that resource can be opened for editing.
- **Properties dialog:** In a WYSIWYG editing-view, alternative content is not displayed, since the editing-view is designed to mimic typical user agents. However, the alternative content can be accessed and edited via a properties editor that displays the properties for the content that currently has focus.

Related Resources for Success Criterion B.2.3.1:

- Understanding WCAG 2.0, especially the section Understanding "Text Alternatives".

Implementing Success Criterion B.2.3.2 Automating Repair of Text Alternatives:

The authoring tool does not attempt to repair text alternatives for non-text content or the following are all true: (**Level A**)

(a) No Generic or Irrelevant Strings: Generic strings (e.g. "image") and irrelevant strings (e.g. the file name, file format) are not used as text alternatives; and

(b) In-Session Repairs: If the repair attempt occurs during an authoring session, authors have the opportunity to accept, modify, or reject the repair attempt prior to insertion of the text alternative into the content; and

(c) Out-of-Session Repairs: If the repair attempt occurs after an authoring session has ended, the repaired text alternatives are indicated during subsequent authoring sessions (if any) and authors have the opportunity to accept, modify, or reject the repair strings prior to insertion in the content.

Return to B.2.3.2 in Guidelines

Intent of Success Criterion B.2.3.2:

The intent of this success criterion is to prevent the production of text alternatives that are not useful to end users because they have not been approved by authors and/or are derived from improper sources.

The limitation against generic or irrelevant strings (a) is intended to reduce the possibility that authors who are unfamiliar with accessibility may approve suggestions that do not properly

serve as text alternatives (e.g. the file name, file format) without realizing the problems these can cause for end users. Potentially relevant strings include those derived from:

- alternative content databases (see Success Criterion B.2.3.3),
- contextual information (e.g. the image is the author's profile picture), and
- image processing. (while not as dependable as a human describer, the intent here is to encourage progress in this rapidly advancing field)

The in-session repair requirement (b) enables knowledgeable authors to have the final say on text alternatives suggested by authoring tools.

The out-of-session repair requirement (c) governs situations in which authors have either not noticed or ignored opportunities for adding text alternatives and have ended their authoring sessions. Because the author is absent, the text alternatives can be inserted into the content without author approval, but only on the condition that they will be indicated to the author if and when a subsequent authoring session occurs. This involves some degree of record-keeping, but this is reasonable considering the accessibility problems that uncontrolled automatic generation of text alternatives could cause.

Examples of Success Criterion B.2.3.2:

- **No repair:** An authoring tool does not make any attempt to automatically fill any fields prompting authors for text alternatives.
- **Metadata on an archive:** A content management system includes a feature that allows authors to make use of images from an extensive photographic archive. The photographic archive includes metadata for each photograph with title and description fields. The values in these fields are neither generic nor irrelevant (meeting (a). The title field is always filled, but the description field is sometimes lacking. When authors select an image for insertion, the metadata title is suggested as the alternative text label and the metadata description (if any) is suggested as the long description. In both cases, some basic guidance on what constitutes correct alternative content is provided to help authors judge the appropriateness of the suggestions. The authors are still given the opportunity to accept, modify, or reject the suggested alternative content prior to insertion, in case the non-text content is being used in a different context (meeting (b)).
- **Alternative content registry:** A web page authoring tool implements an alternative content registry (see Success Criterion B.2.3.3). Since the alternative content was gathered from authors' previous entries into the same fields for the same objects, these are acceptable as relevant sources (meeting (a)). The authors are still given the opportunity to accept, modify, or reject the suggested alternative content prior to insertion (meeting (b)), in case the non-text content is being used in a different context.
- **Contextual information is known:** A social networking authoring tool allows authors to add a description for images that they upload. If authors chooses not to provide a description, the authoring tool automatically labels images using the name of the album and geo-tagging metadata (meeting (a)). When the author logs in again, the images are unobtrusively highlighted as having been labeled automatically (meeting (c)).

- **Auto-generated transcript:** An on-line video editing and hosting authoring tool has a feature that allows authors to create transcripts or captions for their videos. Authors can begin by copying in a transcript, if one is available, or the authoring tool can use speech recognition technology to generate a transcript (meeting (a)) for the authors to correct (meeting (b)). While this is preferred, if no captions or transcript has been added by the authors, then end-users can request an auto-generated transcript (meeting (a)). When, the author logs in again, the uncaptioned videos are unobtrusively highlighted as having been transcribed automatically (meeting (c)).

Related Resources for Success Criterion B.2.3.2:

- Understanding WCAG 2.0, especially the section Understanding "Text Alternatives".

Implementing Success Criterion B.2.3.3 Save for Reuse:

If the authoring tool provides the functionality for adding non-text content, when authors enter programmatically associated text alternatives for non-text content, then both of the following are true: (**Level AAA**)

(a) Save and Suggest: The text alternatives are automatically saved and suggested by the authoring tool, if the same non-text content is reused; and

(b) Edit Option: The author has the option to edit or delete the saved text alternatives.

Return to B.2.3.3 in Guidelines

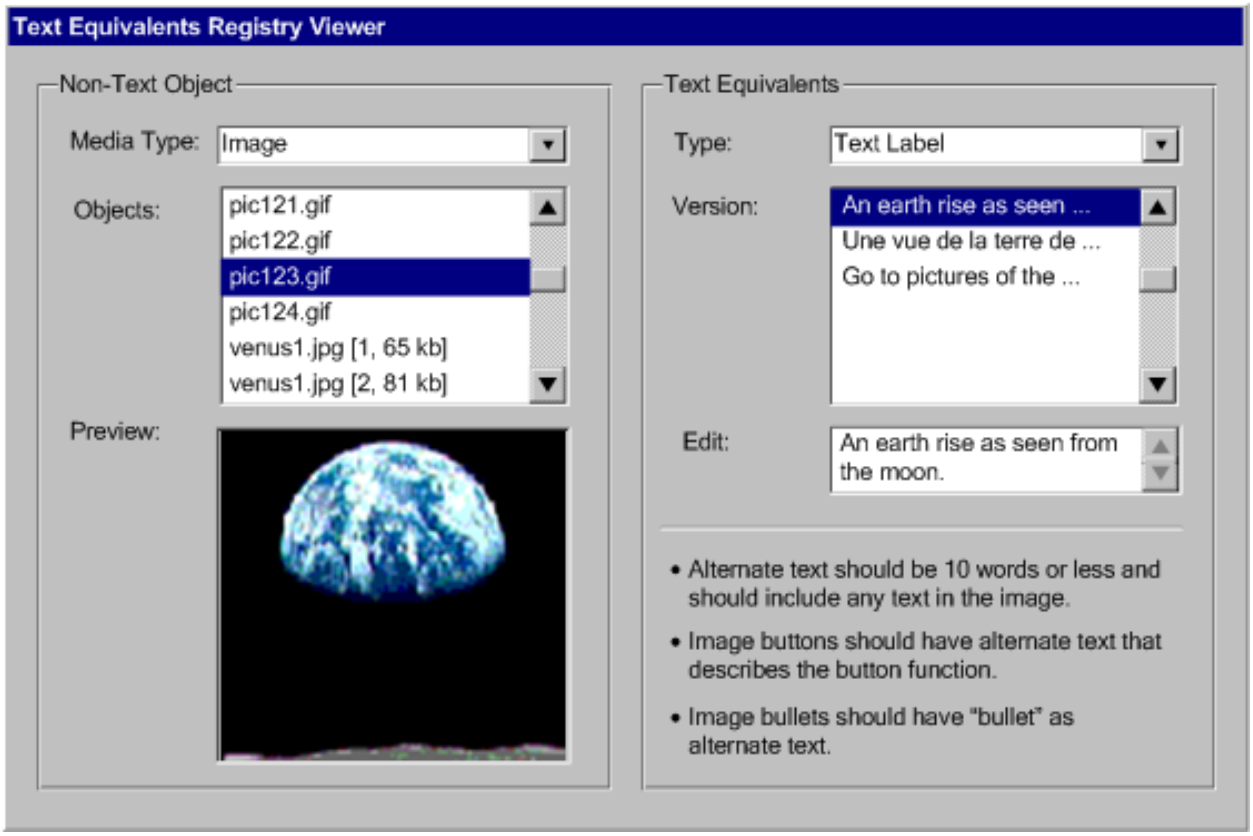
Intent of Success Criterion B.2.3.3:

The intent of this success criterion is to ensure that when authors spend effort providing alternative content, this content is retained by the authoring tool in a form that allows it to be easily reused.

The editing requirement (b) allows authors to correct or remove alternatives in case of content inaccuracies (e.g. out of date, spelling errors).

Examples of Success Criterion B.2.3.3:

- **Alternative content registry:** An authoring tool includes a registry that associates object identity information with alternative content (i.e. text, URIs). Whenever an object is used and any alternative content is collected, the object's identifying information and the alternative content is added to the registry. The stored alternative content is suggested as alternative content for author approval whenever the associated object is inserted. The alternative content registry allows several different versions of alternative content to be associated with a single object (e.g. various translations, various contexts).
- **Figure:** The interface of a sample alternative content registry viewer is shown. The design takes into account multiple non-text content objects of the same name, multiple types of text equivalents for each non-text content object, and multiple versions of each text equivalent type. In the viewer shown here, the author has selected "image" as the "media type" and then selected pic123.gif as the "content" to edit. This has brought up a rendering of the "earthrise" image. The viewer also shows that the content has three text labels. The author has selected one ("An earth rise as seen from the moon") in order to edit it. In addition some authoring tips are included ("Alternate text should be 10 words or less and should include any text in the image", "Image buttons should have alternate text that describes the button function.", and "Image bullets should have "bullet" as alternate text."(Source: mock up by AUWG)



- **Interoperability with pre-authored content:** An enterprise authoring tool's clip art system is integrated with an alternative content registry so that new alternative content created by any author on the enterprise system is stored along with the pre-authored alternative content for the images in the system. The keyword search feature of the clip art system makes use of any alternative content to retrieve matches.

Related Resources for Success Criterion B.2.3.3:

- Understanding WCAG 2.0, especially the section Understanding "Text Alternatives".

Implementing Guideline B.2.4: Assist authors with accessible templates. [Return to Guideline]

Rationale: Providing accessible templates (WCAG) can have several benefits, including: immediately improving the accessibility of the web content (WCAG)of being edited, reducing the effort required of authors, and demonstrating the importance of accessible web content (WCAG).

Implementing Success Criterion B.2.4.1 Accessible Template Options (WCAG):

If the authoring tool provides templates, then there are accessible template (WCAG) options for a range of template uses. (**Level A** to meet WCAG 2.0 Level A success criteria; **Level AA** to meet WCAG 2.0 Level A and AA success criteria; **Level AAA** to meet all WCAG 2.0 success criteria)

Return to B.2.4.1 in Guidelines

Intent of Success Criterion B.2.4.1:

The intent of this success criterion is to reduce the possibility that authors will be forced to use templates that are not accessible to create web content because accessible templates do not exist. It is recommended that the accessible options be identified, but this is not required at Level A. Identification is required at Level AA, by Success Criterion B.2.4.2.

Note: ATAG 2.0 uses the term "range" where absolute measurements may not be practical (e.g. the set of all help documentation examples, the set of all templates). While the strict testable requirement is the definition "More than one item within a multi-item set", implementers are strongly encouraged to implement the success criteria more broadly.

Examples of Success Criterion B.2.4.1:

- **Variety of accessible templates:** A web page authoring tool provides several template choices for home pages, guest books, and on-line albums. For each type of functionality, the basic template option is accessible (see the definition of "accessible template (WCAG)").
- **Content management system:** A content management system offers a variety of templates to authors for different purposes (e.g. information page, interactive form page, registration page). All of the templates are accessible.

Related Resources for Success Criterion B.2.4.1:

- N/A

Implementing Success Criterion B.2.4.2 Identify Template Accessibility:

If the authoring tool includes a template selection mechanism and provides any non-accessible template (WCAG) options, then the template selection mechanism can display distinctions between the accessible and non-accessible options. (**Level AA**)

Note: The distinction can involve providing information for the accessible templates, the non-accessible templates or both.

Return to B.2.4.2 in Guidelines

Intent of Success Criterion B.2.4.2:

The intent of this success criterion is to ensure that when faced with template options that differ in terms of accessibility, authors can more easily determine the accessibility status of templates prior to selecting them.

The note makes it clear that developers have flexibility with respect to implementation. If only a few inaccessible templates exist, it may be preferable to mark the inaccessible ones. If only a few accessible options exist, it may be preferable to mark those. In other cases, the accessibility of every template might be indicated.

The mechanism is not specified and might include: data in dedicated metadata fields (e.g. a WCAG conformance level), plain text in a description field (e.g. "5-day week calendar template. Meets WCAG Level A"), or on-the-fly checkers, once the technology exists.

Examples of Success Criterion B.2.4.2:

- **Accessibility status as metadata:** An HTML editor includes a template selection mechanism that consists of selecting templates from a list. The template list has several sortable fields that are populated from the templates' metadata: the template

name, date, popularity, and accessibility status. The accessibility status values are: "Level A", "Level AA", "Level AAA", "None", and "Not Available". By default, the list of templates is sorted alphabetically, but the author has the option to sort by accessibility status instead. The accessibility status values of the developer-provided templates are based on the degree to which WCAG 2.0 success criteria are met when the template is used (see the definition of "accessible template (WCAG)"). This may have been assessed manually or semi-automatically with an accessibility checker.

- **Accessibility status included in template names/descriptions:** In a wiki system, creating a new page brings up a list of available templates. Each template is only displayed as a name and a short description. When the developer has ensured that a template is accessible, this is indicated by the template name (e.g. "slide show template (accessible)") and/or information in the description ("This template meets WCAG 2.0 Level A as provided and should result in an accessible page, if accessible authoring practices are followed.").

Related Resources for Success Criterion B.2.4.2:

- N/A

Implementing Success Criterion B.2.4.3 Author-Created Templates:

If the authoring tool includes a template selection mechanism and allows authors to create new non-accessible templates (WCAG), then authors can enable the template selection mechanism to display distinctions between accessible and non-accessible templates that they create. (**Level AA**)

Note: The distinction can involve providing information for the accessible templates (WCAG), the non-accessible templates or both.

Return to B.2.4.3 in Guidelines

Intent of Success Criterion B.2.4.3:

The intent of this success criterion is to ensure that new templates that authors create, and which might be used by subsequent authors, interoperate with the relevant template selection identification mechanism (see Success Criterion B.2.4.2).

Examples of Success Criterion B.2.4.3:

- **Save as template:** An authoring tool provides a "save as template" feature. When authors activate this feature, the authoring tool automatically runs an accessibility checker on the template with sample data. Once the checker returns a resulting accessibility status, authors have the option of labeling the template with this status. If the template fails to conform to WCAG 2.0 with sample data, then authors are advised that templates should be held to a high accessibility standard, since they will be repeatedly reused.
- **Edit template name/description:** When saving templates, an authoring tool provides authors with the ability to add their own name and description, which could potentially include accessibility status information.

Related Resources for Success Criterion B.2.4.3:

- WCAG 2.0 (including Understanding WCAG 2.0 and How to Meet WCAG 2.0)

Implementing Success Criterion B.2.4.4 Accessible Template Options (Enhanced):

If the authoring tool provides templates, then all of the templates are accessible template (to WCAG Level AA). (**Level AAA**)

Return to B.2.4.4 in Guidelines

Intent of Success Criterion B.2.4.4:

The intent of this success criterion is to establish an enhanced requirement for accessible templates at Level AAA, without any exceptions, so that authors do not need to be concerned with checking the accessibility status of templates before using them. The target WCAG level is AA because this success criteria is intended to be applicable to a wide range of authoring tool types and, as WCAG 2.0 states, "it is not possible to satisfy all Level AAA Success Criteria for some content".

Examples of Success Criterion B.2.4.4:

- **Courseware system:** In order to serve educational institutions that have adopted strict accessibility requirements, a courseware system is deployed that only offers templates that, when used properly, result in accessible content.

Related Resources for Success Criterion B.2.4.4:

- N/A

Implementing Guideline B.2.5: Assist authors with accessible pre-authored content. [Return to Guideline]

Rationale: Providing accessible pre-authored content (WCAG) (e.g. clip art, synchronized media, widgets) can have several benefits, including: immediately improving the accessibility of web content (WCAG) being edited, reducing the effort required of authors, and demonstrating the importance of accessibility.

Implementing Success Criterion B.2.5.1 Accessible Pre-Authored Content Options:

If the authoring tool provides pre-authored content, then a range of accessible pre-authored content (to WCAG Level AA) options are provided. (**Level AA**)

Return to B.2.5.1 in Guidelines

Intent of Success Criterion B.2.5.1:

The intent of this success criterion is to reduce the possibility that authors will be forced to use pre-authored content that is not accessible to create web content because accessible pre-authored content does not exist.

Note: ATAG 2.0 uses the term "range" where absolute measurements may not be practical (e.g. the set of all help documentation examples, the set of all templates). While the strict testable requirement is the definition "More than one item within a multi-item set", implementers are strongly encouraged to implement the success criteria more broadly.

Examples of Success Criterion B.2.5.1:

- **Clip art collection:** An authoring tool is shipped with a clip art collection. Each image in the collection has a short text label and long text description and the system is interoperable with the alternative content registry, so that whenever authors insert an image from the clip art collection, its alternative content is automatically retrieved.

Related Resources for Success Criterion B.2.5.1:

- N/A

Implementing Success Criterion B.2.5.2 Identify Pre-Authored Content Accessibility:

If the authoring tool includes a pre-authored content selection mechanism and provides any non-accessible pre-authored content (WCAG Level AA) options, then the selection mechanism can display distinctions between the accessible and non-accessible options. (**Level AA**)

Note: The distinction can involve providing information for the accessible pre-authored content, the non-accessible pre-authored content or both.

Return to B.2.5.2 in Guidelines

Intent of Success Criterion B.2.5.2:

The intent of this success criterion is to ensure that when faced with pre-authored content options that differ in terms of accessibility, authors can more easily determine the accessibility status of the pre-authored content prior to selecting them.

The note makes it clear that developers have flexibility with respect to implementation. If only a few inaccessible pre-authored content options exist, it may be preferable to mark the inaccessible ones. If only a few accessible options exist, it may be preferable to mark those. In other cases, the accessibility of every option might be indicated.

The mechanism is not specified and might include: data in dedicated metadata fields (e.g. a WCAG conformance level), plain text in a description field (e.g. "Progress widget. Meets WCAG Level AA"), or on-the-fly checkers, once the technology exists.

Examples of Success Criterion B.2.5.2:

- **Clip art collection:** A clip-art repository lists the available images and provides the alternative text associated with the images in a sortable field. Lack of alternative text is therefore easy to determine.
- Widget palette: A user interface widget palette is provided to allow authors to easily add these controls to their content. Widgets that have been designed according to WAI-ARIA 1.0 Authoring Practices are denoted by an icon.

Related Resources for Success Criterion B.2.5.2:

- N/A

Appendix C: Analysis of 4 Authoring Tools Based on Selected ATAG 2.0

B.1.1.2 Content Auto-Generation During Authoring Session (WCAG) focuses on automatically generated web content. Authoring tools (AT) that satisfy this criteria will: a) automatically generate accessible content b) prompt authors for required accessibility information c) automatically check for accessibility or d) prompts authors to perform accessibility checking. One of the features of all four authoring tools was the ability of the author to drag images and videos into automatically generated web content.

*A synthesis of the three automatic evaluator tools * were used to assess part a) automatically generated accessible content while the remaining parts b), c), and d) were assessed manually by the researcher.*

ARTutor

All three automatic tools showed problems satisfying success criteria 1.1.1 Text Alternatives, 1.3.1 Info and Relationships, 1.4.3 Contrast, 1.4.4 Resize Text, 3.3.2 Labels or Instruction, 4.1.1 Parsing

Blippar

All three automatic tools showed problems satisfying success criterion 3.1.1 Language of Page.

HP Reveal

All three automatic tools showed problems satisfying success criteria 1.3.1 Info and Relationships, 3.1.1 Language of Page, 3.3.2 Labels or Instruction

Metaverse

All three automatic tools showed problems satisfying success criteria 1.1.1 Text Alternatives

Additionally, the author did not include closed captioning or an audio description while making the video augmentation which means that none of the AR content will meet the success criteria of 1.2.1 Audio-only and Video only, 1.2.2 Captions (Prerecorded), and 1.2.3 Audio Description or Media Alternative.

***YouTube** was also evaluated by all three automatic evaluators to capture any additional success criteria problems because all four authoring tools augmented overlays were the video found at the following URL https://www.youtube.com/watch?v=q959IXYqurQ*

All three automatic tools showed problems satisfying success criteria 1.3.1 Info and Relationships, 3.3.2 Labels or Instructions.

Using the reports generated by the automatic evaluators, this researcher determined that a) no accessible web content (or content) was automatically generated based on the WCAG 2.0 level A success criteria b) there were no prompts about accessibility information c) no automatic checks for accessibility nor d) any prompting to perform accessibility checking.

Result: The success criterion **was not satisfied** for any of the four platforms.

B.2.2.1 Accessible Option Prominence (WCAG) focuses on author options that result in accessible web content that are at least as prominent as options that do not. All four platforms provided “what you see is what you get” (WYSIWYG) editing options.

Results from B.1.1.2 part a) for all four authoring tools were used (see above) to determine whether web content produced was accessible based on WCAG 2.0 level A success criteria. The web content produced by all four authoring tools did not meet the WCAG 2.0 level A success criteria. The researcher was able to manually determine that no options leading to accessible web content (WCAG 2.0 level A success criteria) were featured on any of the four authoring tools more prominently or by default so that the web content was accessible by WCAG 2.0 level A standards.

Result: The success criterion **was not satisfied** for any of the four platforms.

B.3.1.1 Checking Assistance (WCAG) focuses on accessibility checking for web content that can be added or modified. The four authoring tools add images or videos or text to web content.

Results from B.1.1.2 part a) for all four authoring tools were used (see above) to determine whether web content produced was accessible based on WCAG 2.0 level A success criteria. The researcher was able to manually determine that none of the authoring tools provided an accessibility check- not automated, semi-automated or manually through instructions for the author.

Result: The success criterion was **not satisfied** for any of the four authoring tools.

B.3.1.2 Help Authors Decide focuses on providing instructions for authors on how to decide whether potential web content accessibility problems (WCAG) are correctly identified.

Results from B.1.1.2 part a) for all four authoring tools were used (see above) to determine whether web content produced was accessible based on WCAG 2.0 level A success criteria. The researcher was able to manually determine that none of the four authoring tools provide any accessibility checking when adding or modifying web content and so consequently they don't provide instructions for authors on how to decide about identified accessibility problems.

Result: The success criterion was **not satisfied** for any of the four authoring tools.

B.3.1.3 Help Authors Locate focuses on the location of the identified accessibility problem of the web content.
The researcher was able to manually determine that none of the four authoring tools provide help locating the accessibility problems of the web content because none of the authoring tools provide accessibility checking or instructions for authors.

Result: The success criterion was **not satisfied** for any of the four authoring tools.

B.3.2.1 Repair Assistance (WCAG) focuses on repair suggestions for accessibility problems of web content based on accessibility checking (B.3.1.1).

Results from B.1.1.2 part a) for all four authoring tools were used (see above) to determine whether web content produced was accessible based on WCAG 2.0 level A success criteria. The researcher was able to manually determine that none of the four authoring tools provide accessibility checking or instructions or location of identified accessibility problems and so consequently they don't provide related repair assistance.

Result: The success criterion was **not satisfied** for any of the four authoring tools.

B.4.1.1 Features Active by Default focuses on a default of accessible content features turned on.
The researcher was able to manually determine that none of the four authoring tools provide accessible content features specifically- to be turned on or off.

Result: The success criterion was **not satisfied** for any of the four authoring tools.

B.4.1.2 Option to Reactivate Features focuses on not including an option to turn off the accessible content features or alternatively an option to turn them back on after being turned off.
The researcher was able to determine manually that none of the four authoring tools provide accessible content features and so consequently, there is no option to keep them on or turn them back on if they are turned off.

Result: The success criterion was **not satisfied** for any of the four authoring tools.

B.4.2.1 Model Practice (WCAG) focuses on modelling or demonstrating accessible authoring practices (WCAG).
Through a manual examination of each authoring tool for examples of how to use the authoring tool and comparing these results to the fact that none of the content met the required WCAG 2.0 success criteria (see B.1.1.2 part a), the researcher found that none of the four authoring tools modelled accessible authoring practices according to WCAG 2.0 level A success criteria.

Result: The success criterion was **not satisfied** for any of the four authoring tools.

B.4.2.2. Feature Instructions focuses on ensuring that authors have help on how to use the accessible content features.
The researcher was able to manually determine that none of the four authoring tools provide accessible content features specifically and consequently do not provide specific help on how to use those features.

Result: The success criterion was **not satisfied** for any of the four authoring tools.
* See Appendix 4

Appendix D: Report on Automatic Evaluators

Results of Automatic Evaluator Reports for WCAG 2.0 and Mobile Accessibility Evaluator

Authoring Tools	AChecker (#sc- ns)	TAW (#sc-ns)	Mobile (#problems)
ARTutor	1.1.1- 9 1.3.1 - 6 1.4.3 - 2 1.4.4 - 5 3.3.2 - 6 4.1.1 - 1 **Totals** Perceivable - 22 Operable- 0 Understandable- 6 Robust- 1	1.1.1- 12 1.3.1 - 13 1.3.2 - 30 1.3.3 - 1 1.4.1 -1 1.4.3 -1 1.4.4 - 15 1.4.5 - 1 2.1.1 - 1 2.1.2 - 1 2.2.1- 1 2.3.1 - 1 2.4.1 - 1 2.4.3-3 2.4.4 - 4 2.4.5 - 1 2.4.6 - 3 2.4.7- 1 3.1.1 - 1 3.1.2 - 1 3.2.1 - 5 3.2.2 - 1 3.2.3 - 1 3.2.4 - 1 3.3.1 - 2 3.3.2 - 7 3.3.3 - 1 3.3.4 - 3 4.1.1 - 86 4.1.2 - 8 **Totals** Perceivable - 74 Operable - 17 Understandable - 23 Robust - 94	* elements must have sufficient color contrast - 2 * id attribute value must be unique - 1 * zooming and scaling must not be disabled- 1

Authoring Tools	AChecker (#sc- ns)	TAW (#sc-ns)	Mobile (#problems)
Blippar	3.1.1 - 2 **Totals** Perceivable- 0 Operable - 0 Understandable - 2 Robust - 0	1.3.1 - 2 1.3.2- 2 1.3.3 - 1 1.4.1 - 1 1.4.3 - 3 1.4.4 -2 1.4.5 - 1 2.1.1 - 1 2.1.2 - 1 2.2.1- 3 2.2.2 - 2 2.3.1 - 1 2.4.1 - 3 2.4.2 - 1 2.4.3- 1 2.4.5 - 1 2.4.7 - 2 3.1.1 - 2 3.1.2 - 1 3.2.1 - 5 3.2.2 - 1 3.2.3 - 1 3.2.4 - 1 4.1.1 - 1 4.1.2 - 1 **Totals** Perceivable - 12 Operable - 16 Understandable - 11 Robust - 2	* elements must have sufficient color contrast - 8 * html element must have a lang attribute -2

Authoring Tools	AChecker (#sc- ns)	TAW (#sc-ns)	Mobile (#problems)
HP Reveal	1.3.1 - 14 3.1.1 - 2 3.3.2 - 9 **Totals** Perceivable - 14 Operable - 0 Understandable - 11 Robust - 0	1.1.1 - 21 1.3.1 - 1 1.3.3 - 1 1.4.1 - 1 1.4.3 - 2 1.4.5 - 1 2.1.1 - 1 2.1.2 - 1 2.2.1 - 3 2.2.2 - 1 2.3.1 - 1 2.4.1 - 2 2.4.2 - 1 2.4.3 - 1 2.4.5 - 1 2.4.6 - 25 2.4.7 - 1 3.1.1 - 2 3.2.1 - 5 3.2.2 - 1 3.2.3 - 1 3.2.4 - 1 3.3.1 - 2 3.3.2 - 1 3.3.3 - 1 3.3.4 - 3 3.3.3 - 1 3.3.4 - 3 4.1.2 - 2 **Totals** Perceivable - 27 Operable - 38 Understandable - 21 Robust- 2	* elements must have sufficient color contrast - 7 * html element must have a lang attribute - 1

Authoring Tools	AChecker (#sc- ns)	TAW (#sc-ns)	Mobile (#problems)
Metaverse	1.1.1- 7 **Totals** Perceivable - 7 Operable - 0 Understandable - 0 Robust - 0	1.1.1 - 11 1.3.1 - 3 1.3.2 - 1 1.3.3 - 1 1.4.1 -1 1.4.3 - 2 1.4.4 - 1 1.4.5 - 1 2.1.1 - 1 2.1.2- 1 2.2.1 - 3 2.2.2 - 1 2.3.1 - 1 2.4.1 - 2 2.4.2 - 1 2.4.3 - 1 2.4.4 - 3 3.1.2 - 1 3.2.1 - 5 3.2.2 - 1 3.2.3 - 1 3.2.4- 1 4.1.1 - 7 4.1.2 - 1 **Totals** Perceivable - 22 Operable - 14 Understandable - 9 Robust - 8	* images must have alternate text - 5 * links must have discernible text - 3 * elements must have sufficient color contrast -2 * zooming and scaling must not be disabled - 1

Authoring Tools	AChecker (#sc- ns)	TAW (#sc-ns)	Mobile (#problems)
youtube	1.3.1 - 3 3.3.2 - 3 **Totals** Perceivable - 3 Operable - 0 Understandable - 3 Robust - 0	1.1.1 - 24 1.3.1 - 6 1.3.2 - 2 1.3.3 - 1 1.4.1 - 1 1.4.3 - 2 1.4.4. -8 1.4.5 - 1 2.1.1 - 1 2.1.2- 1 2.2.1 - 3 2.2.2 - 1 2.3.1 - 1 2.4.1 - 3 2.4.2 -1 2.4.3 - 1 2.4.4 - 26 2.4.5 - 1 2.4.6 - 27 2.4.7 - 2 3.1.2 - 1 3.2.1 - 5 3.2.2 - 2 3.2.3 -1 3.2.4 - 2 3.3.1 - 2 3.3.2 - 3 3.3.3 - 1 3.3.4 - 3 4.1.1 - 1667 4.1.2- 4 **Totals** Perceivable - 45 Operable - 107 Understandable - 20 Robust - 1671	* html element must have a lang attribute- 2 * zooming and scaling must not be disabled - 2 * video elements must have an audio description track - 1 * video elements must have captions - 1

#sc-ns- # of not satisfied for specific success criterion WCAG 2.0

All four authoring tool platforms were analyzed using the 3 automatic evaluator tools. Additionally, the YouTube video that provided the augmented animation was also analyzed using the 3 automatic evaluator tools.

It was difficult to capture the precise web content to be analyzed with the automatic evaluator tools because each tool only allowed a specific uniform resource locator (url) to be used. Due

to the nature of augmented reality, the content is both the real-world target image and the overlay of the video. Three of the authoring tools webpages did not specifically link to either the target image or the animation and therefore the url captured only the entirety of the webpage of the authoring tool. Metaverse was the exception which provided a url to the augmented link. HP Reveal in particular could only provide a home webpage and not even an editing view.
The whole point of using the automatic evaluator tools was to determine if the content satisfied the success criteria of WCAG 2.0 as a preliminary step to assessing several of the ATAG 2.0 success criteria.

The following is a synopsis of this.

ARTutor
The url given for ARTutor was for a webpage that provided the target image and the animation in thumbnail sketches with an opportunity to save. All three automatic tools showed problems satisfying success criteria 1.1.1 Text Alternatives, 1.3.1 Info and Relationships, 1.4.3 Contrast, 1.4.4 Resize Text, 3.3.2 Labels or Instruction, 4.1.1 Parsing

Blippar
The url given for Blippar was for a webpage that provided an editing view of the target image with an overlay of the animation. All three automatic tools showed problems satisfying success criterion 3.1.1 Language of Page.

HP Reveal
The url given for HP Reveal was for a webpage that provided the home view of the studio leading to the creation of “auras” or augmented reality experiences. All three automatic tools showed problems satisfying success criteria 1.3.1 Info and Relationships, 3.1.1 Language of Page, 3.3.2 Labels or Instruction

Metaverse
The url given for Metaverse was for the augmented reality or video link. All three automatic tools showed problems satisfying success criteria 1.1.1 Text Alternatives

YouTube
The URL given for YouTube was for the video that served as the augmented overlay for all four authoring tools. Live closed captioning was chosen as an option but no specific closed captioning or audio description was uploaded. All three automatic tools showed problems satisfying success criteria 1.3.1 Info and Relationships, 3.3.2 Labels or Instructions.

There is validation in the success criteria identified in all three automatic tools for the given urls but there is a question about the relationship to the content created by the authoring tool due to the limitations of the automatic tools.

Appendix E: Research Journal

One of the first things I noticed, is that none of the authoring tools seem to mention accessibility features and/or prompts to look at accessibility features… when creating MAR, there is nothing that makes you question whether the target image and/or video is accessible or not.

There are other considerations that don't fall into the Authoring Tool Guidelines…. (ATAG)—- I know that when students need to use tablets or smart phones to access the MAR—- there is no consideration of mobility of the user… I had the chance to read a blog from LevelAccess— a company dealing in digital accessibility—- blog was about VR/AR accessibility…

There is some concern of people with visual disabilities accessing this technology—- but eventual options could help with navigation—- in my case, I am not looking at location AR so this point does not apply…

Overall— the system controls need to be accessible (powering on/off), accessing sensors and hardware, setup, navigating menus, accessing communication, browsers…

Interaction and Input controls: voice control and recognition, motion and gesture recognition, eye and head tracking, keyboard/controller, sensor, mobile device as input for other devices…

IE. motion control and motion through space…. maybe you don't need to move the mobile device to access the AR image…. look at metaverse….

inclusion included multiple modes of interaction:

*visual disabilities (audio cue, change of size/color text, colorblind options, zoom without getting physically closer, audio placement)

* deaf/hard of hearing (ambient noice indicator, text indicators, closed captioning, giving emotions and feelings not just text)
* vestibular disorders (motion sickness prevention, slow down movement i space, input support)
* cognitive disabilities (tutorial, playground mode, level difficulty, intuitive menus, perspective, customization, context guidance)

What are the best ways to use AR— motivation, real-world/authentic situations, theoretical concepts, collaboration, autonomy and multi-modal learning…

Best ways to use AR in distance education for accessibility—— multi-modal learning, authentic situations and theoretical concepts…..

What about "real" versus "augmented"? Can it address students with other disabilities besides learning/cognitive and sensorial and mobility? What about psychosocial/psychiatric disabilities? autism, depression/anxiety… there is a lot of research on how augmented reality can create accessible situations for students on the autism spectrum…. can it help students with other psychiatric disabilities? such as bi-polar and/or depression and anxiety as we have seen the prevalence of this disability increase in younger students…. is it the tablets? can AR help create accessibility in this area? as a bridge between virtual and real?

Looking at the guidelines… there are only some that someone with my limited experience could evaluate…

From my webinar with LevelAccess in 2017— I found the following:

barriers to accessibility in VR/AR as:

1) heavy emphasis on motion controls

2) specific requirements on positioning in the space

3) strict hardware guidelines

4) limited audio

5) core-reliance on visual stimulus

Some of the concerns that I found is that none of the platforms promote accessibility features or use prompts to include or consider accessibility. Many educators aren't familiar with accessibility considerations- or don't automatically consider them. Training is useful but a program/tool/platform that allowed you to produce products as an expert in accessibility issues would be ideal…..

Critical disability theory emphasizes that people who are disabled in society should be considered as priority in removing barriers…. the push to create something that helps everyone is a great marketing tool as in Universal Design and also Universal Design for Learning but the focus should be for people with disabilities because they are the ones limited in education- in this context.

A lot of the physical, sensorial and mobility disabilities are well-recognized and though there are stigmas of being victims… someone to be pitied… or conversely as having "superpowers" with respect to development of other senses or compensations BUT the cognitive, learning and psychiatric disabilities are disabilities that also have stigmas … as people who are weak or "less-then" or not even believed…. they are the "invisible" disabilities and many students do not advocate for themselves or even communicate their disabilities to others in a education situation… a Deaf person or person who has a hearing disability may never disclose or communicate their disability to the instructor/educator in a distance education situation….

A framework would consider the best ways to use augmented reality….

The most effective end-user evaluations are done with yes/no questions with little to no gray area… very clear questions and answers. This might be useful to incorporate—- better to make changes for accessibility beforehand… save on time and money. As opposed to retrofitting the learning experience to make it accessible.

Some disabilities are more compatible with augmented reality such as hearing impairment….. autism, cognitive disability and learning disability….

dexterity and visual impairment issues can be limiting now with AR's current strong connection to specific movement and position in space to link with target image

it would be interesting to examine psychiatric disabilities… there is potential in the "real-world" interaction with the natural world and with real people in real-time… being outside and interacting with people directly or in-person seems to show positive results for people with depression and anxiety.

The tablet or mobile device becomes the familiar link for many students and comfort bridge for that interaction.

But how would you evaluate this?

Looking at ATAG- the guidelines are proposed to have benefits for everyone and not only people with disabilities but using critical theory as a guiding principle, the benefits should be specifically for people with disabilities who are the ones limited in society and anyone else who benefits— that's just a bonus.

The more I think about Universal Design for Learning… the more I struggle with lessons that are one size fits all. It is great to have options for students ("multi-modal means" of presenting, motivating and evaluating) and definitely try to make the learning experiences accessible for as

many people with disabilities as possible- however people with disabilities are so varied and unique that you always have to consider the specifics of your students.

I think a framework that looks at AR currently and the real-benefits for people with certain impairments… matched with the characteristics of the technology that benefit in certain areas of learning… is a good place to start… with follow-up in areas that should be further explored.

Any tool should provide a checklist for authors that can help ensure that the AR scenarios are as accessible as possible.

Certain aspects of learning/cognitive disabilities are not included in ATAG… and no psychiatric disabilities. Certain mobility aspects are not considered either.

One thing to consider is that many people will eventually have a disability or will be disabled by society in some capacity—- limited hearing, mobility, sight…..

What about intersectionality? and/or more than one disability?

What is a conceptual framework? It's concepts that are linked together to explain a phenomenon — qualitative research

"Conceptual exploration of possibilities" WebAIM not a tool…. is it a model or concept.

Conceptual Framework for Accessibility Tools to Benefit Users with Cognitive Disabilities

Conceptual Framework for MAR Accessibility Tools to Benefit Students with Disabilities

What about functional disability versus This framework consists of:

categories of functional cognitive disabilities,

principles of cognitive disability accessibility,

units of web content analysis,

aspects of analysis,

M

stages of analysis, and

realms of responsibility.

Principles to guide creation of accessible content for people with cognitive disabilities (may include dyslexia, dysgraphia, dyscalculia, ADHD, autism, Down syndrome, fetal alcohol syndrome….) and people with cognitive disabilities may be limited by barriers to memory, problem-solving, attention, reading, linguistic, and verbal comprehension, math comprehension and visual comprehension

1) Simple

2) Consistent

3) Clear

4) Multi-modal

5) Error-tolerant

6) Delay-tolerant

7) Attention-focusing

are principles to follow with cognitive disabilities…..

What about the total user experience? The guidelines don't consider that AR is the relationship between online or virtual and real-life…. it is not one or the other so ATAG is inherently inadequate… nothing currently exists to provide a framework or guide to help developers and/or educators.

At which point for designers should authoring tools for MAR be examined: planning, design, testing and after content is complete—- we are examining "final products" but these products are continually being updated so that is a factor to consider as well.

Will we look at this framework for authoring tool developers or end-users? An authoring tool that has checkpoints throughout the development process to check on accessibility…. this is developed by an authoring tool developer based on the conceptual framework.

"massiveness of the undertaking. Such tools would require hefty investments of time and money. On the optimistic side, such tools could serve the dual purpose of increasing disability access for people with disabilities as well as overall usability for all users." (2005, WebAIM)

https://webaim.org/articles/framework/#demyst

how do we define augmented reality?

Which studies: autism, mobility, ADHD, cognitive disabilities, hard of hearing/hearing impairments, ESL,

what types of disabilities?

which studies and recommendations?

barriers? limits?

As an author without disabilities I am not looking at my limitations or problems in creating these MAR learning scenarios…. there were some problems with uploading of target images and

videos for ARTutor and Metaverse…. these are probably due to this author's limited experience…. also… the video clips needed to be smaller but this was not always identified in th authoring tool.

I am ultimately looking at how useful these authoring tools are in creating accessible MAR—- there were no prompts to check for closed captioning…. target image needed to meet the unique traits so that it could be used as a target image… I made mine black and white which touches on people with colour blindness… but I could have made it with the full colour spectrum.

Metaverse has problems because you must move the mobile device.. this might be a problem for certain students….

The other authoring tools required the student to line-up the target image so that the app could recognize the overlay and play the video… this again would limit certain students with dexterity and mobility issues…. if the response is slow… and hard to line-up… this could effect students with cognitive disabilities… they would question if it is working even.

There is no prompt for clear text—- some of the tablets used existing images and text templates… but I need to check their accessibility…..using the automatic evaluators…

It is also so important to consider Part A - author has disabilities and the authoring tool does not limit the author—- eventually because not only are there educators with disabilities but many educators are using the creation of MAR as a learning activity/assessment and so students with disabilities would be limited in their experience if these students could not create the MAR.

let's look at the ATAG criteria and decide how to pick the most appropriate— obviously Part B —-

But which ones specifically….

software tools can be used in conjunction to meet requirements of part B— an accessibility checking tool can be used in conjunction with the main authoring tool

Some of the success criteria need to meet WCAG 2.0 success criteria for level A so using the automatic evaluators will be useful.

An article that looks at mobile platform accessibility is especially relevant—- can automated evaluators evaluate well— saves on time definitely…

Which properties can be evaluated using automated tools?

W3C has guidelines that line-up with four properties:

Perceivable: information and interface comments must be perceivable by users

Operable: user interface and navigation must be operable

Understandable: users must information and the operation of the user interface

Robust: content must be robust enough to be interpreted reliably by wide variety of user agents- including assistive technologies

BBC- mobility accessibility guidelines—

1) audio and video: subtitles, sign language, audio description and transcripts- audio must not play automatically unless the user is made aware or a pause/stop/mute button is provided; relevant metadata should be provided

2) design: color of text and background content must have sufficient contrast; information or meaning must not be covered by color only, core content must still be accessible when styling is unsupported or removed, touch targets must be large enough to be touched accurately- an inactive space should be provided around actionable elements, users must be able to control font sizing and user interface scaling; links and other actionable elements must be clearly distinguishable; all actionable and focusable elements must have a visible state change; user's experience should be consistent, interfaces must provide multiple ways to interact with content, interactive media including games should be adjustable for user ability and preference and content must not visibly or intentionally flicker or flash more than three times in any one-second period
3) Editorial: consistent labelling should be used across websites and native applications as well as with websites and applications; the language must be indicated when needed, additional instruction should be provided to supplement visual and audio cues…
4) Focus: all interactive elements must be focusable and inactive elements must not be focusable
5) Forms: all form controls must be labelled; a adult input format must be indicated and supported, labels must be placed close to relevant form control and laid out appropriately; controls, labels an other form elements must be properly grouped.
6) Images: images of text should be avoided and background images that convey information or meaning must have additional accessible alternative
7) Links: link and navigation text must uniquely describe target or function of the link or item; links to alternative form must indicate that an alternative is opening and repeated

8) Notifications: notifications must be both visual and audible; standard operating system notifications should be used where available and appropriate; clear error messages must be provided and non-critical feedback should be provided when appropriate
9) Scripts and dynamic content: apps and websites must be build to work in a progressive manner that ensures a functional experience for all users; media that updates or animated content must have a pause, stop or hide control
10) Structure: all pages or screens must be uniquely and clearly identifiable; content must provide a logical and hierarchical heading structure
11) Test equivalence: alternatives must briefly describe the editorial intent or purpose of the image, object or element— decorative images must be hidden from assistive technology; tooltips must not repeat link text

WCAG 2.0 also recommends:

1) minimize the amount of info on each page compared to desktop/laptop
2) position form fields below their labels, rather than beside
3) make all functionality operable thorough a keyboard interface
4) gestures should be as easy as possible to carry out- widgets requiring complex gestures can be difficult or impossible to use for screen readers users
5) interactive elements should be positioned where they can easily be reached- when the device is held in different positions
6) mobile applications should support both orientations once some users have either mobile devices mounted in a fixed orientation— changes in orientation must be programmatically expressed to ensure detection by assistive technology

7) position important information so it is visible without scrolling
8) labels or instructions are provided when content requires user input
9) context-sensitive help should be available
10) reduce amount of text entry needed by providing select menus,, radio buttons or check boxes..

threats to validity because of exploratory nature we may not have found all accessibility testing and analysis tools available…. or al AT MAR in my case ;)

Mobility with apps….

Some things to ensure—-

No time-based video or audio—- enough time for closed captioning….

text to speech compatibility with video or images…

info continuity between portrait and landscape

info presentable for people with colour-blindness

no seizure inducing light flashes

adjustable time for people with LD or visual processing impairments

navigation aides to find content and info

adjustable size text, color and brightness in app

future proof AT compatibility

qPerhaps the best way is to have people with disabilities but also testing with accessibility settings… could work— can you really get enough variety of disabilities to accurately test everything?

Automated Testing of Mobile Apps— Eler Rojas Ge & Fraser…..2018… check out

existing accessibility frameworks? compare to mobile app testing?

MATE— Mobile Accessibility Testing

What about aphasia? brain injury trauma…. strokes….

Can MAR developers and/or educators use automatic testing to ensure accessibility of MAR for students with disabilities in distance education?

There are several studies now that are examining automatic testing for mobile apps—- which has a clear tie with MAR- mobile augmented reality apps.

Although ATAG 2.0- the most current ATAG is compatible with WCAG2.0— WCAG 2.1 considers 17 more guidelines — success criteria that is more comprehensive and relevant to today's technology—- mobile devices and cognitive impairments…

1.3 Adaptable— orientation doesn't effect information=— simpler for mobile devices that are smaller screened and moved horizontally or vertically

1.3. Orientation- 1.3.5 Identity Input Purpose 1.3.6 Identity Purpose

1.4 Distinguishable—- reflow, non-text contrast, text spacing, content on hover or focus

2.1 Keyboard Accessible — character key shortcuts,

2.2 Enough time- timeouts,

2.3 Seizures and physical reactions—— animation from interactions,

2.5 Input Modalities- pointer gestures, pointer cancellation, label in name, target size

4.1 Compatible— status messages

Addresses some cognitive and learning disabilities…. and low visions… not expressly found in WCAG 2.0

Making content more accessible for cognitive disabilities:

1. Create transformable (size), rich, multimodal content
2. Focus attention of user—sensory, content and interaction
3. Design a consistent environment
4. Create simple, concise content
5. Allow user sufficient time to interact with content
6. Allow users to recover from accidental and erroneous interactions

https://webaim.org/articles/cognitive/cognitive_too_little/#recommendations

Cognitive disability is the largest disability group! 1) Perception and processing, 2) memory, 3) problem solving, 4) attention

includes people with learning disabilities, developmental disabilities, attention disorders and neurological impairments—-

https://webaim.org/articles/cognitive/conceptualize/

Can cognitive disability also be connected to psychiatric disabilities—- one article lists a connection to attention and memory, language, executive function, problem solving and social interaction— very similar to previous paper—-Grabinger, S. (2009). A framework for supporting postsecondary learners with psychiatric disabilities in online environments. In Proceedings of the 8th European Conference on e-Learning: ECEL (p. 236). Academic Conferences Limited.

There is WCAG 2.0 and 2.1 but also Revised 508 Non-web Software Checkpoints—-

Including Authoring Tools 504— mainly related to ATAG 2.0… check IBM Checkpoints…

For WCAG 2.1 there was a Cognitive and Learning Disabilities Task Force…(COGA?)

That resulted in 4 new success criterion— other success criterion could also benefit people with cognitive disabilities but not specifically….

1.3.5 Identity Input Purpose—- autocomplete (level AA)

1.3.6 Identity Purpose (level AAA)—- icons versus words— may confuse people.. must offer multiple modes…. AT can read in mark-up language the purpose..

2.2.6 Timeouts (level AAA) user must be informed on length of time for activity or information is lost…

2.2.7 Animation from Interactions (level AAA) possible to disable motion animation that might distract from essential information..

Focus on cognitive function? as opposed to specific disorders or diagnoses?

Cognitive and Learning Disabilities Task Force (W3C)

The research describes challenges in the areas of attention, executive function, knowledge, language, literacy, memory, perception, and reasoning. It is organized by user groups of the

following disabilities: Aging-Related Cognitive Decline, Aphasia, Attention Deficit Hyperactivity Disorder, Autism, Intellectual Disability, Dyscalculia, Dyslexia, and Non-Verbal. https://w3c.github.io/coga/user-research/ (W3C, 2019)

Lots of great work with this task force…but does not include depression and/or anxiety or other psychiatric disabilities…

WCAG success criterion ideas…..https://www.w3.org/WAI/GL/task-forces/coga/wiki/SC_To_Do_list

unified framework— Seale, Garci-Carrizosa, Rix Sheehy & Hayhoe, 2018)

Learning Disabilities:

- instructions clear and easy to understand & age appropriate
- help messages are easy to access
- appropriate screen formatting
- feedback is appropriate and relevant
- multiple levels of mastery and appropriate cues and prompts to responses

Anxiety/depresssion… many youth— growing number of people have disabilities that include psychiatric disabilities ….

how does web content relate? barriers include: and suggestions to remove…

1) urgency- rushing— stop the clock— give enough time…

2) unpredictable don't leave users confused about timelines or next steps or leave people uncertain about their actions— manage expectations— explain what will happen next- make important information clear
3) powerlessness- remove friction- make help or support hard to find/give support (option to cancel hard to find) or apply friction…(check answers before submitting) don't leave users questioning answers they gave
4) sensationalism- keep it real—-clickbait headlines!

Related to WebAim Cognitive and Learning Disabilities Task Force…

Functions versus diagnoses…as in International Classification of Function with World Health Organization

https://hal.archives-ouvertes.fr/hal-01954983/file/CINQUIN_CAE_2018.pdf

ICF—body function impairments/deficiencies, activity limitations and social participation restrictions.

ICF-CY—-for youth…

Activities and Participation…Chapter 1 is Learning and applying knowledge

Purposeful sensory experiences (d110-d129)

d110 watching

d115 listening

d120 other purposeful sensing

d129 purposeful sensory experiences, other specified, unspecified

Basic learning (d130-d159)

d130 copying

d131 learning through actions with objects

d132 acquiring information

d133 acquiring language

d134 acquiring additional language

d135 rehearsing

d137 acquiring concepts

d140 learning to read

d145 learning to write

d150 learning to calculate

d155 acquiring skills

d159 basic learning, other specified and unspecified

Applying knowledge (d160-d179)

d160 focusing attention

d161 directing attention

d163 thinking

d166 reading

d170 writing

d172 calculating

d175 solving problems

d177 making decisions

d179 applying knowledge, other specified and unspecified

d198 learning and applying knowledge other specified

d199 learning and applying knowledge, unspecified

In HP Reveal there are errors in masking… similar images… leading to jittery video… and also an error in overlay position—- the target image no longer matches the video…….

HP Reveal— it's difficult for the image to latch on to target image on paper….

Can't really move things back and forth.. hard to read text… and video doesn't have cc'd….

Each AT requires logging in…then each has different steps…

1) HP Reveal—- create aura— "click"…. create trigger… or target… select image…

HP Reveal is very sensitive….. you cannot move it around while you are watching the video… it easily disconnects if you move it closer/further… different angle or if you change the orientation…. but it connects right away! Hard to read video…and text…… you can connect with the target at a different orientation though… no closed captioning… you can physically move it closer but fingers don't zoom….

2) Blippar- create a "blipp"….upload a "marker" for your blipp…. "hint: for best results…should be jpeg.. 300-8000 pixels… mine lacks enough detail??

uploads… selected movie… under settings… on the video… there is a way to go to advanced settings…

it takes a while for the marker to connect to blippar… but once it does.. you can move it around and orient it in different ways… it is not sensitive… and locked in!… very clear quality…

(blipp setting… portrait/landscape…. sizing…)… you can adjust zoom….and other options of replaying… rewinding… fastforwarding…(15 s) and pausing…

3) ARTutor—-

select AR books….

click on new book… title, description, category… language… book… upload new file— save book….

add asset… open "book" to select target image… save selection (top of page) as target image….

click on augmentation selection… and browse— choose…. save asset…

A little tricky to tell if you are saving the right information…

The target is quickly detected (no need to press anything) and locks in securely… orientation is changeable… and you can move it closer/further without difficulty… you can zoom using fingers….you can pause by pressing the video…and restart by pressing it again…(stop/start… bigger… smaller…)… keeps playing… does not always play audio—- not sure why….

seems hard to use with accessibility features on iPhone….

Compared to Blippar and HP Reveal… you have to select the "book" so that it looks for the correct target image… Blippar… has a moving/wavy circle… HP Reveal has 4-5 bubble/circles that move in and out to detect the target…

4) Metaverse

Click on create experience—- looks like an iPod… grey/silver….. you can type in a speech bubble "Are you ready to start your Osmosis Egg Experiment?"… no choice on text font or size…….click on grey buttons… to answer… yes or no… ..they turn blue.. ad you can type

whatever answers on there… then link yes to transition to next scene…click on image to use from template… some google image.. 2D, 3D…gyfat stickets…(not WCAG 2.0)

+ add new—- selection of scenes….selected “youtube” to connect to youtube for AR… copy and paste youtube link…. or try uploading video …. many templates.. not necessarily WCAG 2.0 compatible…

You go to the app- metaverse… scan the QR code…. perhaps include QR code on paper… and it links automatically to the scene— you must move the mobile device up… the text is typed in..“are you ready to start….”… click “yes” and it leads to youtube video… the video is locked in….you can change orientation… and move it around… but you can’t select closed captioning that youtube provides as an option…

Not really an AR experience in the same way… no “real-life” connection…. unless there is a way to share the QR code on the PDF of the experiment—-

I was able to do a screen capture and copy and paste the QR code into the document about the experiment…. therefore it functions in a very similar way…

the video is the youtube video but without closed captioning.. and you cannot zoom in.. but you can change orientation… and you can pause.. but not rewind.

The best ways that MAR is used… can be both **assistive**… AT- mobile device with voiceover, closed captioning…. low-vision,….

And **therapeutic**… as in for ADHD, autism, depression/anxiety, cerebral palsy, stroke, memory,

And in general is great for learning

1) in the context of real-world/authentic experiences, ESL & terminology

2) motivation,

3) autonomy

4) collaborate

5) multiple methods of learning/showing/motivating, UDL

6) theoretical concepts….

All of these authoring tools don't meet the basic accessibility conditions…

I tested using accessibility features of iPhone and none responded…. some trouble with ARTutor with voiceover…. because of increased interaction.

critical disability doesn't pair well with universal design— because it doesn't recognize the power structure… it doesn't mean that a person is marginalized when they have an imperfect user experience.. issues of disability must be acknowledge specifically

diversity of disabilities.. makes it very difficult to make technical standards…

accessibility practices were used in development of mobile devices— aspect rations, awkward keyboards, font, colors, simplifying pages… mobile phones and assistive devices…

accessibility/disability can advance and contain goals of usable media! not about customer choice and marketing,.. lack of access for poor, disabled, isolated, elderly….UD deny the lived experiences of people with disabilities "everyone is a little disabled"

choice NOT right… this is dangerous…

By going through the mobile accessibility app— I see that there were 4 errors with the video posted to youtube—

Youtube

1) video elements must have an audio description track

2) zooming and scaling must not be disabled

3) video elements must have captions

4) html must have a lang attribute

ARTutor

1) elements must have sufficient color contrast-2

2)

3) Id attribute value must be unique-1

4) zooming and scaling must not be disabled-1

5)

HPReveal

1) elements must have sufficient color contrast- 7

2) form elements must have labels-1

3) html elements must have a lang attribute-1

Blippar

1) elements must have sufficient color contrast - 8

2) html element must have a lang attribute-2

Metaverse

1) elements must have sufficient color contrast-2

2) links must have discernible text-3

3) image must have alternate text-5

4) zooming an scaling must not be disabled-2

The automatic tools used cannot accurately assess the success criteria because they only analyze specific urls… .not the entirety of the content— real-world target and virtual overlay- in this case animation…

I tried to use an url that could capture the content but HP Reveal in particular only allowed the url of the homepage to be copied… so this authoring tool's evaluation by the 3 tools was not representative at all…. for all 4 AT you could assume some of the results from youtube specifically related to the augmented experience/video… since the animation/overlay was the same for all….

There are real limitations in automatic tools but they should be able to assess minimum accessibility.

In practical terms— while I was actually using the authoring tools and mobile device— Blippar seemed to have the most features that would assist someone with disabilities in terms of mobility —- the video locked in and you could manipulate it with stop, start, fast-forward… zoom in and out and change orientation… HP Reveal was the most sensitive and seemed at least superficially the least accessible for mobility issues…

None of the authoring tools addressed minimum closed captioning problems …. to say nothing of the other disabilities.

How can MAR be used in distance education to reduce barriers that exist for students with disabilities…

Is it by function or actual disabilities—— WCAG is examining how cognitive function is a term that can encompass psychiatric disabilities, intellectual disabilities… learning disabilities… but is this representative of the disabling nature in our society of certain impairments— are all limited functions created equally?

creating this MAR I see the limitations in DE with gps—- which could really be interesting if you knew where your students were located…

separately there is real potential for distance education science experiments and theoretical concepts can definitely be helped through MAR if other considerations do not limit other people with disabilities.

technological terms….

what about collaboration? shared experiences with mobile devices….

There are no prompts— this would be the greatest help! asking if certain accessible criteria are there….

It was tricky using WCAG 2.0 automatic evaluators… but also mobile device tools… because it seemed to rely on specific urls… and you would have to run through each of them.. a manually evaluation is definitely needed. the mobile device tools are also supposed to evaluate the web

content through the mobile device… using WCAG 2.1 recommendations… as well as mobile device recommendations from WCAG…. all of these together could be used to examining the usability… but you might initially need to just ask— should I even be using MAR for this learning activity? what are the best ways to use this tool?

Something I did not develop was a scenario that gave feedback for students… meta verse is a good tool for this.. because there is some interaction and ability to "test" or assess students knowledge before progressing.. the other tools don't allow for this.

McMahon writes about UDL and accessibility in MAR as an assistive tool… and therapeutic but it can be more than that for actual "learning" activities.. experiences…

easy check-ins for novice users in accessibility issues to give them expert products would be beneficially for all students with disabilities as it removed obvious barriers… what about stigmas? can MAR do anything with this? deal with stigmas… social barriers. there are ideas in creating collaborations… I did not create a scenario that involved collaborations with other students.. this might be difficult to do in DE…. without having expertise— it's important that MAR is compatible with Assistive Tools (AT)—- you can have something check for this… or the Authoring Tool automatically does this….

using social media with MAR….. to increase communication and collaborations….a shared experiment? or other shared project….

Having students use MAR—- needs to be actually accessible for people with disabilities to create MAR part A for ATAG… this could be a very useful tool for evaluating/assessing students' understanding…

Is there a checklist or something that can be developed to see if the MAR is being used in an easy to understand context… can a student easily figure out how to use the mobile device to access the MAR? easy steps? learning curve… different levels of cognitive ability…. perhaps also in the assessment part… maybe examining understanding.

It's important to look at the context of MAR—not just the MAR… but the whole picture. how do you judge 3-D images in terms of accessibility? is there currently a way? videos/animations are a very popular way to relay information right now…. there are guidelines for videos in terms of accessibility… but what about 3-D aspects?Is the target image accessible? navigation is a very common way to use mobile devices… but this would include using GPS which seems difficult to incorporate in distance education.

No commonality.

The more control you had over the MAR the better this seems for accessiblity… as long as it was accessible in the way you could manipulate it… for screen readers… or contrast… or pressing buttons for mobility…. or other ways.

Reducing frustrations… and increasing confidence are 2 ways to fight barriers of anxiety…. either with guided practice or easy step-by-step methods… zone of proximal … Vygotsky… so

that the challenge is matched to the students abilities….

perhaps the task force on cognitive abilities will be better equipped to challenge web content in terms of other barriers not addressed in WCAG 2.1 or others…. in the future…. but can you really just check boxes to ensure accessibility? …. comprehensive evaluation…. heuretics… experts in accessibility evaluations…ideally the authoring tools allow you to be an expert… or at least minimally accessible in your MAR creations as a distance educator.

Appendix F: Codes and Themes of Research Journal Analysis

Table 1 Codes and Themes from Research Journal Data

+ add new—- selection of scenes….selected "youtube" to connect to youtube for AR… copy and paste youtube link…. or try uploading video …. many templates.. not necessarily WCAG 2.0 compatible…	**Creation of MAR**	**Current Testing**
target image needed to meet the unique traits so that it could be used as a target image	**Creation of MAR**	**Current Testing**
1) HP Reveal—- create aura— "click"…. create trigger… or target… select image…	**Creation of MAR**	**Current Testing**
2) Blippar- create a "blipp"….upload a "marker" for your blipp…. "hint: for best results…should be jpeg.. 300-8000 pixels… mine lacks enough detail?? uploads… selected movie… under settings… on the video… there is a way to go to advanced settings…	**Creation of MAR**	**Current Testing**
3) ARTutor—- select AR books…. click on new book… title, description, category… language… book… upload new file— save book…. add asset… open "book" to select target image… save selection (top of page) as target image…. click on augmentation selection… and browse— choose…. save asset… A little tricky to tell if you are saving the right information…	**Creation of MAR**	**Current Testing**
Click on create experience—- looks like an iPod… grey/silver….. you can type in a speech bubble "Are you ready to start your Osmosis Egg Experiment?"… no choice on text font or size…….click on grey buttons… to answer… yes or no… ..they turn blue.. ad you can type whatever answers on there… then link yes to transition to next scene…click on image to use from template… some google image.. 2D, 3D…gyfat stickets…(not WCAG 2.0)	**Creation of MAR**	**Current Testing**

Table 1 Codes and Themes from Research Journal Data

I was able to do a screen capture and copy and paste the QR code into the document about the experiment…. therefore it functions in a very similar way…	**Creation of MAR**	**Current Testing**
you have to select the "book" so that it looks for the correct target image	**Operating MAR**	**Current Testing**
Blippar… has a moving/wavy circle… HP Reveal has 4-5 bubble/circles that move in and out to detect the target…	**Operating MAR**	**Current Testing**
You go to the app- metaverse… scan the QR code…. perhaps include QR code on paper… and it links automatically to the scene— you must move the mobile device up… the text is typed in.."are you ready to start…."… click "yes" and it leads to youtube video… the video is locked in….you can change orientation… and move it around…	**Operating MAR**	**Current Testing**
All of these authoring tools don't meet the basic accessibility conditions…	**results of test-automatic tool**	**Current Testing**

Table 1 Codes and Themes from Research Journal Data

By going through the mobile accessibility app— I see that there were 4 errors with the video posted to YouTube— YouTube 1) video elements must have an audio description track 2) zooming and scaling must not be disabled 3) video elements must have captions 4) html must have a lang attribute ARTutor elements must have sufficient color contrast-2 Id attribute value must be unique-1 zooming and scaling must not be disabled-1 HPReveal elements must have sufficient color contrast- 7 form elements must have labels-1 html elements must have a lang attribute-1 Blippar elements must have sufficient color contrast - 8 html element must have a lang attribute-2 Metaverse elements must have sufficient color contrast-2 links must have discernible text-3 image must have alternate text-5 zooming an scaling must not be disabled-2	**results of test-automatic tool**	**Current Testing**
The target is quickly detected (no need to press anything) and locks in securely	**results of test-manually**	**Current Testing**
you can physically move it closer but fingers don't zoom….	**results of test-manually**	**Current Testing**
Hard to read video…and text…… you can connect with the target at a different orientation though… no closed captioning…	**results of test-manually**	**Current Testing**

Table 1 Codes and Themes from Research Journal Data

orientation is changeable… and you can move it closer/further without difficulty… you can zoom using fingers….you can pause by pressing the video…and restart by pressing it again…(stop/start… bigger… smaller…)… keeps playing…	**results of test-manually**	**Current Testing**
does not always play audio—- not sure why….	**results of test-manually**	**Current Testing**
and you cannot zoom in.. but you can change orientation… and you can pause.. but not rewind.	**results of test-manually**	**Current Testing**
Can't really move things back and forth.. hard to read text… and video doesn't have cc'd…. Each AT requires logging in…then each has different steps…	**results of test-manually**	**Current Testing**
it takes a while for the marker to connect to blippar… but once it does.. you can move it around and orient it in different ways… it is not sensitive… and locked in!… very clear quality… (blipp setting… portrait/landscape…. sizing…)…	**results of test-manually**	**Current Testing**
but you can't select closed captioning that youtube provides as an option…	**results of test-manually**	**Current Testing**
None of the authoring tools addressed minimum closed captioning problems …. to say nothing of the other disabilities.	**results of test-manually**	**Current Testing**
you can adjust zoom….and other options of replaying… rewinding… fastforwarding…(15 s) and pausing…	**results of test-manually**	**Current Testing**

Table 1 Codes and Themes from Research Journal Data

In HP Reveal there are errors in masking… similar images… leading to jittery video… and also an error in overlay position—- the target image no longer matches the video……. HP Reveal— it's difficult for the image to latch on to target image on paper….	**results of test-manually**	**Current Testing**
Perhaps the best way is to have people with disabilities but also testing with accessibility settings… could work—	**ways to test-accessibility experts**	**Current Testing**
software tools can be used in conjunction to meet requirements of part B— an accessibility checking tool can be used in conjunction with the main authoring tool Some of the success criteria need to meet WCAG 2.0 success criteria for level A so using the automatic evaluators will be useful.	**ways to test-automatic tool**	**Current Testing**
Can MAR developers and/or educators use automatic testing to ensure accessibility of MAR for students with disabilities in distance education?	**ways to test-automatic tool**	**Current Testing**
Which properties can be evaluated using automated tools? W3C has guidelines that line-up with four properties: Perceivable: information and interface comments must be perceivable by users Operable: user interface and navigation must be operable Understandable: users must information and the operation of the user interface Robust: content must be robust enough to be interpreted reliably by wide variety of user agents-including assistive technologies	**ways to test-automatic tool**	**Current Testing**
There are several studies now that are examining automatic testing for mobile apps—- which has a clear tie with MAR- mobile augmented reality apps.	**ways to test-automatic tool**	**Current Testing**
But how would you evaluate this?	**ways to test-automatic tool**	**Current Testing**

Table 1 Codes and Themes from Research Journal Data

the mobile device tools are also supposed to evaluate the web content through the mobile device…	**ways to test-automatic tool**	**Current Testing**
but I need to check their accessibility…..using the automatic evaluators…	**ways to test-automatic tool**	**Current Testing**
can you really get enough variety of disabilities to accurately test everything?	**ways to test-critique**	**Current Testing**
What about "real" versus "augmented"?	**ways to test-critique**	**Current Testing**
It's important to look at the context of MAR—not just the MAR… but the whole picture.	**ways to test-critique**	**Current Testing**
What about the total user experience? The guidelines don't consider that AR is the relationship between online or virtual and real-life…. it is not one or the other so ATAG is inherently inadequate… nothing currently exists to provide a framework or guide to help developers and/or educators.	**ways to test-critique**	**Current Testing**
how do you judge 3-D images in terms of accessibility? is there currently a way?	**ways to test-critique**	**Current Testing**
diversity of disabilities.. makes it very difficult to make technical standards…	**ways to test-critique**	**Current Testing**
There are other considerations that don't fall into the Authoring Tool Guidelines…. (ATAG)—	**ways to test-critique**	**Current Testing**
The automatic tools used cannot accurately assess the success criteria because they only analyze specific urls… .not the entirety of the content— real-world target and virtual overlay- in this case animation…	**ways to test-critique**	**Current Testing**

Table 1 Codes and Themes from Research Journal Data

I tried to use an url that could capture the content but HP Reveal in particular only allowed the url of the homepage to be copied… so this authoring tool's evaluation by the 3 tools was not representative at all…. for all 4 AT you could assume some of the results from youtube specifically related to the augmented experience/video… since the animation/ overlay was the same for all…. There are real limitations in automatic tools but they should be able to assess minimum accessibility.	**ways to test-critique**	**Current Testing**
It was tricky using WCAG 2.0 automatic evaluators… but also mobile device tools… because it seemed to rely on specific urls…	**ways to test-critique**	**Current Testing**
but can you really just check boxes to ensure accessibility? …. comprehensive evaluation…. heuretics… experts in accessibility evaluations	**ways to test-critique**	**Current Testing**
threats to validity because of exploratory nature we may not have found all accessibility testing and analysis tools available…. or all AT MAR in my case ;)	**ways to test-critique**	**Current Testing**
As an author without disabilities I am not looking at my limitations or problems in creating these MAR learning scenarios…	**ways to test-critique**	**Current Testing**
a manually evaluation is definitely needed.	**ways to test-manually**	**Current Testing**
The most effective end-user evaluations are done with yes/no questions with little to no gray area… very clear questions and answers.	**ways to test-manually**	**Current Testing**
there are only some that someone with my limited experience could evaluate…	**ways to test-novice end-user**	**Current Testing**
HP Reveal was the most sensitive and seemed at least superficially the least accessible for mobility issues…	**ways to test-novice end-user**	**Current Testing**

Table 1 Codes and Themes from Research Journal Data

In practical terms— while I was actually using the authoring tools and mobile device— Blippar seemed to have the most features that would assist someone with disabilities in terms of mobility—- the video locked in and you could manipulate it with stop, start, fast-forward… zoom in and out and change orientation	**ways to test-novice end-user**	**Current Testing**
a Deaf person or person who has a hearing disability may never disclose or communicate their disability to the instructor/educator in a distance education situation….	**Defining barriers**	**Defining Disability**
A lot of the physical, sensorial and mobility disabilities are well-recognized and though there are stigmas of being victims… someone to be pitied… or conversely as having "superpowers" with respect to development of other senses or compensations	**Defining barriers**	**Defining Disability**
BUT the cognitive, learning and psychiatric disabilities are disabilities that also have stigmas … as people who are weak or "less-then" or not even believed…. they are the "invisible" disabilities and many students do not advocate for themselves or even communicate their disabilities to others in a education situation	**Defining barriers**	**Defining Disability**
One thing to consider is that many people will eventually have a disability or will be disabled by society in some capacity—- limited hearing, mobility, sight…..	**Defining disability**	**Defining Disability**
What about intersectionality? and/or more than one disability?	**Defining disability**	**Defining Disability**
Cognitive disability is the largest disability group!	**Disability not in WCAG 2.0**	**Defining Disability**
Certain aspects of learning/cognitive disabilities are not included in ATAG… and no psychiatric disabilities. Certain mobility aspects are not considered either.	**Disability not in WCAG 2.0**	**Defining Disability**

Table 1 Codes and Themes from Research Journal Data

Lots of great work with this task force…but does not include depression and/or anxiety or other psychiatric disabilities…	**Disability not in WCAG 2.0**	**Defining Disability**
1) Perception and processing, 2) memory, 3) problem solving, 4) attention	**Function Impairments= Cognitive Disability**	**Defining Disability**
may be limited by barriers to memory, problem-solving, attention, reading, linguistic, and verbal comprehension, math comprehension and visual comprehension	**Function Impairments= Cognitive Disability**	**Defining Disability**
The research describes challenges in the areas of attention, executive function, knowledge, language, literacy, memory, perception, and reasoning.	**Function Impairments= Cognitive Disability**	**Defining Disability**
includes people with learning disabilities, developmental disabilities, attention disorders and neurological impairments—-	**Function Impairments= Cognitive Disability**	**Defining Disability**
Principles to guide creation of accessible content for people with cognitive disabilities (may include dyslexia, dysgraphia, dyscalculia, ADHD, autism, Down syndrome, fetal alcohol syndrome….) and people with cognitive disabilities	**Function Impairments= Cognitive Disability**	**Defining Disability**
Can cognitive disability also be connected to psychiatric disabilities—- one article lists a connection to attention and memory, language, executive function, problem solving and social interaction— very similar to previous paper—	**Function Impairments= Cognitive Disability**	**Defining Disability**
Is it by function or actual disabilities—— WCAG is examining how cognitive function is a term that can encompass psychiatric disabilities, intellectual disabilities… learning disabilities… but is this representative of the disabling nature in our society of certain impairments	**Function Impairments= Cognitive Disability**	**Defining Disability**

Table 1 Codes and Themes from Research Journal Data

It is organized by user groups of the following disabilities: Aging-Related Cognitive Decline, Aphasia, Attention Deficit Hyperactivity Disorder, Autism, Intellectual Disability, Dyscalculia, Dyslexia, and Non-Verbal.	**Function Impairments= Cognitive Disability**	**Defining Disability**
On the optimistic side, such tools could serve the dual purpose of increasing disability access for people with disabilities as well as overall usability for all users."	**"accessibility for all"/UDL-critique**	**Framework Foundation**
Such tools would require hefty investments of time and money.	**"accessibility for all"/UDL-critique**	**Framework Foundation**
the push to create something that helps everyone is a great marketing tool as in Universal Design and also Universal Design for Learning but the focus should be for people with disabilities because they are the ones limited in education- in this context.	**"accessibility for all"/UDL-critique**	**Framework Foundation**
The more I think about Universal Design for Learning… the more I struggle with lessons that are one size fits all. It is great to have options for students ("multi-modal means" of presenting, motivating and evaluating) and definitely try to make the learning experiences accessible for as many people with disabilities as possible- however people with disabilities are so varied and unique that you always have to consider the specifics of your students.	**"accessibility for all"/UDL-critique**	**Framework Foundation**
accessibility/disability can advance and contain goals of usable media! not about customer choice and marketing,.. lack of access for poor, disabled, isolated, elderly….UD deny the lived experiences of people with disabilities "everyone is a little disabled"	**"accessibility for all"/UDL-critique**	**Framework Foundation**
choice NOT right… this is dangerous…	**Critical Disability Theory**	**Framework Foundation**
are all limited functions created equally?	**Critical Disability Theory**	**Framework Foundation**

Table 1 Codes and Themes from Research Journal Data

critical disability doesn't pair well with universal design— because it doesn't recognize the power structure… it doesn't mean that a person is marginalized when they have an imperfect user experience.. issues of disability must be acknowledge specifically	**Critical Disability Theory**	**Framework Foundation**
Critical disability theory emphasizes that people who are disabled in society should be considered as priority in removing barriers….	**Critical Disability Theory**	**Framework Foundation**
Looking at ATAG- the guidelines are proposed to have benefits for everyone and not only people with disabilities but using critical theory as a guiding principle, the benefits should be specifically for people with disabilities who are the ones limited in society and anyone else who benefits— that's just a bonus.	**Critical Disability Theory**	**Framework Foundation**
"Conceptual exploration of possibilities" WebAIM not a tool…. is it a model or concept. Conceptual Framework for Accessibility Tools to Benefit Users with Cognitive Disabilities Conceptual Framework for MAR Accessibility Tools to Benefit Students with Disabilities	**Exploring Conceptual Framework**	**Framework Foundation**
-Grabinger, S. (2009). A framework for supporting postsecondary learners with psychiatric disabilities in online environments. In Proceedings of the 8th European Conference on e-Learning: ECEL (p. 236). Academic Conferences Limited.	**Exploring Conceptual Framework**	**Framework Foundation**
existing accessibility frameworks? compare to mobile app testing?	**Exploring Conceptual Framework**	**Framework Foundation**
How can MAR be used in distance education to reduce barriers that exist for students with disabilities…	**Exploring Conceptual Framework**	**Framework Foundation**
What is a conceptual framework? It's concepts that are linked together to explain a phenomenon— qualitative research	**Exploring Conceptual Framework**	**Framework Foundation**

Table 1 Codes and Themes from Research Journal Data

What about functional disability versus This framework consists of: categories of functional cognitive disabilities, principles of cognitive disability accessibility, units of web content analysis, aspects of analysis, stages of analysis, and realms of responsibility.	**Exploring Conceptual Framework**	**Framework Foundation**
At which point for designers should authoring tools for MAR be examined: planning, design, testing and after content is complete—- we are examining "final products" but these products are continually being updated so that is a factor to consider as well.	**Exploring Conceptual Framework**	**Framework Foundation**
This might be useful to incorporate—- better to make changes for accessibility beforehand… save on time and money. As opposed to retrofitting the learning experience to make it accessible.	**Exploring Conceptual Framework**	**Framework Foundation**
Will we look at this framework for authoring tool developers or end-users? An authoring tool that has checkpoints throughout the development process to check on accessibility…. this is developed by an authoring tool developer based on the conceptual framework.	**Exploring Conceptual Framework**	**Framework Foundation**
A framework would consider the best ways to use augmented reality….	**Exploring Conceptual Framework**	**Framework Foundation**
I think a framework that looks at AR currently and the real-benefits for people with certain impairments… matched with the characteristics of the technology that benefit in certain areas of learning… is a good place to start… with follow-up in areas that should be further explored.	**Exploring Conceptual Framework**	**Framework Foundation**
There is WCAG 2.0 and 2.1 but also Revised 508 Non-web Software Checkpoints—-	**Exploring Conceptual Framework**	**Framework Foundation**

Table 1 Codes and Themes from Research Journal Data

Including Authoring Tools 504— mainly related to ATAG 2.0… check IBM Checkpoints…	**Exploring Conceptual Framework**	**Framework Foundation**
barriers? limits?	**Exploring Conceptual Framework**	**Framework Foundation**
which studies and recommendations?	**Exploring Conceptual Framework**	**Framework Foundation**
videos/animations are a very popular way to relay information right now…. there are guidelines for videos in terms of accessibility… but what about 3-D aspects?	**Exploring Conceptual Framework**	**Framework Foundation**
easy check-ins for novice users in accessibility issues to give them expert products would be beneficially for all students with disabilities as it removed obvious barriers…	**Accessibility check**	**Principles**
ideally the authoring tools allow you to be an expert… or at least minimally accessible in your MAR creations as a distance educator.	**Accessibility check**	**Principles**
Many educators aren't familiar with accessibility considerations- or don't automatically consider them. Training is useful but a program/tool/platform that allowed you to produce products as an expert in accessibility issues would be ideal…..	**Accessibility check**	**Principles**
Any tool should provide a checklist for authors that can help ensure that the AR scenarios are as accessible as possible.	**Accessibility check**	**Principles**
without having expertise— it's important that MAR is compatible with Assistive Tools (AT)—- you can have something check for this… or the Authoring Tool automatically does this….	**Accessibility check**	**Principles**

Table 1 Codes and Themes from Research Journal Data

when creating MAR, there is nothing that makes you question whether the target image and/or video is accessible or not.	**Accessibility check**	**Principles**
I am ultimately looking at how useful these authoring tools are in creating accessible MAR—- there were no prompts to check for closed captioning…	**Accessibility check**	**Principles**
There is no prompt for clear text—- some of the tablets used existing images and text templates…	**Accessibility check**	**Principles**
Is the target image accessible?	**Accessibility check**	**Principles**
One of the first things I noticed, is that none of the authoring tools seem to mention accessibility features and/or prompts to look at accessibility features…	**Accessibility check**	**Principles**
There are no prompts— this would be the greatest help! asking if certain accessible criteria are there….	**Accessibility check**	**Principles**
Some of the concerns that I found is that none of the platforms promote accessibility features or use prompts to include or consider accessibility.	**Accessibility check**	**Principles**
Reducing frustrations… and increasing confidence are 2 ways to fight barriers of anxiety…. either with guided practice or easy step-by-step methods… zone of proximal … Vygotsky… so that the challenge is matched to the students abilities….	**Ideas for Guidelines - impairments**	**Principles**

Table 1 Codes and Themes from Research Journal Data

Anxiety/depresssion… many youth— growing number of people have disabilities that include psychiatric disabilities ….how does web content relate? barriers include: and suggestions to remove… 1) urgency- rushing— stop the clock— give enough time… 2) unpredictable don't leave users confused about timelines or next steps or leave people uncertain about their actions— manage expectations— explain what will happen next- make important information clear 3) powerlessness- remove friction- make help or support hard to find/give support (option to cancel hard to find) or apply friction…(check answers before submitting) don't leave users questioning answers they gave 4) sensationalism- keep it real—-clickbait headlines!	**Ideas for Guidelines - impairments**	**Principles**
1) Simple 2) Consistent 3) Clear 4) Multi-modal 5) Error-tolerant 6) Delay-tolerant 7) Attention-focusing are principles to follow with cognitive disabilities…..	**Ideas for Guidelines - impairments**	**Principles**
can a student easily figure out how to use the mobile device to access the MAR? easy steps?	**Ideas for Guidelines - impairments**	**Principles**

Table 1 Codes and Themes from Research Journal Data

For WCAG 2.1 there was a Cognitive and Learning Disabilities Task Force…(COGA?) That resulted in 4 new success criterion— other success criterion could also benefit people with cognitive disabilities but not specifically…. 1.3.5 Identity Input Purpose—- autocomplete (level AA) 1.3.6 Identity Purpose (level AAA)—- icons versus words— may confuse people.. must offer multiple modes…. AT can read in mark-up language the purpose.. 2.2.6 Timeouts (level AAA) user must be informed on length of time for activity or information is lost… 2.2.7 Animation from Interactions (level AAA) possible to disable motion animation that might distract from essential information..	**Ideas for Guidelines - impairments**	**Principles**
learning curve… different levels of cognitive ability…	**Ideas for Guidelines - impairments**	**Principles**
perhaps the task force on cognitive abilities will be better equipped to challenge web content in terms of other barriers not addressed in WCAG 2.1 or others…. in the future	**Ideas for Guidelines - impairments**	**Principles**
Learning Disabilities: - instructions clear and easy to understand & age appropriate - help messages are easy to access - appropriate screen formatting - feedback is appropriate and relevant - multiple levels of mastery and appropriate cues and prompts to responses	**Ideas for Guidelines - impairments**	**Principles**
… I made mine black and white which touches on people with colour blindness… but I could have made it with the full colour spectrum.	**Ideas for Guidelines - impairments**	**Principles**
Is there a checklist or something that can be developed to see if the MAR is being used in an easy to understand context…	**Ideas for Guidelines - impairments**	**Principles**

Table 1 Codes and Themes from Research Journal Data

* vestibular disorders (motion sickness prevention, slow down movement i space, input support)	**Ideas for Guidelines - impairments**	**Principles**
* cognitive disabilities (tutorial, playground mode, level difficulty, intuitive menus, perspective, customization, context guidance)	**Ideas for Guidelines - impairments**	**Principles**
* deaf/hard of hearing (ambient noice indicator, text indicators, closed captioning, giving emotions and feelings not just text)	**Ideas for Guidelines - impairments**	**Principles**
*visual disabilities (audio cue, change of size/color text, colorblind options, zoom without getting physically closer, audio placement)	**Ideas for Guidelines - impairments**	**Principles**
I know that when students need to use tablets or smart phones to access the MAR—- there is no consideration of mobility of the user	**Ideas for Guidelines -mobile devices**	**Principles**

Table 1 Codes and Themes from Research Journal Data

WCAG 2.0 also recommends: 1) minimize the amount of info on each page compared to desktop/laptop 2) position form fields below their labels, rather than beside 3) make all functionality operable thorough a keyboard interface 4) gestures should be as easy as possible to carry out- widgets requiring complex gestures can be difficult or impossible to use for screen readers users 5) interactive elements should be positioned where they can easily be reached- when the device is held in different positions 6) mobile applications should support both orientations once some users have either mobile devices mounted in a fixed orientation— changes in orientation must be programmatically expressed to ensure detection by assistive technology 7) position important information so it is visible without scrolling 8) labels or instructions are provided when content requires user input 9) context-sensitive help should be available 10) reduce amount of text entry needed by providing select menus,, radio buttons or check boxes..	**Ideas for Guidelines -mobile devices**	**Principles**
accessibility practices were used in development of mobile devices— aspect ratios, awkward keyboards, font, colors, simplifying pages… mobile phones and assistive devices…	**Ideas for Guidelines -mobile devices**	**Principles**

Table 1 Codes and Themes from Research Journal Data

1) audio and video: subtitles, sign language, audio description and transcripts- audio must not play automatically unless the user is made aware or a pause/stop/mute button is provided; relevant metadata should be provided 2) design: color of text and background content must have sufficient contrast; information or meaning must not be covered by color only, core content must still be accessible when styling is unsupported or removed, touch targets must be large enough to be touched accurately- an inactive space should be provided around actionable elements, users must be able to control font sizing and user interface scaling; links and other actionable elements must be clearly distinguishable; all actionable and focusable elements must have a visible state change; user's experience should be consistent, interfaces must provide multiple ways to interact with content, interactive media including games should be adjustable for user ability and preference and content must not visibly or intentionally flicker or flash more than three times in any one-second period 3) Editorial: consistent labelling should be used across websites and native applications as well as with websites and applications; the language must be indicated when needed, additional instruction should be provided to supplement visual and audio cues… 4) Focus: all interactive elements must be focusable and inactive elements must not be focusable 5) Forms: all form controls must be labelled; a adult input format must be indicated and supported, labels must be placed close to relevant form control and laid out appropriately; controls, labels an other form elements must be properly grouped. 6) Images: images of text should be avoided and background images that convey information or meaning must have additional accessible alternative	**Ideas for Guidelines -mobile devices**	**Principles**

Table 1 Codes and Themes from Research Journal Data

Some things to ensure—- No time-based video or audio—- enough time for closed captioning…. text to speech compatibility with video or images… info continuity between portrait and landscape info presentable for people with colour-blindness no seizure inducing light flashes adjustable time for people with LD or visual processing impairments navigation aides to find content and info adjustable size text, color and brightness in app future proof AT compatibility	**Ideas for Guidelines -mobile devices**	**Principles**
success criteria that is more comprehensive and relevant to today's technology—- mobile devices and cognitive impairments… 1.3 Adaptable— orientation doesn't effect information=— simpler for mobile devices that are smaller screened and moved horizontally or vertically 1.3. Orientation- 1.3.5 Identity Input Purpose 1.3.6 Identity Purpose 1.4 Distinguishable—- reflow, non-text contrast, text spacing, content on hover or focus 2.1 Keyboard Accessible — character key shortcuts, 2.2 Enough time- timeouts, 2.3 Seizures and physical reactions—— animation from interactions, 2.5 Input Modalities- pointer gestures, pointer cancellation, label in name, target size 4.1 Compatible— status messages Addresses some cognitive and learning disabilities…. and low visions… not expressly found in WCAG 2.0	**Ideas for Guidelines -mobile devices**	**Principles**
inclusion included multiple modes of interaction:	**Ideas for Guidelines-MAR**	**Principles**
but you might initially need to just ask— should I even be using MAR for this learning activity? what are the best ways to use this tool?	**Ideas for Guidelines-MAR**	**Principles**

Table 1 Codes and Themes from Research Journal Data

Overall— the system controls need to be accessible (powering on/off), accessing sensors and hardware, setup, navigating menus, accessing communication, browsers…	**Ideas for Guidelines-MAR**	**Principles**
barriers to accessibility in VR/AR as: 1) heavy emphasis on motion controls 2) specific requirements on positioning in the space 3) strict hardware guidelines 4) limited audio 5) core-reliance on visual stimulus	**Ideas for Guidelines-MAR**	**Principles**
Interaction and Input controls: voice control and recognition, motion and gesture recognition, eye and head tracking, keyboard/controller, sensor, mobile device as input for other devices… IE. motion control and motion through space…. maybe you don't need to move the mobile	**Ideas for Guidelines-MAR**	**Principles**
The other authoring tools required the student to line-up the target image so that the app could recognize the overlay and play the video… this again would limit certain students with dexterity and mobility issues…. if the response is slow… and hard to line-up… this could effect students with cognitive disabilities… they would question if it is working even.	**Ideas for Guidelines-MAR**	**Principles**
The more control you had over the MAR the better this seems for accessiblity	**user control**	**Principles**
as long as it was accessible in the way you could manipulate it… for screen readers… or contrast… or pressing buttons for mobility…. or other ways.	**user control**	**Principles**
The best ways that MAR is used… can be both assistive… AT- mobile device with voiceover, closed captioning…. low-vision,….	**MAR as tool**	**Uses of MAR**
McMahon writes about UDL and accessibility in MAR as an assistive tool…	**MAR as tool**	**Uses of MAR**

Table 1 Codes and Themes from Research Journal Data

autonomy	**MAR as tool**	**Uses of MAR**
autonomy	**MAR as tool**	**Uses of MAR**
The tablet or mobile device becomes the familiar link for many students and comfort bridge for that interaction.	**MAR as tool**	**Uses of MAR**
as a bridge between virtual and real?	**MAR as tool**	**Uses of MAR**
And therapeutic… as in for ADHD, autism, depression/anxiety, cerebral palsy, stroke, memory,	**MAR as tool**	**Uses of MAR**
Can it address students with other disabilities besides learning/cognitive and sensorial and mobility? What about psychosocial/psychiatric disabilities? autism, depression/anxiety… there is a lot of research on how augmented reality can create accessible situations for students on the autism spectrum…. can it help students with other psychiatric disabilities? such as bi-polar and/or depression and anxiety as we have seen the prevalence of this disability increase in younger students…. is it the tablets? can AR help create accessibility in this area?	**MAR as tool**	**Uses of MAR**
it would be interesting to examine psychiatric disabilities… there is potential in the "real-world" interaction with the natural world and with real people in real-time… being outside and interacting with people directly or in-person seems to show positive results for people with depression and anxiety.	**MAR as tool**	**Uses of MAR**
and therapeutic but it can be more than that for actual "learning" activities.. experiences…	**MAR as tool**	**Uses of MAR**
And in general is great for learning in the context of real-world/authentic experiences, ESL & terminology	**MAR for learning**	**Uses of MAR**
authentic situations	**MAR for learning**	**Uses of MAR**
What are the best ways to use AR real-world/authentic situations	**MAR for learning**	**Uses of MAR**

Table 1 Codes and Themes from Research Journal Data

collaborate	**MAR for learning**	**Uses of MAR**
there are ideas in creating collaborations… I did not create a scenario that involved collaborations with other students.. this might be difficult to do in DE	**MAR for learning**	**Uses of MAR**
using social media with MAR….. to increase communication and collaborations….a shared experiment? or other shared project….	**MAR for learning**	**Uses of MAR**
collaboration,	**MAR for learning**	**Uses of MAR**
what about collaboration? shared experiences with mobile devices….	**MAR for learning**	**Uses of MAR**
motivation,	**MAR for learning**	**Uses of MAR**
motivation	**MAR for learning**	**Uses of MAR**
multiple methods of learning/showing/motivating, UDL	**MAR for learning**	**Uses of MAR**
Best ways to use AR in distance education for accessibility——multi-modal learning,	**MAR for learning**	**Uses of MAR**
and multi-modal learning…	**MAR for learning**	**Uses of MAR**
navigation is a very common way to use mobile devices… but this would include using GPS which seems difficult to incorporate in distance education. No commonality.	**MAR for learning**	**Uses of MAR**
There is some concern of people with visual disabilities accessing this technology—- but eventual options could help with navigation—- in my case, I am not looking at location AR so this point does not apply…	**MAR for learning**	**Uses of MAR**

Table 1 Codes and Themes from Research Journal Data

theoretical concepts….	**MAR for learning**	**Uses of MAR**
theoretical concepts	**MAR for learning**	**Uses of MAR**
separately there is real potential for distance education science experiments and theoretical concepts can definitely be helped through MAR if other considerations do not limit other people with disabilities. technological terms….	**MAR for learning**	**Uses of MAR**
and theoretical concepts…..	**MAR for learning**	**Uses of MAR**
Something I did not develop was a scenario that gave feedback for students… meta verse is a good tool for this.. because there is some interaction and ability to "test" or assess students knowledge before progressing.. the other tools don't allow for this.	**MAR in evaluation**	**Uses of MAR**
Having students use MAR—- needs to be actually accessible for people with disabilities to create MAR part A for ATAG… this could be a very useful tool for evaluating/assessing students' understanding…	**MAR in evaluation**	**Uses of MAR**
It is also so important to consider Part A - author has disabilities and the authoring tool does not limit the author—- eventually because not only are there educators with disabilities but many educators are using the creation of MAR as a learning activity/ assessment and so students with disabilities would be limited in their experience if these students could not create the MAR.	**MAR in evaluation**	**Uses of MAR**
perhaps also in the assessment part… maybe examining understanding.	**MAR in evaluation**	**Uses of MAR**

Table 1 Codes and Themes from Research Journal Data

Some disabilities are more compatible with augmented reality such as hearing impairment….. autism, cognitive disability and learning disability….	**MAR match to disability**	**Uses of MAR**
dexterity and visual impairment issues can be limiting now with AR's current strong connection to specific movement and position in space to link with target image	**MAR match to disability**	**Uses of MAR**
Which studies: autism, mobility, ADHD, cognitive disabilities, hard of hearing/hearing impairments, ESL,	**MAR match to disability**	**Uses of MAR**
what about stigmas? can MAR do anything with this? deal with stigmas… social barriers.	**MAR match to disability**	**Uses of MAR**
what types of disabilities?	**MAR match to disability**	**Uses of MAR**