Augmented reality reading support in higher education: Exploring effects on perceived motivation and confidence in comprehension for struggling readers in higher education

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Augmented reality reading support in higher education: Exploring effects on perceived motivation and confidence in comprehension for struggling readers in higher education

by

Laura Anne Huisinga

A dissertation submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Major: Human Computer Interaction

Program of Study Committee:
Larysa Nadolny, Major Professor
Anne Estapa
Alex Braidwood
Fred Malven
Judy Vance

Iowa State University

Ames, Iowa

2017

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DEDICATION

I would like to dedicate this dissertation to my parents, Wes and Lisa Huisinga. Their unwavering love and support have allowed me to pursue my dreams and forge them into realities. I would also like to dedicate this to Glenn Terpstra who encourages me daily and puts up with all my quirks as well as the roller-coaster of emotion that comes with writing a dissertation.

I love you all, and thank you for your support.
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ABSTRACT

Technology has shown promise to aid struggling readers in higher education, particularly through new and emerging technologies. Augmented reality (AR) has been used successfully in the classroom to motivate and engage struggling learners, yet little research exists on how augmented print might help struggling readers. This study explores this gap, specifically art/design students in higher education and their perceived motivation to read, as well as their engagement with, and comprehension of an augmented design theory text. This study employed an exploratory, mixed methods design. Analysis of the findings indicates most students, including self-identified struggling and typical readers, would use AR support for other text if provided. Results highlight the potential for using AR on text to provide reading support and the need for additional research on its implementation and impact.
CHAPTER 1. INTRODUCTION

Background

Augmented reality (AR) can engage and motivate students by allowing them to experience content through multiple mediums. AR can be defined as a Medium wherein digital information overlays the physical world; dependent on the perspective of the individual interacting with and experiencing the AR Medium (Caudell, 1992; Azuma, 1997; Kaufmann, 2003; Zhou, Dah & Billinghurst, 2008; and Craig, 2013). Digital handheld devices such as smartphones or Tablets provide one way to experience AR by overlaying digital content with the physical environment. The camera of the device can recognize physical content using natural feature tracking or GPS coordinates to trigger the augmented content. By looking through the handheld digital device, a viewer sees the digital content overlaid with the real-time image pulled in through the camera. AR allows for digital resources to infuse the world of non-digitally connected items. For instance, AR can add digital support and aids for struggling readers to use with non-digital printed text and books. This connectivity of the physical world resources augments students’ experience and understanding (Dunleavy, Dede, & Mitchell, 2009).

Research has shown that AR can improve engagement and motivation. During a study conducted by Dunleavy, Dede, & Mitchell (2009) an interviewed teacher stated “One of the greatest challenges for classroom teachers is trying to engage students who are unmotivated in conventional classrooms. The finding that these students are highly engaged during an AR unit is significant and encouraging”. Using AR with a text could increase engagement and motivation for struggling readers. AR allows for information to be experienced through channels other than printed text (Billinghurst, & Denser, 2012). For instance, incorporation of 3D models can engage
struggling readers and promote deeper comprehension (Billinghurst, & Denser, 2012; Green, Lea, & McNair, 2014).

AR can be used in the classroom many ways. Some tools like Layar, Blippar and Aurasma can be used for creating augmented classroom content. Unfortunately, these tools can be cumbersome to work with or expensive. No streamlined AR tools exist specifically for teachers to build AR for classroom use. Of the three previously mentioned tools, Aurasma is the most cost effective for classroom use. Many teachers have experimented with Aurasma in the classroom and tutorials for its use in the classroom can be found online. Previous research has shown an emerging theme of high management overhead that accompanies AR (Dunleavy, Dede, & Mitchell, 2009). However, with AR creation apps like Aurasma, instructors and students are able to create and customize their educational AR experiences (Craig, 2013). This ability to create customized AR allows instructors to create reading support for struggling readers; however, currently that process can be time consuming.

By augmenting printed text with proven reading support such as explicit instruction practices like scaffolding, AR can aid struggling readers. Research supports explicit instruction practice, particularly when used for struggling learners (Archer, & Hughes, 2011; Kirschner, Sweller, & Clark, 2006; Marchand-Martella, Slocum, & Martella, 2004; Marchand-Martella, Martella, Modderman, Petersen, & Pan, 2013). Scaffolding, a component of direct, explicit instruction breaks down an issue by providing prompts for ideas and concepts during a learning activity (Azevedo, Cromley, & Seibert, 2004; Hill & Hannafin, 2001; Huang, Wu, & Chen, 2012). Additionally, vocabulary knowledge allows students to access, understand and apply content, “Vocabulary knowledge is content knowledge” (Templeton, Bear, Invernizzi, Johnston, Flanigan, Townsend, Helman, & Hayes, 2015). A study by Chen, Teng, & Lee (2011), showed
that scaffolded comprehension questions accessed digitally improved understanding. Since providing vocabulary and explicit instruction through scaffolding aids struggling readers, augmenting a printed text with these components should also assist struggling readers. The addition of this augmented support should improve perceived comprehension and confidence. Research has shown clear benefits of using AR and digital text for struggling readers, particularly when aligned with appropriate reading strategies. This augmented-reading-activity case study explores the use of scaffolded comprehension questions, vocabulary building, and content chunking through AR to combine proven teaching approaches and benefits of digital text with a printed document.

Statement of Problem

Printed text cannot access the advantages of digital text, such as built-in dictionaries or Text to Speech (TTS) (Billinghurst, & Denser, 2012). Digital text allows for different modes of reading and writing (Biancarosa, & Griffiths, 2012; Hutchison et al. 2012; Lankshear & Knobel, 2003; Leu, Kinzer, Coiro, & Cammack, 2004; Leu, 2006). While e-textbooks are available for some fields, art/design theory/history e-texts are not always available. Billinghurst, & Denser (2012) examined AR in the classroom and concluded that AR created a significant benefit to students struggling with traditional print text-based learning. Little research exists on providing digital scaffolding and visual reading aids in conjunction with printed material through AR for higher education students. Billinghurst, & Denser (2012) concluded that there was a significant benefit to struggling readers when using AR in the classroom but more research was needed.
Purpose of Study

This study aims to explore gaps in the research literature, including: (1) looking at struggling readers in higher education, (2) exploring the use of AR for reading support, and (3) using AR in the classroom. AR technology has changed due to rapidly evolving smartphone and Tablet devices and increasing access to AR in the classroom. As AR technologies advance, researchers should reevaluate how best to use AR in the classroom. Early AR may have been too cumbersome, the challenges of using it outweighing the benefits. Now with advanced mobile technology, the benefits of AR in the classroom outweigh any negatives.

Research Question

The guiding question of the study was: How does augmented text impact struggling readers’ perceived motivation, engagement and confidence in understanding?

The areas of investigation include: (1) the level of motivation a design student has to read a design theory text, (2) engagement with vocabulary acquisition and (3) comprehension of academic text in higher education. This study addressed how the use of an augmented printed text, enhanced with instructional scaffolds and visual aids, influences these three main areas.

Definition of Terms

Augmented Reality (AR): a medium in which digital information overlays the physical world. The experience of that medium depends on the physical location or perspective of the individual interacting with the AR interface.

Struggling Reader: refers to a vast, diverse population of readers who find reading tasks difficult for different reasons. Wolf (2008) points out four diverse reasons a reader might
struggle: (1) developmental issues, (2) lack of exposure to reading material, (3) poor health, and (4) cognitive overload.

**Motivation:** To be moved to do something. Ryan and Deci (2000) point out that motivation not only has varying levels but different origins as well. Origins of motivation can be divided into intrinsic and extrinsic motivation (Deci, 1975; Ryan and Deci, 2000).

**Intrinsic Motivation:** Doing a task for the joy of the task itself rather than its outcome (Deci, 1975; Ryan and Deci, 2000).

**Extrinsic Motivation:** Preforming a task because it will result in a desired reward or preforming a task to avoid an undesirable consequence (Deci, 1975; Ryan and Deci, 2000).

**Engagement:** Level of attention, interest, and curiosity a student shows while they are learning (Student Engagement, 2016).

**Confidence:** Having or showing assurance and self-reliance (Confidence. n.d.).

**Procedures**

A mixed method design was utilized within this case study to allow quantitative survey data to support qualitative interview data. A post-activity quantitative survey, which included the Instructional Material Motivational Survey (IMMS) looked at the motivational impact of the learning activity (Keller, 1987). A follow-up focus group interview gathered qualitative data to expand on the quantitative survey data (Creswell, Plano, Gutmann, & Hanson, 2003).

Within this study, I specifically looked at art/design students in higher education reading an academic design theory text. Conducted during the Visual Literacy course taught in Spring 2016 at Iowa State University, the case study explored an augmented reading activity. I provide a graphic interpretation of the conceptual framework (Miles, Huberman, & Saldana, 2013) in
Figure 1.1 to illustrate the key aspects of this study. The lead researcher taught the Visual Literacy course, considered a history and theory/criticism class in the Bachelor of Arts in Interdisciplinary Design program at Iowa State University. In accordance with IRB protocol the study was conducted using an activity that qualified as normal classroom workflow. Participation in the post-activity survey was optional, and the data was not reviewed by the lead researcher until the final class grades were submitted. The class was composed of 19 art and design students (X men and X women) of various reading abilities who completed the augmented reading activity. While not all art and design students are struggling readers, research has shown that a higher percentage of art students are dyslexic (Bacon, Bennett, 2013). Students were asked to self-evaluate to determine if they identified as struggling readers. No reading level test occurred before the study; struggling and typical reading levels are self-reported.
Figure 1.1: Graphic, conceptual framework for augmented reality reading activity study.

Theoretical Background

Motivational Theory

Deci (1975) divides motivation into two separate categories, intrinsic motivation and extrinsic motivation. Intrinsic motivation is based on enjoyment and performing a task for the sake of the task itself. Extrinsic motivation originates from obtaining a desired result or avoiding a consequence, for example, to be externally motivated to read homework to obtain good grades. Research has shown that students enjoy using AR and find the use of the technology motivating and enjoyable (Billinghurst, & Denser, 2012). Their article examined AR experiences in
educational settings (elementary and high school) to research how AR can enhance traditional learning models and pinpoint obstacles to broader adoption of AR in the classroom (Billinghurst, & Denser, 2012).

Within this study, I analyzed students perceived change in motivation. The change in perceived motivation could be internal, external or a combination of both. For instance, a student may be internally motivated to use the augmented reading supports because they enjoy using their smartphone or tablet. The student may also be internally motivated to use the augmented reading support because they feel increased confidence in their comprehension, but externally motivated by acquiring a good grade. Motivational impact of the augmented reading activity was measured through the use of the Instructional Material Motivational Survey (IMMS). The IMMS is based off of Keller’s (1987) ARCS Motivation Model. The model uses four dimensions of motivation: attention (A), relevance (R), confidence (C), and satisfaction(S) (Keller 1999). The IMMS survey asked questions to target these four areas of motivation: attention (A), relevance (R), confidence (C), and satisfaction(S) (Keller 1999). Therefore, motivational theory (Deci 1975) influenced the conceptual framework developed for this study and analysis of the findings. For example, with the incorporation of motivational theory (Deci 1975) the exploration phase of the activity allowed students to be intrinsically motivated or externally motivated to read the design theory text (see Figure 1.2). While exploring the perceived motivation of the students the data was viewed though the ARCS Motivation Model (Keller 1999) as well as if their motivations were more intrinsically motivated, externally motivated, or a combination (Deci 1975).
Figure 1.2: Theory influence on conceptual framework for augmented reality reading activity.

Significance of the Study

The results of this research are intended to impact design educators and design students. Educators may be able to improve motivation, engagement, and confidence for difficult theory text by augmenting the text with scaffolding, while creating visual aids for a multi-media experience. Visual, auditory, and non-linguistic infrastructures that multimedia experiences provide allow students to think in visual images as well as written language (Bloom, 2001). A study conducted on student preferences for multimedia technology in a literature class by Speaker (2004) showed “a majority of students find that technology aids their learning process when in the classroom” (Speaker, 2004). Since students find technology aids their learning experience, augmentation can give students access to the multimedia technology they prefer though printed text.
A limited amount of research on struggling readers in higher education exists but even that research shows an increase in the amount of reporting being done on learning disabilities among students in higher education. Therefore, it is important to continue studying struggling readers in higher education. Research on AR in the classroom is still limited, even though it has become more common. New research needs to occur to understand augmented reality benefits for classrooms as AR technology changes.

**Limitations of the Study**

This study was limited to AR technology accessed through mobile devices using Aurasma. Availability and cost affected this decision. However, the future of AR could evolve rapidly. “Ultimately, we will see extensive use of multisensory AR systems” (Craig, 2013, Chap. 9 Sec. 4 Para 9). The evolution of how AR can be used in the classroom could bring even greater improvements for struggling readers, based on the mode of delivery. This study used AR viewed through a hand-held mobile device.

Depending on what you are augmenting, and the size of the device, the act of holding the device in place could prove cumbersome, frustrating, or tiring. The device used for implementing AR can also present challenges. While mobile AR applications can be conveniently run through a phone or Tablet, the applications are limited to the constraints of that device (Craig, 2013). This study used a bring-your-own-device (BYOD) approach; students have a range of devices, some with more limitations than others. Several backup devices were available for students to use if they ran into issues on their device or were unable to bring one.
Summary

The aim of this study was to explore how the use of an augmented printed text, enhanced with instructional scaffolds and visual aids influenced: (1) the motivation of design students to read a design theory text, (2) engagement with vocabulary acquisition, and (3) comprehension in higher education. This study used an augmented reading activity created for a college level, design theory course, after evaluating previous literature and similar studies. Students could volunteer to participate in the study and take a post-activity survey. Some students also participated in a focus group interview. The data is expected to indicate augmented reading supports for academic text increase perceived motivation, engagement, and confidence in understanding for struggling readers. If this is indeed the case, research needs to further this line of inquiry. Future research should look into designing AR experiences for the classroom as well as AR games to improve comprehension and retention for art history classes in higher education.
CHAPTER 2. LITERATURE REVIEW: USE OF TECHNOLOGY TO SUPPORT STRUGGLING READERS AND AUGMENTED REALITY IN THE CLASSROOM

Introduction

Augmented reality (AR), has gone from science fiction to a functional technology medium that can be used in the classroom. AR, the blending of virtual and physical worlds in real time (Azuma, 1997; Craig, 2013), can be used in the classroom to supplement physical materials and add new dimensions to classroom learning. Over the last few years the ability to use AR in the classroom has rapidly evolved as devices have become increasingly powerful and mobile. All students may benefit from AR in the classroom. However, struggling readers may stand to benefit the most from the use of AR. This chapter examines the existing literature about: (1) defining struggling readers, (2) how technologies such as AR can aid struggling readers, (3) defining AR, (4) using AR in the classroom, (5) how to design an AR experience, and (6) lessons learned from previous studies.

Definition of Struggling Reader

The term struggling reader refers to a vast, diverse population of readers who find reading tasks difficult for different reasons. Wolf (2008) points out four diverse reasons a reader might struggle: (1) developmental issues, (2) lack of exposure to reading material, (3) poor health, and (4) cognitive overload. Developmental issues may include learning disabilities like Specific Learning Disorder commonly referred to as dyslexia. Lack of exposure to literature or “word poverty”, may cause an individual to struggle. Wolf (2008 p.102) points out how drastic this discrepancy in vocabulary can be at a young age. “By five years of age some children from impoverished learning environments have heard 32 million fewer words spoken to them than the
average middle class child” (Wolf, 2008, p.102). Poor health also may contribute to struggling readers. For instance, ear infections are common in young children, but reoccurring or prolonged infections can result in inconsistent acoustic information during critical periods of learning (Wolf, 2008). Finally, cognitive overload from learning dual languages may cause a reader to struggle.

Due to the multifaceted nature of struggling readers, definitions vary, and solutions focus on different points. This literature review explores several definitions from the research and defines struggling readers for this study. For example, Edmonds et al. (2009, p.265) defines struggling readers as “low achievers or students with unidentified reading difficulties, with dyslexia, and/or with reading, learning, or speech or language disabilities”. Guthrie, Wigfield, & Klauda (2012) defined struggling readers not only as students with learning disabilities or word reading difficulties but any student considerably challenged by reading comprehension tasks. Roberts, Torgesen, Boardman, and Scammacca (2008) point out that many older struggling readers received poor early reading instruction despite the absences of a learning disability, while other students may have received adequate instruction but still struggle because of a learning disability such as dyslexia. Faggella-Luby, Ware, & Capozzoli (2009) refer to struggling readers as students with disabilities, students at risk for failure, or English Language Learners. These students may not respond equally to literacy instruction and may need additional academic support. Even if the students are receiving excellent core literacy instruction, additional academic support may be needed to overcome reading struggles (Faggella-Luby, Ware, & Capozzoli 2009). As you can see, definitions vary according to the multifaceted nature of struggling readers.
It should also be noted that an individual can struggle with reading at any age. Elementary grades tend to focus intensely on reading instruction. Once students reach middle school, reading assignments are predominantly for learning new content, they are not intended to provide reading instruction (Edmond et al. 2009). This transition can quickly widen the gap between struggling readers and their peers (Edmonds et al, 2009). The National Center for Education Statistics (NCES, 2016) reported that 11% of undergraduate students self-reported a learning disability during the 2007–08 and 2011–12 school years. Further, an NCES report on disabilities at degree-granting postsecondary institutions provides a breakdown of disability types. During the 2008–09 academic year (86 percent of public two-year and four-year institutions reported enrolling students with specific learning disabilities. Students with specific learning disabilities made up 31% of reported disabilities in 2008-09 (Raue, & Lewis, 2011). Struggling readers are in all grade levels including higher education. This study has focused on higher education since many studies focus on early struggling readers.

**Struggling Readers in Design Education**

College students of any major can struggle with reading or writing and Bacon, Bennett (2013) research shows an increasing number of students within higher education have dyslexia, including a high percentage of art and design students. Wolff and Lundberg (2002) used objective testing to conclude that art students had significantly lower phonological abilities than non-art university students and that the incident of dyslexia (specific learning disability) was higher in art students than non-art students. Kennard (2000) conducted a survey at the Surrey School of Art and Design (UK) which focused on students with learning disabilities, and 90 percent indicated they struggled with reading, writing and spelling. The analysis of this Needs
Assessment survey was carried out by the SLDD (Students with Learning Difficulties and Disabilities) project to test the hypothesis that specific clusters of learning difficulties are associated with dyslexic art and design students compared with dyslexic non-art and design students. A comparison of these two groups in higher education was carried out across a wide spectrum of courses and from 200 National Federation of Access centers needs Assessment Reports.

Hickman and Brens (2014) argued that some students may select a studio-based program rather than one that relies on lecture and notetaking because of deficits identified with dyslexia. While the literature regarding dyslexia among university students is limited, research shows evidence that dyslexia in higher education is not evenly distributed across disciplines amongst students in the UK (Collinson & Penketh 2010). Little research on the distribution of dyslexia among higher education in the United States can be found. The UK’s Quality Assistance Agency (QAA) benchmark statement on Art and Design states, “Research indicates that dyslexia is more prevalent amongst students of art and design than in other subjects” (www.qaa.ac.uk 2008, 5.10).

Hickman and Brens (2014) also pointed out that, according to the Equality Challenge Unit (2012), part of the UK effort to assure equality of higher education, a higher percentage of art and design students declared disabilities compared to students enrolled in any other subject (Hickman & Brens 2014). Among students declaring disabilities, the highest percent (14.7%) was declared by students studying Art and Design, while disabilities were declared by only 4.6% of students studying business and administrative studies (Equality Challenge Unit, 2012). This statistic further backs up by the more recent 2015 Equality Challenge Unit. Reports of disability were high among students studying creative arts and design (17.5%), and lowest among students studying business and administrative studies (5.6%). It should be noted that the reported
disabilities varied but disabilities related to struggles with reading made up almost half of all reported disabilities in 2013-14. Research shows an increase in reported disabilities that contribute to struggling readers in higher education, particularly in studio majors such as Art and Design.

For the purposes of this study, a struggling reader is defined as an individual who does not read at the age and developmental level of a typical reader. This could be caused by factors such as learning disabilities, lack of exposure, poor health, and cognitive overload. This definition encompasses a diverse population of individuals with a wide age range. To further refine the aim of this chapter, this section focuses on literature about struggling readers in higher education, who have difficulty with advanced comprehension tasks. The next section will outline some existing technologies that can support struggling readers. While reasons why a reader struggles may be diverse, technology aids and instructional reading strategies can benefit struggling readers as well as typical readers.

Technology to Support Struggling Readers

Technology that can assist with reading can be divided into digital tools and digital devices. Tools include e-books, audio books, text-to-speech software, assistive technologies, word-by-word tracking, recording, mind mapping tools, and educational apps. Devices include eReaders, Tablets, smartphones or laptops (Biancarosa, & Griffiths, 2012; Hutchison, Beschorner, & Schmidt-Crawford, 2012; Pullen & Cash, 2011; Stearns, 2012; Wissick & Gardner, 2011). Each technology discussed has been shown to support struggling readers, with a specific focus on affordances for struggling readers. For example when Text to Speech (TTS) has simultaneous digital highlighting of the spoken words, it can strengthen the contextual
placement of words (Berkeley, & Lindstrom, 2011). The term affordances will be used from the perspective of the Human Computer Interaction (HCI) field. James J. Gibson, who coined the concept in his seminal book *The Ecological Approach to Visual Perception*, intended the term to include all possible actions available to an individual regardless of the individual’s ability to perceive the possible options. Donald Norman, who introduced the concept of affordances in his 1988 book *The Psychology of Everyday Things* to the HCI community, defines the term as any actual or perceived properties (Soegaard, 2005). To summarize, the term *affordances* refers to the qualities or properties of an object that define its possible uses. These affordances could be perceivable or hidden; however, for the most part the affordances discussed will be known affordances based on the user’s previous experiences with digital devices or technology.

**Progression of Digital Devices Used for Reading**

Devices that support a struggling reader are integrated into our daily lives. Since their introduction in 2000, Smartphone subscriptions in the U.S. had by February 2012 grown to include about 40% of the population; by December 2013 65% of the population had a smartphone (Wang, Xiang, & Fesenmaier 2014). According to comScore Inc. in 2016 “198.5 million people in the U.S. owned smartphones (79.1 percent mobile market penetration) during three months ending in January” (ComScore, Inc. 2016).

The majority of today’s college students carry a smart phone. PEW Research Center has found that as 85% of Americans 18-29 own a smartphone (Smith, 2015) and many have access to eReaders, Tablets, and laptops. Laptops offer innate support for a struggling reader, including text-to-speech, digital dictionaries and adjustable formatting. They also allow for the addition of specific applications or extensions to improve reading support. These range from auditory
assistance that reads text in changeable natural sounding voices to extensions linked to the Internet that can provide specific vocabulary support. Laptops offer an advantage over traditional computers, because students are no longer tied to a computer lab to access the reading and writing support a computer can provide. “Decades of research have shown that computer technology in the classroom can enrich teaching and learning and boost student achievement, compared to teaching without such aids” (Billinghurst, & Denser, 2012, p. 56).

While laptops are considerably more mobile than traditional computers, smaller devices such as eReaders, Tablets and smart phones have become more common in many homes (Smith, 2015). Individuals often have access to multiple devices because they have become increasingly affordable. However, a digital divide still exists. Some students do not have access to digital devices and some schools do not be able to provide devices for all students for financial reasons. Even so many individuals now have multiple devices that may include: a tablet, e-reader and smartphone. Any one of these devices can do many tasks previously done on a computer. The common thread through all these devices are their use of digital text, audio and the ability to access the Internet. Affordances of digital text include built-in dictionary, text to speech, highlighting, notes, digital search-ability, and formatting adjustments such as text size or background color. Opportunities to reformat a text’s line length, font, size or background can support reading comprehension (Anderson-Inman, & Horney, 2007; MacArthur, Ferretti, Okolo, & Cavalier, 2001). “Text to speech (TTS) engines can help struggling readers improve comprehension, fluency, and accuracy” (Berkeley, & Lindstrom, 2011). These tools assist in word recognition and vocabulary by allowing a student to hear words in context without interrupting comprehension (Silver-Pacuilla, Ruedel, & Mistrett, 2004). When TTS has simultaneous digital highlighting of the spoken words, it can strengthen the contextual placement
of words (Berkeley, & Lindstrom, 2011). All these affordances offered by digital text can support text comprehension, phonological awareness, word-reading skills and vocabulary, which are important means to engage struggling readers (Berkeley, & Lindstrom, 2011; Biancarosa, & Griffiths, 2012; Korat 2010; Leu & Reinking, 1996; Reinking, 1992, 1998, 2001).

E-readers also can offer specialized reading support. Since they are smaller than a laptop, they are far more convenient for reading e-books, which also can be read on other digital devices. Some e-readers such as Kindle use e-ink technology, which may cut down on eyestrain compared to backlit screens (Hoyer, 2015). This could be very important for a struggling reader, who can receive the benefits of a digital device without the added strain of a backlit screen. Many e-readers offer text-to-speech capabilities, word-by-word tracking, built-in dictionaries, ability to highlight and take notes, as well as adjustable formatting to change fonts, size of text, or contrast.

Tablets and smartphones have become increasingly powerful, and offer many support options for a struggling reader. The use of Tablets for mobile learning becomes increasingly common with the creation of the iPad and similar devices (Hutchison, Beschorner, & Schmidt-Crawford, 2012; Traxler, 2009). Tablets provide many benefits of a computer without the person having to be tied to a computer lab (Brand, & Kinash, 2010; Hutchison et al 2012). A Tablet’s ability to aid struggling readers stems from the perceived and known affordances of digital text, which allows for different modes of reading and writing (Biancarosa, & Griffiths, 2012; Hutchison et al 2012; Lankshear & Knobel, 2003; Leu, Kinzer, Coiro, & Cammack, 2004; Leu, 2006). Similar to laptops and eReaders, Tablets offer text-to-speech options, recording, some word-by-word tracking, built-in dictionaries and word lookup via the Internet. Many reading applications have highlighting and note-taking abilities as well as various formatting adjustments
both in individual applications or universally across the device. Tablets and smart phones also allow easy access to AR without needing additional technology. AR allows for digital information to be overlaid in the physical environment. This ability to bring digital text, auditory, and Internet access to static, physical items opens up new ways of supporting struggling readers with existing devices.

**Technology for Types of Reading Support**

Technology, through the evolution of digital devices, continues to support struggling readers. However, older struggling readers may struggle with one specific aspect of reading, such as comprehension but not with sight words or individual word reading (Edmonds, et al. 2009). Regardless of the specific focus for the struggle, struggling readers must become digitally literate to seek the supports that digital devices offer. Within the next session, I discuss the use of specific strategies such as explicit instruction through scaffolding and vocabulary acquisition that have been digitally used to support struggling readers.

**Digital Literacy for Reading Support**

Knowing how to use technology to read, write, and communicate affects a student’s ability to learn (Leu, Kinzer, Coiro, & Cammack, 2004), and introduces new literacy skills (Leu, Forzani, Rhoads, Maykel, Kennedy, & Timbrell, 2014). Understanding how to use digital technology is imperative for literacy instruction and assisting struggling readers (Hutchison, Beschorner, & Schmidt-Crawford, 2012; Hutchison, & Colwell, 2015). Hutchison, Beschorner, and Schmidt-Crawford also noted that the International Reading Association issued a statement in 2009 regarding literacy and technology:
To become fully literate in today’s world, students must become proficient in the new literacies of 21st-century technologies. IRA believes that literacy educators have a responsibility to integrate information and communication technologies (ICTs) into the curriculum, to prepare students for the futures they deserve. (2012, p.16)

Digital literacy, especially imperative for struggling readers as digital devices, digital text, and the Internet, offers a vast array of support. Students need to be digitally literate before they can fully access the reading support these devices can provide. There are many strategies used to support students in becoming digitally literate, including the use of scaffolding.

**Scaffolding for Reading Support**


Scaffolding, a component of direct/explicit instruction, breaks down a larger issue by providing prompts for ideas/concepts during a learning activity (Azevedo, Cromley, & Seibert, 2004; Hill & Hannafin, 2001; Huang, Wu, & Chen, 2012). Students can achieve beyond their un-
aided abilities through the use of instructional scaffolding (Xun & Land, 2004). Scaffolding provides a struggling student with support that fades away as the student becomes more independent. The fading away of the support scaffolding is a key aspect in aiding learning and success (Chen, Kao, & Sheu, 2003; Kim & Hannafin, 2011).

Research has shown that scaffolding helps struggling readers. Scaffolding does not require any advanced technologies and can be implemented for static text-based documents. A synthesis of reading interventions and effects on reading comprehension outcomes for older struggling readers was published in 2009. Research on struggling readers from a 10-year period was pulled and analyzed to create the synthesis of reading interventions. Results suggested that “explicit instruction in comprehension benefited students with reading difficulties and disabilities” (Edmonds, Vaughn, Wexler, Reutebuch, Cable, Tackett, & Schnakenberg, 2009 p.292). It also was noted that background knowledge, word knowledge and the use of strategies contribute to comprehension (Kintsch & Kintsch, 2004). The importance of word knowledge for comprehension suggests that vocabulary acquisition plays an important part in helping struggling readers.

**Vocabulary for Reading Support**

Vocabulary acquisition is one on the five content standards of reading acquisition, along with phonemic awareness, phonics, fluency and comprehension (Rupley, Blair, & Nichols, 2009). Vocabulary knowledge allows students to access, understand and apply content; “Vocabulary knowledge is content knowledge” (Templeton, Bear, Invernizzi, Johnston, Flanigan, Townsend, Helman, & Hayes, 2015, p.15). By increasing vocabulary knowledge
students are able to comprehend and analyze text. In a study of adult struggling readers, evidence showed weaker expressive vocabulary skills than expected for the participants’ ages.

Our study also provides preliminary evidence of a relationship between expressive vocabulary knowledge and some reading skills for adult struggling readers, suggesting that expressive vocabulary knowledge is, in fact, related to both reading comprehension and exceptional word-reading skills for adult struggling readers. Our findings support the notion of incorporating explicit instruction in all the different reading components for adult struggling readers.

(Hall, Greenberg, Laures-Gore, & Pae, 2014, p.10)

Based on this research, a student’s comprehension of an academic text should improve with the use of vocabulary acquisition scaffolding. Any of the five core standards of reading acquisition can be taught through explicit instruction and the use of scaffolding (Rupley, Blair, & Nichols, 2009). Within this study, I have focused my research on older students who may have achieved fluency but still struggle with comprehension.

**Use of AR for Reading Support**

Since digital literacy has become an important factor in overall literacy and digital text has many perceived and known affordances for struggling readers, it makes sense to use AR in the classroom. Support for struggling readers, including scaffolding for vocabulary acquisition and comprehension, could be overlaid on static text with AR. The design of the augmented scaffolding could be based on common core literacy standards, particularly looking at improving synthesis and analysis of reading material and vocabulary acquisition. Research supports explicit instruction practice, particularly when used for struggling learners (Archer & Hughes, 2011;
Kirschner, Sweller, & Clark, 2006; Marchand-Martella, Slocum, & Martella, 2004; Marchand-Martella, Martella, Modderman, Petersen, & Pan, 2013). Yet, direct teacher involvement is not always possible. Developing scaffolding for struggling readers through the use of AR could provide the needed support independently, to be used in a classroom or at home.

Direct instruction through the use of scaffolding has been proven to help struggling readers achieve above the level they could on their own (Xun and Land, 2004). Scaffolding could be built into an AR experience to provide direct instruction for vocabulary acquisition and comprehension. AR also would bring many affordances of digital text to static print text, which can aid struggling readers. I define AR in the next section and provide clarity of four main areas: (1) the uses for AR in the classroom, (2) the affordances and challenges of using AR for education, (3) how AR experiences are designed, and (4) insights and lessons that can be pulled from studies for both AR research and instruction. Examining previous studies using AR in an educational setting as well as looking at AR concepts, hardware, software, design and application literature, will clarify these four points.

**Defining Augmented Reality**

The term AR can be broadly described as a “digital display that blended virtual graphics with a physical reality” (Vyas, 2015, para. 1). To further explain this technology, it is important to discuss how AR has developed by looking at early definitions from seminal research. AR is a relatively new term, despite having its beginnings in the 1960’s with the creation of Morton Heilig’s Sensorama Simulator, which was the first real multi-sensorial simulator (Gigante, 1993). The term “augmented reality” wasn’t coined until the early 1990’s. Tom Caudell and David Mizell first used it during their research work for Boeing where they developed a head mounted
display (HMD) that showed simple wire frames, template outlines, designators, and text displayed over the physical world (Caudell, & Mizell, 1992). In 1997 Ronald T. Azuma published his paper “A Survey of Augmented Reality,” which was the first comprehensive paper examining the existing varied uses for AR. Azuma (1997) lays out three main characteristics that, as other researches in the field have agreed, define AR as something that: (1) combines real and virtual, (2) is interactive in real time, and (3) is registered in 3D (Azuma, 1997; Kaufmann, 2003; Zhou, Dah & Billinghurst, 2008). Azuma (1997) defines AR as a variation of virtual environments (VE), or virtual reality (VR). However, where a VE can completely immerse a user in a simulated environment, AR supplements reality, rather than completely replacing it (Azuma, 1997).

This definition is pulled from a Milgram and Kitshino (1994) term, mixed reality, that defines the continuum between our real, physical environment and the virtual environment. See Figure 2.1, for a visual depiction of the mixed reality continuum. The space between a fully virtual environment, where all input is digitally simulated, and the completely real world, where no content is digitally simulated, is designated as mixed reality. AR falls into the category of mixed reality, where both real physical and digital simulations are experienced (Azuma, 1997; Milgram & Kitshino 1994).
Technology has evolved over the last decade since Azuma’s paper. While the main concept of AR has not changed, the ways in which it can be accessed have advanced. The next section will discuss the more recent work of Alan Craig (2013) who wrote *Understanding Augmented Reality: Concepts and Applications*. He takes a comprehensive look at AR’s concepts, hardware, software, content, interactions, mobility, applications and then looks at the future of AR. Craig defines AR not as a specific technology but as a medium utilizing a multitude of technologies. He references Azuma’s (1997) definition, then further expands and clarifies his own definition of AR. “Augmented reality: A medium in which digital information is overlaid on the physical world that is in both spatial and temporal registration with the physical world and that is interactive in real time” (Craig, 2013, Chapter 1 Section 3 para. 17). This definition follows the three main characteristics of AR that Azuma (1997) laid out, while adding the clarification that AR should be considered a medium, not a specific technology. Craig lists the key aspects or ingredients of AR (Table 2.1) that further expand on Azuma’s three defining principles. Craig focuses on AR as a medium for interacting with physical and virtual objects to create an experience. These key aspects could be particularly relevant to educators.
designing AR experiences for their classroom. By focusing on the key aspects of AR, educators can bring to the classroom the affordances of AR that go beyond printed static text or fully digital text.

**Table 2.1: Key aspects of augmented reality (Craig, 2013, Chapter 1 Section 3 para. 2)**

<table>
<thead>
<tr>
<th>Key aspects (ingredients) of augmented reality:</th>
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<tbody>
<tr>
<td>1. The physical world is augmented by digital information superimposed on a view of the physical world.</td>
</tr>
<tr>
<td>2. The information is displayed in registration with the physical world.</td>
</tr>
<tr>
<td>3. The information displayed is dependent on the location of the real world and the physical perspective of the person in the physical world.</td>
</tr>
<tr>
<td>4. The AR experience is interactive, that is, a person can sense the information and make changes to that information if desired. The level of interactivity can range from simply changing the physical perspective (e.g., seeing it from a different point of view) to manipulating and even creating new information.</td>
</tr>
</tbody>
</table>

Based on the definitions set forth by Caudell (1992), Azuma (1997), Kaufmann (2003), Zhou, Dah & Billinghurst (2008), and Craig (2013), AR can be defined as a medium in which digital information is overlaid with the physical world, dependent on the perspective of the individual interacting and experiencing the AR medium. With this definition, I discuss the potential for AR use as an educational experience in the classroom.

**Uses for Augmented Reality in the Classroom**

The defining features of AR include: combines real and virtual world (Azuma, 1997; Craig, 2013), interactivity in real time (Azuma, 1997; Craig, 2013), and interactions experienced by the user (Craig, 2013). The ways in which AR can be used in the classroom are extensive. I outline potential ways AR could be incorporated into the classroom in Table 2.2. This
information is compiled from AR studies discussed in this paper and affordances of AR and different education apps available in the iTunes store.

Table 2.2: Uses for AR in the classroom

<table>
<thead>
<tr>
<th>Uses for AR in the classroom</th>
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<tbody>
<tr>
<td>• Adding audio and definitions to a word wall (Arasma app, Layar app)</td>
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<tr>
<td>• Augmented posters with images, video, audio, 3D models, text, links to websites; quizzes to engage students. (Arasma app, Layar app)</td>
</tr>
<tr>
<td>• Connecting videos of project presentations or lectures to an overview bulletin board/poster or summary hand out. (Arasma app, Layar app)</td>
</tr>
<tr>
<td>• Showing 3D visual representations of chemical reactions, where students get to push different elements together. (Elements 4D app by DAQRI)</td>
</tr>
<tr>
<td>• Showing interactive 3D models of items difficult to access (Organ dissection, cellular systems or functions). (Anatomy app by DAQRI)</td>
</tr>
<tr>
<td>• Gamifying learning and allowing everyday spaces to be transformed with overlay of information. (Dunleavy, Dede, Mitchell, 2009).</td>
</tr>
<tr>
<td>• Using AR to “travel” on class field trips not only too difficult to reach locations but different times as well. (Dunleavy, Dede, Mitchell, 2009).</td>
</tr>
<tr>
<td>• Allowing students to access digital resources while interacting outside. (Star maps of constellations overlaid on the actual night sky. Names of mountain ranges overlaid on actual mountains, Names of tree overlaid on leaf.)</td>
</tr>
<tr>
<td>• Showing real-time translations of printed text to different languages. (Google Translate app)</td>
</tr>
<tr>
<td>• Engaging students in mathematics by connecting real world experiences to mathematic equations (Kaufmann, 2003).</td>
</tr>
</tbody>
</table>

As highlighted in the table, there is a broad range of ways AR can be incorporated into the classroom. Interestingly, despite the diversity of activates, all the listed AR applications allow for students to experience content in a different way.
Experience Learning in the Classroom Though AR

Craig (2013) discusses how AR can be used in a variety of situations ranging from advertisements, entertainment, education, manufacturing or medical applications. One thing that all these situations have in common is they constitute an experience. In these situations, a person must engage and interact with the physical world to gain the experience each situation offers. This interactive engagement increases motivation and learning retention (Billinghurst, & Denser, 2012).

When considering AR in education, these key aspects of AR by Craig (2013) in Table 2.1 are extremely relevant to why AR can be useful in the classroom. Most important for education may be the fourth aspect. AR is an experience that requires interaction. As many of the examples in Table 2.2 demonstrate, AR experiences go beyond simply consuming content. Students must first use physical objects or the environment to access the digital content. They can then manipulate the digital content by moving around in the environment, and in some cases, they can edit or change the digital content. Learning through an experience and interaction will allow the learner to correlate an experience with new information, thus strengthening the ability to recall and retain the information.

Billinghurst and Denser compared learning outcomes between print-only text and an augmented text with interactive 3D models. “In a test administered directly after exposure to the two books, the AR group answered more questions correctly—both factual and inferential—with a mean score of 72 percent, relative to 60 percent for the non-AR group” (Billinghurst, & Denser, 2012, p.61). Additionally, students of the AR group scored higher during a follow-up retention test than the non-AR group. “From these results, it appears that the AR interface’s additional interactivity and visual representation enhance subject learning” (Billinghurst, &
Denser, 2012, p.61). AR in education research has documented increases in motivation and engagement (Billinghurst, & Denser, 2012; Green, Lea, & McNair, 2014). For instance, during an augmented learning activity conducted by Dunleavy, Dede, Mitchell (2009), “teachers reported a significant difference in the behavior and engagement of students during the AR implementation as compared to their normal classroom behavior: ‘I saw a lot of the kids...the lower end ones who are sort of turned off of class at this point in the year...those kids were some of the most engaged’ (Teacher Interview 6/8/07)” (Dunleavy, Dede, Mitchell, 2009, p.18).

When AR is added to an educational setting or to static print text, a layer of digital information is added, such as video, audio, 3D models, or links to websites. “Augmented reality adds digital information to the world that you can interact with in the same manner that you interact with the physical world” (Craig, 2013, Chapter 1, Section 1, para. 4). Since AR adds digital information we can interact with over our physical world, AR has a host of possible uses in education (Asai, Kobayashi, & Kondo, 2005, July; Billinghurst, & Denser, 2012).

Examples of AR in the Classroom

The ways in which digital information could be overlaid in our physical environment create endless learning opportunities (Green, Lea, & McNair, 2014). In all cases, though, they allow for the student to engage with information beyond what is immediately available in our physical world (Billinghurst, & Denser, 2012). For instance, we can see a physical flower in the world, but AR allows us to access information about that flower’s history, see detailed models of its internal structures without dissecting it, or what it looks like at different stages of growth, even as we are experiencing the physical flower in real life.
AR also allows for students to explore experiences digitally that would otherwise be too dangerous, rare or impossible in our physical world as well as bridge the gap between static print and digital content. Table 2.3 lists a few educational AR applications that could be used in a classroom setting. Three AR applications were developed as classroom activities, one for printed books, and two applications aimed at exploring educational experiences bridging the gap between print and digital.

Table 2.3: Examples of AR in the Classroom from Other Studies

<table>
<thead>
<tr>
<th>Examples of AR in the Classroom from Other Studies</th>
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<tbody>
<tr>
<td><strong>Construct3D (2003)</strong></td>
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Construct3D uses AR through HMDs to overlay digital content in the real world. This allows multiple people to see the AR and real world content allowing for natural interaction. (Kaufmann, 2003)

(Kaufmann, 2003)
**Table 2.3: continued**

<table>
<thead>
<tr>
<th><strong>colAR (Quiver)</strong></th>
<th>This application original ColorAR is now known as Quiver <a href="http://quivervision.com">http://quivervision.com</a>, and allows students to bring their coloring pages to life with 3D and animation.</th>
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<tbody>
<tr>
<td></td>
<td>(Craig, 2013)</td>
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</table>

<table>
<thead>
<tr>
<th><strong>Alien Contact! (2009)</strong></th>
<th>Alien Contact! Was designed to teach math, language arts, and scientific literacy skills to middle and high school students. The AR game is narrative-driven and inquiry-based using a handheld computer with AR tied to GPS coordinates. (Dunleavy, Dede, &amp; Mitchell, 2009). As the students move around a physical location, such as their school playground or sports fields, a map on their handheld device displays digital objects and virtual people who exist in an AR world superimposed on real space.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Dunleavy, Dede, &amp; Mitchell, 2009).</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th><strong>Penguin Publishing</strong></th>
<th>Penguin has recently partnered with Zappar to enhance their classic literary novels, such as <em>Moby Dick</em>, with AR apps (Sawers, 2012).</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Sawers, 2012)</td>
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</table>
### Ethnobotany Workbook

The Ethnobotany Workbook started as a physical book. AR was added later with markers. When a student views these markers through a tablet they can see the 3D plant graphics.

(Craig, 2013)

### Daqri Anatomy

Daqri created and an AR application that allows students to view the human body. They can engage by exploring different layers by turning various systems on and off. They are also able to rotate the body and adjust the transparency of the skin.

(Craig, 2013)
To conclude this section on uses for AR in the classroom, it should be noted that while not currently considered mainstream technology AR “is on the cusp of turning the corner into becoming a mainstream part of life” (Craig, 2013, Chapter 9, Section 1, para. 1). Incorporating mainstream AR technology should be thought of in a way that is similar to incorporating computers, calculators or Tablets into the classroom. Students today would have difficulty learning with a typewriter or a slide ruler. By incorporating AR into education now, educators can help shape the future of AR and become a driving force in its development (Billinghurst, & Denser, 2012). With AR creation apps like Aurasma, instructors and students will increasingly be able to create and customize their own educational AR experiences (Craig, 2013). The next section of the paper will examine the affordances of AR. It is important to understand the affordances of AR in order to incorporate AR into the classroom in a meaningful way.

**Affordances of Augmented Reality**

Craig (2013) discusses AR as a medium that utilizes multiple technologies. AR allows us to overlay digital content on the physical world through the use of mobile devices, projection or stationary kiosks. Overlaid content can affect any of our five senses; however, visual and auditory content currently is the most common. Content could include: text, audio, video, links to websites, social media, images, or quizzes. With special equipment, it could also include haptic feedback, olfactory and gustation simulation. Craig (2013) shows two ways to leverage AR’s affordances to solve a problem. “The first is any application area that can use AR in a way that is advantageous. The second is the set of application areas where there is no other way (or only significantly different ways) to experience the application” (Craig, 2013, Chapter 8, Section 2, para. 3). While several different types of AR systems are available, most classroom AR
experiences would be accessed through mobile devices such as Tablet or smartphone. One of the benefits is that the mobile device allows the AR application to be “experienced at the location where it makes the most sense” (Craig, 2013, Chapter 7, Section 3, para. 1).

Dunleavy, Dede, & Mitchell, (2009, p.8) list some unique AR affordances including: “greater fidelity of real world environments, the ability of team members to talk face-to-face with its bandwidth on multiple dimensions, and the capacity to promote kinesthetic learning through physical movement through richly sensory spatial contexts”. Additionally, it creates hybrid immersive learning environments that facilitate critical thinking, problem solving, and communication (Dunleavy, Dede, & Mitchell, 2009).

Another affordance of AR is the potential for 3D graphics. Kinesthetic learning experiences can be incorporated and students can explore content through intuitive interactions. This ability to change viewpoint allows for a deeper examination of content than can be achieved with a 2D image (Huang, Arem, Ö Livingston, 2013; Ko, Chang, Chen, Ö Hua, 2011). Viewing structures in 3D allows for multiple angles to be seen to help map the relationship of the structure (Maier, Tönnis, Et Klinker, 2009). For instance, an architect student could virtually walk through a building she designed or a chemistry student could view 3D models of a molecule from different angles.

Finally, we must remember to look to the future. Technologies that use AR may offer many education benefits in the classroom even if they have not yet been perfected.

AR is a relatively new medium, and as such, not all the details are worked out regarding the capabilities and affordances of the medium. This means that what we see in current AR applications is not the full suite of possibilities that will exist in the future. Some aspects of AR will only be possible with new
developments in hardware and software. (Craig, 2013, Chapter 6, Section 1, para. 1)

Educators’ increased activity with AR will allow for the development of classroom-appropriate software and hardware that can further students’ education, based on core standards and known pedagogical approaches (Billinghurst, & Denser, 2012). How students gain access to the AR experiences in the classroom is an important consideration. The next section will focus on the use of mobile devices to access AR in the classroom.

**Mobile Devices To Access AR**

AR has become increasingly portable with the rise of the mobile smartphone and Tablet AR applications (Craig, 2013; Yuen, Yaoyuneyong, & Johnson, 2011). With the use of marker-less AR, any physical space or feature can now have additional information attached to it. Instead of markers, the AR applications use natural feature tracking with the mobile device’s camera to detect edges/patterns of target imagery. Students are able to use mobile devices such as phones or Tablets to engage with information overlaid in the physical world such as a leaf of a plant to describe botanical information or using GPS markers to overlay historical information about a location.

Dunleavy, Dede, & Mitchell (2009) look at how AR can affect students’ experiences and interactions. As Klopfer et al (2004) have argued, AR can infuse digital resources directly into our physical world. It has been noted that several advantages of AR in education include “aligning with many of the guiding principles of constructivist learning, appealing to a variety of learning styles, and enabling greater understanding through 3D visualization” (Green, Lea, & McNair, 2014, p.29). With the use of mobile devices, students can now access the AR
experiences anywhere if they have a device that allows them to benefit from the immersion of AR. The next section will look at using AR with traditional printed text and how AR experiences through mobile devices can bridge the gap between a static paper classroom and a completely digital classroom.

**Printed Text vs Digital Text in the Classroom**

Physical, existing textbooks can have additional interactive content added to them such as images, video, audio, 3D models, text, links to websites, or quizzes. The addition of this content allows students to engage with content beyond what is available in a printed book (Billinghurst, & Denser, 2012). Kesim and Ozarslan point out that educators often prefer two-dimensional media because it is “convenient, familiar, flexible, portable and inexpensive. This 2D medium is also often static and only allows the user to process the information through one channel” (2012, p.297). The addition of AR to a print book preserves all the benefits of two-dimensional print media while enhancing it to incorporate technological advancements available in e-books (Asai, Kobayashi, & Kondo, 2005, July). Currently, many of the virtual additions to printed text consist of visual or auditory input; however, as the technology evolves, the ability for robust multisensory experiences will be possible. “In the beginning we will likely see simple uses of other senses, such as vibration or temperature in haptic displays, but ultimately we will see extensive use of multisensory AR systems” (Craig, 2013, Chapter 9, Section 4, para. 10).

Billinghurst, & Denser (2012) looked at using AR in the classroom and concluded that AR created a significant benefit to students struggling with traditional printed text-based learning. With the addition of AR, educators can bridge the gap between traditional static paper and digital
content. This could reach a broader group of students, both those who prefer and benefit from traditional paper-based learning as well as students who struggle with it.

**Challenges of Augmented Reality in the Classroom**

While AR affords exciting new possibilities in the classroom, as a relatively new field that continues to evolve rapidly, it also offers challenges. Kaufmann (2003) points out that no single technology can fit all needs. When considering the user interface and display type, the educational needs as well as the users themselves need to be considered.

This continuous rapid evolution often focuses more on possible hardware/software capabilities while paying less attention to creating specific use cases that work inside a classroom. Registration and latency can also be an issue (Craig, 2013). Registration is how the virtual world aligns with the physical world, while latency deals with the amount of time that virtual aspects lag behind when they should occur. Slow Wi-Fi can be a detrimental factor for mobile AR experience latency (Craig, 2013).

The use of 3D graphics in AR offers a unique affordance; however, it also presents a challenge. Three-dimensional graphics can be made in programs like Google SketchUp or found for free in Google SketchUp libraries; however, quality detailed 3D graphics can be extremely time-consuming to create. While a free version of Google SketchUp is available, many 3D graphics are created in complex 3D modeling programs that require in-depth skills of a professional designer (Green, Lea, & McNair, 2014).

Another challenge is that many AR applications used on Tablets or smart phones to augment print are set up to cater to marketing or advertising. Even with vast potential for what these programs can do in a classroom, they are not set up to best cater to one. Using AR to create
interactive print in the classroom can require prior knowledge of file types for audio, video, as well as some front-end development in order to achieve more advanced interactions.

The device used for implementing AR also can present challenges. While mobile AR applications can be conveniently run through a phone or Tablet, the applications are limited to the constraints of that device (Craig, 2013). Mobile devices such as Tablets and smartphones have become more affordable, yet not every classroom has access to a set of devices. Also, when using a bring-your-own-device (BYOD) approach, students may have a range of devices, some with more limitations than others.

Lastly, when we talk about using AR in the classroom, we are frequently using mobile AR that incorporates a device, which has to be held. Depending on what you are augmenting, and the size of the device, the act of holding the device in place could prove cumbersome, frustrating or tiring. Craig (2013) notes that in the future more will be done through lightweight displays, such as glasses or contact lenses, as well as projected environments, instead of relying on Tablets or smartphones.

**How AR Experiences Are Designed**

When designing AR experiences for education or classroom use, it is important to ensure that AR will be enhancing the classroom experience. Craig (2013) gives us ten steps that can be used to guide the creation of AR for the classroom (Table 4). These ten steps can help walk through a problem to see if it can be solved with AR. It might be important to also keep in mind the key aspects of AR shown in Table 2.1.
Table 2.4: Ten steps for applying AR to a problem

<table>
<thead>
<tr>
<th>Ten steps for applying AR to a problem:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Identify the problem.</td>
</tr>
<tr>
<td>2. Determine if there are other solutions to the problem.</td>
</tr>
<tr>
<td>3. Determine the affordances of AR that will aid with the problem.</td>
</tr>
<tr>
<td>4. Design AR application.</td>
</tr>
<tr>
<td>5. Implement AR application.</td>
</tr>
<tr>
<td>6. Test AR application.</td>
</tr>
<tr>
<td>7. Evaluate results of AR application with respect to the problem.</td>
</tr>
<tr>
<td>8. Modify design and application.</td>
</tr>
<tr>
<td>9. Test modified application.</td>
</tr>
<tr>
<td>10. Loop iteratively to appropriate step.</td>
</tr>
</tbody>
</table>

Many considerations when designing for AR come into play. The three top-level components to an AR system include the sensor, processor, and display (Craig 2013). When using AR through a mobile application such as Aurasma, the Tablet or smartphone fills the requirements of sensor, processor and display, leaving the user free to focus on the virtual content, the interactions and the physical world. This augmented reading study focuses on the creation of AR experiences through the mobile AR application Aurasma.

Designing content for AR through mobile apps like Aurasma consists of creating overlays that can be seen/heard virtually over physical content. Overlays can consist of videos, images, audio, URL links or 3D graphics. While some AR systems are capable of haptic feedback, olfactory or gustation simulation, these abilities are not readily available currently for mobile AR technology. When creating video, audio or photos for an Aura, a digital overlay in Aurasma, the simplest course is to use your smart phone or Tablet. Content can be directly uploaded to create an AR experience through the Aurasma App. Otherwise, content can be added to an AR experience through Aurasma’s browser creator studio. Three-dimensional models also
can be added to AR experiences. Adobe SketchUp, Mya from Autodesk, Cinema 4D, or Blender are a few 3D rendering programs that can be used to create 3D graphics.

Discussions on what is involved in designing for AR could be a whole book in itself. Especially, if a discussion of designing AR systems from the ground up were included instead of focusing on using a pre-existing AR creator application. Discussions on hardware regarding sensors, memory and displays would play an important role, as would discussions on software implementations. Since this paper has focused on using Aurasma to design an AR experience this section will focus on the type of content and interaction currently possible to implement using existing mobile devices, such as Tablets and smartphones with camera and Internet capabilities. The next section will point out some insights and lessons for conducting AR research and using AR experiences in the classroom.

**Insights and Lessons for Both Research and Instruction**

Using new technology in a classroom can present a unique set of challenges including software/hardware issues. Like many new technologies, an initial learning curve may seem to get in the way of why you are using the technology in the first place. “It can be difficult to successfully implement an interdependent AR unit without significant modeling, facilitating, and scaffolding of this skill” (Dunleavy, Dede, & Mitchell, 2009, p.19). One way to overcome this is to test your technology in a variety of scenarios, always have a back-up plan and spend some time introducing the technology before using it to teach new concepts.

By using mobile technologies such as smartphones or Tablets, the cost of implementing AR experiences becomes substantially less compared to permanent or special-purpose systems (Craig, 2013). Additionally, during a study comparing AR interactive print through HMD or a
hand-held computer, students preferred the hand-held computer (Asai, Kobayashi, & Kondo, 2005, July). As technology evolves and HMDs become lighter, less cumbersome with increased resolution, that preference may change. “Mobile augmented reality is especially well suited to ideas such as ‘ubiquitous learning’ in which the plan is that every person learns all the time, wherever they are, when they need to” (Craig, 2013, Chapter 7, Section 3, para. 3). Many students own their own Tablet or smartphone and it may be possible to allow students to use their own devices to interact with AR.

When using mobile devices such as Tablets or smartphones, the fear of students disengaging from each other and completely immersing in the device can reduce the appeal of incorporating mobile technology into the classroom. By designing AR experiences for collaboration, interaction among students replaces students’ use of the device in isolation. Students were given only certain pieces of information requiring them to work together as a group to solve the problems and access all information. “The vast majority of students reported that this interdependent nature of their teams as one of the most engaging and interesting features of AR: This project gave us a chance to communicate with our teammates to solve questions, to work together (to) solve problems” (Dunleavy, Dede, & Mitchell, 2009 p.15).

Compton (2016) offers recommendations to educators who want to implement AR experiences in their classroom.

(1) Allow students to collaborate and share their AR experiences.

(2) Use field trips to optimize AR’s inherent mobile capabilities.

(3) Utilize AR as an additional learning platform in conjunction with other visual, auditory, and tactile opportunities.

(4) Connect AR experiences to educational standards.
(5) Think outside the box, rather than try to fit AR to a traditional approach. These recommendations can help instructors take advantage of the AR medium to capture its full potential. Integrating new technology should be done in a way that takes advantage of its inherent attributes.

AR offers the ability to overlay virtual information in our physical world. This allows for ubiquitous learning, as well as allowing users to learn and explore through their own path. Learning through an experience and interaction will allow the learner to correlate an experience with new information. AR also allows for students to explore experiences digitally that would otherwise be too dangerous, rare or impossible in our physical world. With the ability of mobile devices such as smart phones and Tablets, the creation of AR experiences is attainable for teachers as well as students. By incorporating AR into the classroom now, educators can help shape how the technology develops, ensuring the technology can have practical and impactful implementations in the classroom. The next section will discuss how to design an AR experience that utilizes the affordances of devices, as well as the instruction support that aids struggling readers.

**How Technologies for Struggling Readers Are Designed**

As discussed previously, technologies that aid struggling readers include tools, such as, e-books, audio books, text-to-speech capabilities, mind-mapping tools, and educational apps, while devices include eReaders, Tablets, smartphones or laptops (Biancarosa, & Griffiths, 2012; Hutchison et al 2012; Pullen & Cash, 2011; Stearns, 2012; Wissick & Gardner, 2011). Both tools and devices use the affordances of digital text, audio capabilities (including pronunciation and text to speech) and access to the Internet. Mobile devices automatically come with many
affordances that can help struggling readers; yet these devices were not originally designed specifically to assist struggling readers. How to design AR devices falls outside the scope of this study. Instead, a deeper look at how to design an AR experience using existing devices to create proven academic support follows. The design of AR experiences should take advantage of the affordances of digital text and bring them to a print-based environment.

While the affordances of digital text and mobile devices offer aid to struggling readers, many may not know how to use these affordances to their advantage. By building scaffolding into an AR experience, teachers would be able to guide a student through a text and provide guided access to digital text resources. Chen, Teng, & Lee (2011) created a Table of some uses for scaffolding (Table 5) to aid with literacy from Graves & Graves (2003). Table 2.5 can be used to help guide instructors in the creation of scaffolding for an AR experience. Scaffolding can be implemented by taking a three-step approach to using AR with a text. Content can be provided to prep a student to read a document, content can be made available to refer back to while reading, and post reading content can evaluate student comprehension or guide them back to readdress various sections.
Table 2.5: Adapted from Chen, Teng, & Lee (2011) Scaffolded Reading Activities

Possible activities in a Scaffolded Reading Experience (Graves & Graves, 2003).

<table>
<thead>
<tr>
<th>Pre-reading</th>
<th>During-reading</th>
<th>Post-reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Relating the reading to student’s lives</td>
<td>▪ Silent reading</td>
<td>▪ Questioning</td>
</tr>
<tr>
<td>▪ Motivating</td>
<td>▪ Reading to students</td>
<td>▪ Discussing</td>
</tr>
<tr>
<td>▪ Activating and building background knowledge</td>
<td>▪ Supported reading</td>
<td>▪ Writing</td>
</tr>
<tr>
<td>▪ Providing text-specific knowledge</td>
<td>▪ Oral reading by students</td>
<td>▪ Drama</td>
</tr>
<tr>
<td>▪ Pre-teaching vocabulary</td>
<td>▪ Modifying the text</td>
<td>▪ Artistic and outreach activities</td>
</tr>
<tr>
<td>▪ Pre-teaching concepts</td>
<td>▪ Questioning</td>
<td>▪ Application and outreach activities</td>
</tr>
<tr>
<td>▪ Pre-questioning, predicting and direction setting</td>
<td>▪ Discussing</td>
<td>▪ Building connections</td>
</tr>
<tr>
<td>▪ Suggesting strategies</td>
<td>▪ Writing</td>
<td>▪ Re-teaching</td>
</tr>
</tbody>
</table>

Successfully integrating scaffolding into an AR experience would require teachers to understand digital text affordances and set up scaffolding for comprehension and vocabulary acquisition based on core standards that utilize the affordances of AR and digital text. Next, I discuss lessons learned from AR studies.

Lessons from Other Studies

This section looks at three studies aimed at improving literacy and comprehension through the use of technology. The first will look at using AR in a classroom setting, the second will look at the importance of instructional goals and core standards and the last will look at the
use of digitally accessed resources and scaffolding through QR codes. These lessons helped shape the design of the augmented reading study.

**AR in the Classroom**

Billinghurst & Denser (2012) showed a significant benefit to students who struggled with traditional print text-based learning by using AR in the classroom. Billinghurst & Denser (2012) looked at both elementary and high school classrooms during their AR research. The multimodal experience provided by AR increased engagement, motivation and learning support. “Some researchers argue that interactivity can promote learning by activating certain cognitive processes” (Billinghurst & Denser, 2012, p.61). Interactivity can help retrieve content from long-term memory and integrate it with new ideas (Billinghurst & Denser, 2012). They stated that students interacting with content could remember more, even increasing ability to transfer knowledge to new problems. “Interacting students work harder to make sense of the material, and they rate their interest in the material higher. So far, however, relatively few user studies have investigated AR’s educational value in classroom settings” (Billinghurst & Denser 2012). This study points out the need for more research on AR in classroom settings and the positive effect of interactive AR experiences on motivation, engagement and learning retention, especially for struggling readers.

**Instructional Goals and Core Standards**

*Exploring the Use of the iPad for Literacy Learning* (Hutchison, Beschorner, & Schmidt-Crawford, 2012) points out the importance of incorporating technology to achieve specific learning goals. Keeping the core standards and learning goals in mind will help integrate the
technology in a useful way. Digital text has been shown to aid and engage struggling readers but it should be through the lens of specified learning goals. “The instructional goal should be explicitly stated and tied to overall course goals, grade-level goals, and state and national standards” (Hutchison, & Woodward, 2014). Hutchison, Beschorner, & Schmidt-Crawford (2012) also point out that digital text has more opportunities for the student to engage with, explore and manipulate the text to meet their individual needs. The lesson to take away is to incorporate specific learning goals in the creation of an AR experience and use the affordances of digital text to allow for individualized reading support options.

**Digital Scaffolding with QR Codes**

Lastly, a study where QR codes were used to link background knowledge and scaffolded questions to aid struggling readers was conducted by Chen, Teng, & Lee (2011). The use of QR codes has some similarities to a marker-less AR experience using a Tablet, but the use of marker-less AR may provide a more streamlined experience as it can be incorporated directly into the text.

The results suggested that direct access to digital resources using QR codes does not significantly influence students’ reading comprehension; however, the reading strategy of scaffolded questioning significantly improves students’ understanding about the text. The survey showed that most students agreed that the integrated print-and-digital-material-based learning system benefits English reading comprehension but may not be as efficient as expected. (Chen, Teng, & Lee, 2011)
This study discussed the current lack of the system’s ability to personalize scaffolding as well as issues with the layout of printed text and added QR codes. It also pointed out that providing links to background information did not significantly improve comprehension like the scaffold questions did. This shows that simply providing the resources such as those already available in digital text is not enough. Lessons to take away include: add the resources provided through digital text as well as scaffolded comprehension and vocabulary questions. The incorporation of resources and digital text affordances through scaffolding may provide greater aid to struggling readers.

Overall lessons that can be taken away from these three studies include: (1) need for more AR research in the classroom, (2) incorporation of instructional goals/standards, and (3) use of scaffolding. Billinghurst & Denser (2012) showed a significant benefit to struggling readers when using AR in the classroom but more research was needed. Hutchison, Beschorner, & Schmidt-Crawford (2012) pointed out the importance of incorporating instructional goals and core standards when using technology in the classroom. Finally, the Chen, Teng, & Lee (2011) study showed that just adding digital resources for background knowledge was not enough to improve literacy but incorporating scaffolding had significant benefits to comprehension.

Summary

To conclude, several gaps in the research remain for aiding struggling readers, the use of AR in the classroom, as well as the designing of scaffolding with AR to aid struggling readers. Most research on struggling readers focuses on young readers with very little attention to high school or college-age struggling readers. Some research demonstrated the high rate of dyslexia in college art students (Equality Challenge Unit, 2015; Kennard, 2000; and Wolff, & Lundberg,
2002), which is a contributing factor to the struggling reader population. Yet not many studies look at all struggling readers at the college level (Collinson & Penketh 2010). More research on AR in the classroom is also needed (Billinghurst, & Denser, 2012). Many older studies using AR in the classroom have used markers, glasses, and desktop computers, or QR codes. Since mobile devices such as smartphones and Tablets have become increasingly powerful, they can be used to naturally-feature-track text-based documents with AR applications. Natural-feature-tracking uses the line edges of an image to pull up digital content like a marker or QR code. Some studies show the benefits of digital text for struggling readers and others show the importance of scaffolding for struggling readers; however, there are no studies specifically looking at how the affordances of AR can use scaffolding to aid struggling readers. Research addressing these gaps includes: (1) looking at older struggling readers, (2) analyzing current AR technology in the classroom, and (3) exploring development of scaffolding for comprehension and vocabulary acquisition through AR. Therefore, within this study I explored all three of these areas to extend the knowledge of using AR to support struggling readers.
CHAPTER 3. RESEARCH DESIGN AND METHOD

The focus of this study was to explore the use of augmented reality (AR) to supplement academic text in the classroom. Mixed methods were used to investigate the motivational influence on art and design students that AR can have on reading about design theory. Additionally, the engagement level with vocabulary and comprehension questions, and the perceived confidence level of comprehension were analyzed. If perceived confidence in comprehension is increased with augmented text, future studies of quantitative data could be designed specifically to measure comprehension and vocabulary acquisition. A conceptual framework was developed to graphically explain key factors to be studied (Figure 3.1; Miles, Huberman, & Saldana, 2013). The research question guiding this study was: How does augmented text impact struggling readers’ perceived motivation, engagement and confidence in understanding?

I used a mixed method design with predominantly quantitative data, supported by qualitative data (Jup, 2006; Yin, 2013), through a survey within a case study (Yin, 2013). Mixed method design has become increasingly common as it allows for the combination of qualitative and quantitative data that results in a multidimensional approach (Miles, Huberman, & Saldana, 2013). Quantitative data was collected through the Instructional Material Motivational Survey (IMMS) in order to look at the motivational impact of the learning activity (Keller, 1987). A follow-up focus group interview gathered qualitative data to expand on the quantitative survey data (Creswell, Plano, Gutmann, & Hanson, 2003). This follow up was important since little research on providing digital scaffolding and visual reading aids through AR exists for higher education students.
Methods

Context for the Study

This study specifically looked at art and design students in higher education reading academic design theory texts. A case study of an augmented reading activity was conducted in a Visual Literacy course. The Visual Literacy course is considered a history and theory/criticism class in the Bachelor of Arts in Interdisciplinary Design, a program at Iowa State University. The reading activity was performed with a class composed of 19 art and design students of various reading abilities. While not all art and design students are struggling readers, research has shown that a higher percentage of art students are dyslexic (Bacon, Bennett, 2013). Students were asked to self-evaluate to determine if they identified as struggling readers. Prior to this study no formal reading level test was given.

Participants

The Visual Literacy class had 19 students (10 boys and nine girls, ranging from sophomores to seniors) who performed the activity in class; of those, 16 opted to participate in the study. Sixteen of the 19 students opted to participate in data collection. Students were seeking a Bachelor of Design degree, and this class fulfilled one of their required history and criticism classes.

All the students had prior experience with Aurasma, through prior class activities. They were familiar with how to access and use the augmented content, as well as how to take Qualtrics surveys though a mobile device.

Research Design

Research for this study was collected and analyzed though the lens of Motivational Theory (Deci 1975), using the conceptual framework in Figure 1.1 as a roadmap to the study.
The use of a conceptual framework supports the exploratory nature of this study (Miles, Huberman, & Saldana, 2013). Conceptual frameworks can evolve with the study and they can help a researcher focus on the most important variables and relationships, which will help guide what data should be collected or analyzed (Miles, Huberman, & Saldana, 2013). Figure 3.1 shows the overlay of the motivational theory lens on the conceptual framework. Through the use of this theory students’ motivation to read the text, and engage with vocabulary could be examined. Exploring if their motivations were extrinsic, intrinsic, or a combination of both could help development of this technology and future studies.

**Figure 3.1:** Theory influence on conceptual framework for augmented reality reading activity.

This study’s conceptual framework (Figure 1.1) shows the AR was designed using proven reading supports. It defines the participants as both struggling and typical readers in a higher education art and design program. Finally, the framework lays out what the study aims to investigate. How does AR influence motivation to read, engagement with vocabulary and
comprehension of text? Also, does AR improve perceived motivation to read, engagement with text, and confidence in understanding text?

Data Collection Procedures

The reading activity augmented a design theory text, *Visual Literacy and the Design of Digital Media* by Susan Roth. Students used Aurasma, an AR app, to access digital content, including a visual summary of the text, vocabulary definitions, and scaffolded comprehension questions. The data for this study was collected through a survey and from a small informal focus group after the completion of an AR reading activity. Both qualitative and quantitative data has been collected. Instruments used include: (a) scaffolded comprehension questions (in activity), (b) IMMS motivation assessment of AR, (c) a post-activity survey questionnaire, and (d) a focus group. All student participants had used Aurasma on multiple occasions and were familiar with how to access augmented content. Students had used Aurasma to access content a minimum of 10 times for various class activities. They had also built their own Auras (Aurasmas triggers) for two class projects.

Approval from the Institutional Review Board (IRB) for this study was granted (Appendix A) and an informed consent screen was developed to explain optional participation in the study (Appendix G). Optional participation in the study was again explained verbally before starting the class activity and listed on the directions before starting the survey (Appendix B).

AR Design Methodology

The students used the augmented app Aurasma to access the digital content for the reading activity. Figure 3.2 shows the augmented interface to access the augmented content.
Aurasma was chosen because it was free and worked on both IOS and Android devices. Aurasma had been used multiple times in the class, prior to the study. During the reading activity, students accessed the AR (1) pre-reading, (2) while reading, and (3) post-reading to provide scaffolding to support comprehension and vocabulary acquisition (Chen, Teng, & Lee, 2011). See Appendix B for the opening activity instructions provided to the students.

Proven scaffolding techniques were used to aid in the design of the AR experience. The Design of the AR experience used 11th-12th grade reading standards to inform the design, particularly: CCSS.ELA-LITERACY.RI.11-12.3, CCSS.ELA-LITERACY.RI.11-12.4, CCSS.ELA-LITERACY.RI.11-12.7. Standards were taken from the core standards web site http://www.corestandards.org/ELA-Literacy/RI/11-12/. The following standards were used:

(CCSS.ELA-LITERACY.RI.11-12.3) Key Ideas and Details: to analyze a complex set of ideas or sequence of events and explain how specific individuals, ideas, or events interact and develop over the course of the text.

(CCSS.ELA-LITERACY.RI.11-12.4) Craft and Structure: to determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings; analyze how an author uses and refines the meaning of a key term or terms over the course of a text (e.g., how Madison defines faction in Federalist No. 10).

(CCSS.ELA-LITERACY.RI.11-12.7) Integration of Knowledge and Ideas: to integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a question or solve a problem.
These standards have been designed to define the expected abilities for college and/or a career. Students in higher education should be able to meet these core standards.

The students first used the Aurasma app to view key vocabulary and a visual breakdown of the structure of the text. Figure 3.3 shows the augmented vocabulary sections, Figure 3.4 and 3.5 shows the pre-reading visual breakdown of the text. This pre-reading scaffolding stage allowed for pre-learning vocabulary and text-specific information as well as direction setting (Chen, Teng, & Lee, 2011). Second, the students commenced reading through the text. If an unknown word appeared while they read, the students could access definitions through the Aurasma app. Key vocabulary was linked to a definition, including a more specific definition of
how it is used in the text. This provided scaffolding during reading by providing support (Chen, Teng, & Lee, 2011).

**Figure**: 3.3 Screenshots of vocabulary accesses through Aurasma.

After the student read though the text, referring when needed to the AR experience, they again used the Aurasma app to access comprehension questions in Qualtrics. The comprehension questions were scaffolded so that if a student answered a question incorrectly Qualtrics would redirect them to a subsequent question. This question then referenced a section of text or referred to a vocabulary definition before the student moved on to answer the new question. This final post-reading scaffolding was designed to potentially help build connections, use questions to scaffold the material and verify that students have comprehended the text (Chen, Teng, & Lee, 2011). When the students completed answering the comprehension questions they finished the case study task.
**Figure 3.4:** Screen shots of pre-reading visual breakdown of article (page one).
**Figure:** 3.5 Screen shots of pre-reading visual breakdown of article (page two).
Survey

The IMMS was included in the post survey taken by students after the reading exercise. The IMMS questions can be found in appendix H. A modified 20-question version of the IMMS (Appendix H) was used, with an overall reliability of 8.585 (Huang, Huang, Diefes Dux, & Imbrie, 2006). The IMMS instrument looks at the motivational impact of a learning activity; the instrument was based on Keller’s (1987) ARCS Model. The ARCS Model (attention, relevance, confidence, satisfaction) pulls from psychological and educational research on motivation and learning (Keller, 1987). The IMMS has been verified through several studies (Keller, 2010). The second section of the post-activity survey collected qualitative information on students’ confidence in reading and enjoyment level of reading. The last section in the survey asked about using Aurasma to access reading support for academic texts.

Focus Group

The focus group interview consisted of three students who volunteered to meet two weeks after the reading activity. Questions were asked and discussed as a fluid guided conversation among participants (Rubin & Rubin, 2011). See Table 4.10 for focus group questions. This semi-structured interview was used to collect qualitative data to back up the quantitative post-survey data about the use of AR with the reading activity (Weiss, 1994, p. 207–208; Yin, 2013, p.110). The focus group conversation was audio-recorded with permission of the participants and selectively transcribed. The recording was not transcribed verbatim; only relevant content was transcribed.
Data Analysis

The collected qualitative data was analyzed in two stages: first cycle and second cycle. Two elemental methods were used, In Vivo and Descriptive. The first cycle used In Vivo coding, a method that uses words or short phrases from the participant’s own language in the data record as codes (Miles, Huberman, & Saldana, 2013; Saldana, 2009). The data was then recoded in a second cycle. Descriptive coding was used to attach a label to the collected qualitative data, this provided indexing information that was used in the second cycle of coding. The qualitative method of In Vivo coding was chosen to see if students used similar language for similar content. Descriptive coding was chosen to group similar content, and outcomes even if students were using different languages. Coding in two stages aided in understanding the data. By revisiting the data after the initial coding, deeper meaning was accessed from the data.

This first stage of coding was done to initially summarize larger blocks of data to be used in the second cycle method of coding where those summaries are grouped into smaller categories or constructs. Four summarizer types were looked for during the second cycle of coding using pattern matching: (a) categories or themes, (b) causes/explanations, (c) relationships among people, and (d) theoretical constructs. Matrix displays were used during both the first and second cycle of coding to provide a visual aid for analyzing the data. These matrixes are a visual that presents information systematically so the researcher can draw conclusions about the data. By creating a matrix, a full analysis of that data can be made ignoring the non-relevant information while focusing and organizing the information coherently (Miles, Huberman, & Saldana, 2013).

The collected quantitative data was reviewed and a series of appropriate visuals were created to visualize the quantitative data. Several cross-tabulation charts were also created to show how students answered one question in relation to another. These cross-tabulation charts
were created to show questions the researcher thought would give deeper insight into the data. Seeing the results of one question alone was not as meaningful as seeing how the participants responded to both questions. Deeper understanding was gained from the extended data comparing answers from two different questions. This allowed a larger picture to be examined.

The IMMS (Appendix H) used was the modified 20-question version for computer-based learning. Cronbach's Alpha, calculated using all of the IMMS questions, was .772 and Cronbach's Alpha Based on Standardized Items was .812. Recommended values for Cronbach’s Alpha are 0.7 or higher (DeVillis, 2003; Kline, 2005).

**Trustworthiness**

Data quality can be assessed through checking triangulation across data sources and methods (Miles, Huberman, & Saldana, 2013 pp 294). This implementation of the survey data was triangulated by looking at the data from the IMMS, the post-activity questions, and the focus group interview. Coding of the qualitative data went through first and second cycles to gain a deeper understanding of the data (Miles, Huberman, & Saldana, 2013). Pie charts showing the number of students were used to visualize the qualitative post-survey data. The size of the case study was limited to one class; showing the actual number of students instead of a percentage, gives a better understanding of the scope of this study. Chronbach’s Alpha was found to show the reliability of the IMMS used during this exploratory study with a small sample size.

**Ethical Issues and Considerations**

Several ethical issues were addressed before this study was conducted, including the important issues of consent and confidentiality (Esterberg, 2002). The Institutional Review
Board (IRB) declared this study to be exempt due to the activity being presented as course work in the normal flow of a class with participation in the study as optional. Students gave consent and verified they were over 18 before their survey data was collected. Because participants were also in a class graded by the researcher, special guidelines needed to be followed for viewing the data. The data was not looked at or analyzed until after the grades of the participants were submitted in accordance with IRB procedures. However, although Miles Huberman & Saldana (2013) strongly advised starting the analysis of data while continuing to gather more data, this study was unable to fully utilize that process. Due to the fact that the participants were in a class graded by the researcher, the data from the activity could not be looked at until grades had been processed. Waiting to view the data from the reading activity meant no secondary opportunity to engage with the participants as a whole. After returning grades, a small focus group met during the summer. The focus group interview allowed follow-up qualitative data to be collected based on the initial survey results.

Students needed to bring their own device (BYOD) to view the AR for this activity. Prior to the activity, participants were asked if anyone was unable to bring a device as several iPads were available. The Aurasma app was chosen because it was free and worked on both Android and ISO devices, of various ages. This was an ethical concern because it would have placed some students at an unfair disadvantage to favor one type of device over another.

**Delimitations and Limitations**

This case study was conducted with one design theory class in which 16 students opted to participate. For that reason, the sample size is small. The small sample size fits with the exploratory nature of this study. This study makes an argument that AR can help struggling
readers. The participants were not all struggling readers, nor were they tested. Still, some did self-identify with being a struggling reader. Looking at how all readers were affected was important for this exploratory study because most classrooms have a range of student abilities.

Summary

The conceptual framework (Figure 3.1) of this exploratory study was developed to focus the data collection and analysis on finding answers to the main research question. Both qualitative and quantitative data has been collected. Instruments used include: (a) scaffolded comprehension questions (in activity), (b) IMMS motivation assessment of AR, (c) a post-activity survey questionnaire, and (d) a focus group. The collected qualitative data was analyzed in two stages: In Vivo coding during the first cycle and Descriptive coding for the second cycle. Appropriate visuals were created for the quantitative data including pie charts and cross-tabulation graphs of the post-survey questions. The next chapter will display graphic charts of the collected data and report data used during the final chapter to answer the research question.
CHAPTER 4. RESULTS AND FINDINGS

I present the findings of this exploratory study (Miles, Huberman, & Saldana, 2013) in this chapter, with a detailed overview of the data collected, including the results of the IMMS, post-activity survey and the focus group interview data. Visuals and cross-tabulation tables have been created to allow for post activity survey data to be quickly understood and compared.

IMMS Results

Overview of IMMS Results

A modified 20-question version of the IMMS was used, with an overall reliability of 8.5 (Huang, Huang, Diefes Dux, & Imbrie, 2006) that looked at the motivational impact of this learning activity. Cronbach's Alpha, calculated using all of the IMMS questions from this study, was .772 and Cronbach's Alpha Based on Standardized Items was .812. Recommended values for Cronbach’s Alpha are 0.7 or higher (DeVillis, 2003; Kline, 2005). See Appendix H for the IMMS questions viewed by participants in Qualtrics. Of the 19 students in the class 16 consented to participate in the study. The IMMS showed medium to high motivation for 12 of the 16 surveyed students, three students were neutral and one showed low motivation. Students were asked to rate each question on a Likert scale of one, low motivation, to nine, high motivation. This data is represented in table 4.1 below to show a color-coded chart of the IMMS student responses. The data is coded with green representing highly motivated/engaged, blue moderately motivated/engaged, yellow neutral, and red less than motivated/engaged.
Table 4.1: Color coded chart of IMMS responses.

Based on the responses to the IMMS, students thought the AR was relatable and the AR layout held their attention. When asked: “I could relate the content of the activity to things I have learned in class or thought about in my own life”; 15 students responded with a seven or higher, one student responded with 6.5. When asked: “The way the augmented information is arranged on the pages helped keep my attention”, 14 students responded with a six or higher; eight of those responded with a seven or higher. All students responded above a six when asked: “There are sufficient vocabulary and visual aids that showed me how this reading activity could be important to some people who struggle with reading academic texts”. Question 14 asked “The content of the activity will be useful to me in terms of comprehending and retaining the academic article.” Thirteen students responded with a seven or higher, two with a six and only one with a five and a half.
Table 4.2: IMMS Questions with mean and variance from a nine point Likert scale. See appendix H for layout of questions in Qualtrics.

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. There was something interesting at the beginning of this activity that got my attention.</td>
<td>6.22</td>
<td>2.82</td>
</tr>
<tr>
<td>2. The Augmented Overlay and links are eye catching.</td>
<td>7.23</td>
<td>0.82</td>
</tr>
<tr>
<td>3. The quality of the writing in this activity holds my attention.</td>
<td>5.63</td>
<td>2.86</td>
</tr>
<tr>
<td>4. The way the Augmented information is arranged on the pages helped keep my attention.</td>
<td>6.92</td>
<td>1.26</td>
</tr>
<tr>
<td>5. This activity has things that stimulated my curiosity.</td>
<td>6.54</td>
<td>2.94</td>
</tr>
<tr>
<td>6. The variety of reading passages’ vocabulary’ illustrations’ etc.” helped keep my attention on the reading.</td>
<td>5.76</td>
<td>3.18</td>
</tr>
<tr>
<td>7. I could relate the content of the activity to things I have learned in class’ or learned or thought about in my own life.</td>
<td>8.18</td>
<td>0.72</td>
</tr>
<tr>
<td>8. I enjoyed this activity so much that I would like to know more about it.</td>
<td>5.4</td>
<td>3.26</td>
</tr>
<tr>
<td>9. I really enjoyed learning with this activity.</td>
<td>6.26</td>
<td>2.71</td>
</tr>
<tr>
<td>10. The augmented layer and/or vocab links made me feel rewarded for my effort.</td>
<td>5.91</td>
<td>2.28</td>
</tr>
<tr>
<td>11. It was a pleasure to work on this activity.</td>
<td>6.21</td>
<td>1.46</td>
</tr>
<tr>
<td>12. It is clear to me how the content of this activity relates to this class.</td>
<td>8.16</td>
<td>0.68</td>
</tr>
<tr>
<td>13. There are sufficient vocabulary and visual aids that showed me how this reading activity could be important to some people who struggle with reading academic texts.</td>
<td>7.29</td>
<td>0.79</td>
</tr>
<tr>
<td>14. The content of the activity will be useful to me in terms of comprehending and retaining the academic article.</td>
<td>7.45</td>
<td>0.53</td>
</tr>
<tr>
<td>15. This activity was so abstract that is was hard to keep my attention on it.</td>
<td>2.27</td>
<td>2.29</td>
</tr>
</tbody>
</table>
Table 4.2: continued

<table>
<thead>
<tr>
<th>Question</th>
<th>1.37</th>
<th>1.05</th>
</tr>
</thead>
<tbody>
<tr>
<td>16. The exercises in the activity were too difficult.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. Many of the pages contained so much information that it was hard to</td>
<td>3.07</td>
<td>5.81</td>
</tr>
<tr>
<td>remember the important points.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. After working with this activity for a while I was confident that I</td>
<td>6.32</td>
<td>1.41</td>
</tr>
<tr>
<td>would be able to explain what this article was about to a peer.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19. I could not really understand quite a bit of the material in this</td>
<td>3.03</td>
<td>5.76</td>
</tr>
<tr>
<td>activity.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20. The amount of repetition in this activity caused me to be bored</td>
<td>3.97</td>
<td>5.10</td>
</tr>
<tr>
<td>sometimes.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

By looking at Table 4.1 and Table 4.2, there are a number of columns with almost complete agreement but many more with a wide range. Students were in agreement that the activity related to the class but were torn on the quality of writing holding their attention.

The IMMS measured motivation for reading a design theory text with AR reading supports. It should be noted that students’ motivation for reading an academic design theory article without AR supports was not measured. However, the post-survey data expands on students perceived motivation.

Post Activity Survey Results

Overview of Post Activity Survey Results

The post activity survey results showed that while 13 out of 16 students were already “mostly to very confident” (Figure 4.1) in their ability to read academic design theory text, 13 out of 16 students said that having access to the AR while reading the text improved their confidence (Figure 4.2). Interestingly, seven out of 16 students identified themselves as struggling readers (Figure 4.8) when reading art/design history and theory text. This data points
out that students may feel confident but also feel that they are struggling. The survey results indicate that the students found value in the AR for the text and indicated that they were likely to use it for other text if available. When asked if they would use similar AR for other text if it was available 11 students said yes and five said maybe (Figure 4.10). None of the students in this study said they definitely would not use AR if it was provided for another text. Students believed that the AR was simple to access; 11 said it was “extremely easy” while only two said they found it “slightly difficult”, no one believed it was “moderately or extremely difficult” (Figure 4.11). A graphic representation of student responses for these questions can be viewed starting on page 78 Figures 4.1 though 4.18. See Appendix I for the post activity survey questions viewed by participants in Qualtrics.

The pre-reading AR was found to be helpful for all students in the study; three thought it was extremely helpful, ten said helpful and three thought it was slightly helpful (Figure 4.12). Most students also agreed that having access to the vocabulary was helpful (Figure 4.13). All the students also agreed that answering the comprehension questions helped them comprehend the article (Figure 4.15), three said it was only slightly helpful however, eight found them helpful and five found them extremely helpful.

Some survey responses were cross tabulated in Qualtrics, to further explore how the AR in this activity influenced: (1) motivation, (2) engagement, and (3) comprehension in higher education. The cross-tabulated data also provided the opportunity to explore how self-reported struggling readers perceive their confidence and motivation compared to self-reported typical readers. Table 4.4 cross tabulates three survey questions examining struggling readers’ motivation and confidence in reading academic text. Out of seven self-reported struggling readers, five said they would be more motivated to read class readings if AR support was
available. Interestingly, five out of six students who did not identify as struggling readers also said the AR would motivate them to read. Additionally, the two students who reported they would probably skip any required readings also reported that they would be “extremely motivated” and “slightly more motivated” to read required class material if AR support was provided. These cross-tabulations (Table 4.4) show that AR support for reading could motivate those most at risk for skipping the readings, those who struggle, as well as those who already feel confident in their reading abilities.

**Table 4.4:** Cross tabulates three survey questions examining struggling readers’ motivation and confidence in reading academic text. The numbers in the table represent the number of subject responses.

<table>
<thead>
<tr>
<th>Would you be more motivated to do the readings for a class if these augment features were provided?</th>
<th>Typically, how confident are you with your ability to read art/design history/theory texts?</th>
<th>Would you consider yourself a struggling reader when reading academic history/theory texts?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Extremely motivated</td>
<td>Mostly motivated</td>
</tr>
<tr>
<td>Extremely motivated</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Slightly more motivated</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>No more motivation than normal</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Less motivated, because it adds a layer of complexity</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>I still wouldn’t read the required readings</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
<td>10</td>
</tr>
</tbody>
</table>

While most students (13 out of 16) stated that they were confident in their ability to read art history/design theory text, Table 4.5 shows 10 of those 13 felt having the augmented reality improved their confidence. Perhaps more importantly the two students who said they would normally skip the reading also felt that the AR improved their confidence.
Table 4.5: Cross-tabulation of confidence reading art history or design theory text compared to if AR improved comprehension confidence of art history or design theory text

| Did having access to the augmented content improve your confidence in reading this academic design ... | Typically, how confident are you with your ability to read art/design history/theory texts? |
|---|---|---|---|---|---|
| | Very confident | Mostly confident | Not sure | Not very confident | I would probably skip required readings | Total |
| Yes | 2 | 8 | 0 | 1 | 2 | 13 |
| Not sure | 1 | 2 | 0 | 0 | 0 | 3 |
| No | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 3 | 10 | 0 | 1 | 2 | 16 |

When students’ confidence with reading art history/design theory was cross tabulated with perceiving themselves as a struggling reader, the results were unexpected. Out of the 10 students who said they were confident with reading art history/design theory, four said they felt they were struggling readers, four said they were not, and two were unsure. This shows that students may still identify as struggling as well as confident in their abilities. The two students who said they would normally skip required readings also identified as struggling readers.
Most students said they would feel more confident reading an academic text if it had AR support features. Both the students who felt they were struggling readers as well as the students who felt they were typical readers said the AR would make them feel much more confident or slightly more confident (Table 4.7). Only one student who felt they were a struggling reader said the AR would have no impact on their reading confidence. One other student also said they were unsure if they were a struggling reader and that the AR would have no impact on their confidence. However, the other two students who stated they were unsure if they were struggling readers or not said the AR would make them slightly more comfortable. This data indicates that the AR supports increased reading confidence in all students, both typical and struggling.
Table 4.7: Cross-tabulation of self-perceived struggling readers and perceived confidence in reading from AR support features.

<table>
<thead>
<tr>
<th>Would you consider yourself a struggling reader when reading academic history/theory texts?</th>
<th>Would you feel more confident reading academic text if these augmented features were provided?</th>
<th>Much more confident</th>
<th>Slightly more confident</th>
<th>Normal level of confidence</th>
<th>Less confident because it adds a layer of complications</th>
<th>I would probably skip required readings</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Not sure</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>No</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>7</td>
<td>7</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>16</td>
</tr>
</tbody>
</table>

Self-reported struggling and typical readers found the structure overview and answering the comprehension questions almost equally helpful (Table 4.8). Struggling readers also found access to the vocabulary and using the prompts in the comprehension questions of equal importance to the comprehension questions and overview. Using AR support allows for struggling readers to access the supports they need without hindering typical readers with extra content.

Table 4.8: Cross-tabulation of which AR features struggling readers found most helpful

<table>
<thead>
<tr>
<th>How confident are you with your ability to read art/design history/theory texts?</th>
<th>Would you consider yourself a struggling reader when reading academic history/theory texts?</th>
<th>Yes</th>
<th>Not sure</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very confident</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Mostly confident</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Not sure</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Not very confident</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>I would probably skip required readings</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>7</td>
<td>3</td>
<td>6</td>
<td>16</td>
<td></td>
</tr>
</tbody>
</table>
Students were asked to expand on why they found certain features helpful or not helpful and 11 out of 16 students provided comments. The qualitative responses were coded into categories; eight of the 11 comments were coded as dealing with comprehension. Some comments dealing with comprehension included:

(1) “Because the reading was so dense, having things to help pick out main points helped a lot”.

(2) “The comprehension quiz is good to make sure I am understanding and retaining the information”.

(3) “Better understanding of the text”.

(4) “It gave a quick summary of what I was about to read”.

(5) “Comprehension questions helped give a push on what sections may need to be looked over again for the reader”.

(6) “For me personally, my range of vocabulary is extremely low. I constantly have to google search words to make sure I use them in the correct context, so having terms available on Aurasma is more efficient and can directly relate to the article”.

(7) “I am a visual learner”.

It is interesting to note that no one left a comment about features not being helpful. All 11 comments dealt with the support helping comprehension, motivation, understanding vocabulary, being simple to use, or confidence.

The data indicated adding the AR text support will motivate students to read academic text and they would actually use the AR support if it was provided. The cross-tabulation of Table 4.9 shows this comparison. Out of 16 students, 12 said they would be more motivated to read an academic text with AR support; of those 12, nine said they would use the AR support if it was provided. Interestingly, three students stated that they might use the AR support but it would
improve their motivation to read an academic text if it was available. Of the four students that said having the AR would not change their motivation to read an academic text, two said they would use the AR support if it was provided and two said they might use it.

**Table 4.9:** Cross-tabulation showing motivation for reading academic text with AR and desire to use AR support in the future.

| Would you use this technique if it were available for other texts? | Would you be more motivated to do the readings for a class if these augmented features were provided? |
|---|---|---|---|---|---|
| | Extremely motivated | Slightly more motivated | Normal level of motivation | Less motivated, because it adds a layer of complication | I would probably skip required readings | Total |
| Yes | 7 | 2 | 2 | 0 | 0 | 11 |
| Not sure | 0 | 3 | 2 | 0 | 0 | 5 |
| No | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 7 | 5 | 4 | 0 | 0 | 16 |

It should be noted that current motivation for reading an academic text was not measured. The four students who said the AR had no effect on their reading motivation could already be highly motivated to read an academic text for class based on other factors. This data shows students, believe that AR supports increased their perceived motivation for many of the students and was seen as something they would use again. The following section presents all of the graphic representations of post activity survey responses.
Graphics of Post Activity Survey Results

**Figure 4.1:** Typically, how confident are you with your ability to read art/design history/theory texts?

**Figure 4.2:** Did having access to the augmented content improve your confidence in reading this academic design theory text?

**Figure 4.3:** Have you ever dropped a college level class because of the reading load?

**Figure 4.4:** Do you enjoy reading for fun outside of required class material?
**Figure 4.5:** Do you prefer listening to audio books over reading on your own?

**Figure 4.8:** Would you consider yourself a struggling reader when reading academic history/theory texts?

**Figure 4.9:** What type of device did you use to access Aurasma?

**Figure 4.10:** Would you use this technique if it were available for other texts?
**Figure 4.11:** How difficult was it to access the augmented content in general?

**Figure 4.12:** How helpful was the pre-reading structure content for your understanding of the text?

**Figure 4.13:** How often did you refer back to augmented vocabulary while reading?

**Figure 4.14:** How helpful was the ability to refer back to vocabulary while reading?
**Figure 4.15:** Did you find answering the comprehension questions helped you understand the article better?

**Figure 4.16:** Did you refer back to the text while answering the questions?

**Figure 4.17:** Did you use the audio feature?

**Figure 4.18:** Which features did you find the most helpful in understanding the article? (pick 1-3 of the most helpful features)
Focus Group Interview

Focus Group Interview Results

This section presents the focus group interview data, which supports and expands on the post survey data. The focus group interview was conducted with three students after grades had been returned for their spring semester. Participation was voluntary and allowed for a follow up of the post activity survey where qualitative data could be collected. An audio file was recorded of the interview and selectively transcribed. Relevant responses were transcribed.

Occasionally tangents related to Aurasma’s interface design, the creation of Auras for Aurasma or accessing an Aurasma Aura were discussed during the focus group. Since these tangents did not have direct bearing on this study, they have been omitted from the transcription. Table 4.10 shows a list of questions that guided the interview. During the interview, several more questions were added based on student responses. Those questions have been included at the bottom of Table 4.10 after the original questions.

Table 4.10: Focus Group Interview Questions

<table>
<thead>
<tr>
<th>Original focus group questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How did you feel about using Aurasma to access digital content for the text?</td>
</tr>
<tr>
<td>2. If you had the choice of an eBook or printed book with augmented content what would you prefer?</td>
</tr>
<tr>
<td>3. If no eBook version was available would you prefer an augmented print book or just a regular print book?</td>
</tr>
<tr>
<td>4. In the survey almost everyone reported higher confidence in reading the article using AR. What about the AR gave you more confidence in your reading?</td>
</tr>
<tr>
<td>5. In the survey people admitted that they would be more motivated to read academic articles for class if they were augmented. What about the AR did you find motivating or engaging?</td>
</tr>
<tr>
<td>6. Would you be more likely to take an art history/theory class if all the readings were augmented? Why?</td>
</tr>
<tr>
<td>7. Are there any other augmentations that you would find helpful to understanding an academic reading?</td>
</tr>
</tbody>
</table>
Table 4.10: continued

8. Is there anything else we haven’t talked about that you want to say about Aurasma or the augmented reading?

9. Would you say you are less likely to look up a word on your phone or a physical dictionary than by using an e-book dictionary or AR where the vocabulary is linked directly to the text you are reading?

10. You mentioned learning games: Art history books have a lot of time lines: would you find it helpful if you could get into an Augmented time line and expand or explore it?

The qualitative interview data confirmed findings from the post activity survey. Particularly: (1) preference for AR support over plain printed text, (2) AR helped vocabulary acquisition and comprehension, and (3) AR supports motivation to read. When the students were asked if they preferred an e-book to a regular text book: all three students express liking the digital text capabilities of e-books especial the text to speech option. However, two students said they would prefer to read print if AR could add text to speech capabilities. One student stated “E-book! I’ll lose the printed book and I’m definitely not going to carry it around.” The student went on to state if no e-book was available, AR support on print would be preferred. Especially, if the printed books could be made shorter with some previously printed content accessed through AR such as quizzes, and in-depth content.

Concern over reading e-books on a phone was expressed by one student. They did not have access to a Tablet. All the students agreed that reading e-books on a phone was difficult but using AR through a phone was fine if it was set up for a phone. AR support was also preferable particularly for art history because it could streamline studying.

Students expressed how helpful pointing out main content during the pre-reading phase was. “It’s like we know what the instructor is looking for at that point. You are actually showing what could be on the test, What’s the main point? What am I supposed to know?” They
also expressed desire for flash cards to be added to an art history text book with AR. “Like adding review flash cards. That is always one of the hardest parts styling for art history you have to make your own flash cards of the slides. too much of a hassle and time consuming.” “Worst part of studying is getting started when it takes so long to prepare the cards; then I don't even want to start studying.” Students explained that having access to AR supports could increase motivation to study art history if it could streamline tedious study preparations.

Students expressed their belief that the AR supports increased their comprehension of the article as well as assisted them with vocabulary.

Not everyone is a reading-something-learner, some people need to see it being done or hear it. Aurasma could lean toward that so you don't have to pound your head into a text book in order to learn. You could have a documentary about an art piece or an interview with an artist, or someone walking you though the art piece like a miniature lecture. (Student response focus group interview 2016)

This response came from a student who previously had reported frustration at how art history classes had been taught. The student reported not learning well from readings without an audio option, also they expressed a desire to experience content through hands-on activities.

Vocabulary can be a stumbling block for struggling readers. “I think the vocabulary was the best use. If I have to look up six words per page it’s too time consuming; but if they are right in the text I can look up the definitions very quickly.” By providing vocabulary through AR it can be linked directly to the text as well as providing explanations based on the context of how the word has been used in the text. The students were asked if they would look up a word they
didn’t know from a printed text using a dictionary or their phone. All the students said they were highly unlikely to use a dictionary. However, they were more likely to use their phone. “I just ask Siri.” One student expressed concern over asking Siri the meaning of a word; “I don't know how to say the word sometimes so I don't even know how to look it up.” When asked if they use the dictionary feature in e-books one student emphatically stated “All the time!” another student said “Depends, if I go through and see a word I sort of know I keep reading, but if I still don't know what it means after a few sentences I go back and look it up [through the e-book].”

Findings from the post activity survey showed AR increased motivation to read an academic text as well as increased confidence in understanding the text. Responses during the focus group interview also supported this increase in motivation and confidence.

I felt like I understood more, so I felt like I was actually learning. Not just, oh, I think I'm understanding it. So, I wanted to keep reading, because I felt like I was successful. And then being able to take the quiz at the end to make sure I am understanding the content (Student Response Focus Group 2016).

When asked what they found engaging about the AR support, a student’s responses indicated that the increase in motivation and confidence in understanding were the driving factors for engagement. Another student noted the device itself. “Academic readings are always very dry readings, so to bring in something that we use every day, whether it’s your phone or a tablet; when you use that, it makes it feel more engaging, like it’s trying to talk back to you.” By bringing in technology that a student finds engaging, they may become more engaged with the reading because of the technology. The third participant nodded and verbally agreed with both responses.
During the interview students remarked on their low motivation for taking any art history or design theory classes. When asked if they would be more likely to take art history or design theory classes with AR support they agreed that they would prefer AR support over no support but they would not want to take additional history/theory classes beyond the required amount. Responses included:

- “I would be more likely to take an art history class than I am currently but only because if there was AR and it was done the right way it could benefit me. All the stuff that was lacking before that I couldn't get into my head, especially the quantity -- that was the biggest issue. Remembering stuff from art history would be more vivid and simpler to recall if AR was part of the art history course.”

- “Yea. I wouldn't want to take MORE art history then I had to, but it [AR] would make it less terrible.”

- “Yes, I’d be more likely to pick AR then non-AR.”

- "Remembering stuff from art history would be more vivid and simpler to recall if AR was part of the art history course.”

- “Not everyone is a reading-something-learner. Some people need to see it being done or hear it. Aurasma could lean toward that, so you don't have to pound your head into a text book trying to learn. You could have a documentary about an art piece or an interview with an artist, or someone walking you through the art piece like a miniature lecture.”
This data shows students preferred using the AR over plain text; preferring a history class with AR over one without AR support. However, this was not necessarily enough to motivate them to take on additional art history classes beyond graduation requirements.

They were asked what other supports they would like to see built into the augmented reality. This was followed by a brief discussion of the elements previously identified as being helpful: vocabulary, a short video or audio, quizzes and chunking out content and pointing things out. One student mentioned liking to doodle and then said that including educational games could help. Since learning games was mentioned, the students were asked “Art history books have a lot of timelines: would you find it helpful if you could get into an Augmented timeline and expand or explore it?” All nodded their heads and agreed, “Yes that would be much more beneficial.” “The simplified printed timeline could give you all the in-depth information.” The ability to dive into a timeline and explore could allow students to experience historic connections in a more intuitive structure. Replacing the 2D linear timeline with a web of historic connections to be moved through.

Overall everyone agreed the AR was helpful and beneficial for an art history or design theory class. They agreed the supports provided with AR would make them more confident in comprehending the content. They also agreed that while AR was preferred to non-AR, the addition of AR would not make them want to take more art history or design theory classes than necessary.

**Summary**

The findings of this study have been presented in this chapter. The IMMS was used to measure motivation and showed that the AR reading activity had medium-to-high motivation for
12 students. The post activity survey made several points including: (1) AR increased the motivation for reading academic theory text, (2) students would use similar AR supports in the future if they were provided, (3) both struggling and typical readers felt the AR support of visuals and content questions were helpful, and (4) struggling readers were able to access additional support like vocabulary without hindering typical readers with extra content. Finally, the focus group interview supports and expands on the post survey data. Interview responses supported points made in the survey including: (1) AR increased motivation, (2) students would use similar AR support in the future, (3) students felt the AR supports were helpful to an understanding of the content. The next chapter will display graphic charts of the collected data and report data used during the final chapter to answer the research question.

In the next chapter, I will discuss key findings, make connections to existing literature, and share recommendations for future research.
CHAPTER 5. DISCUSSION

Summary

The focus of this study was to explore how augmented reality could supplement academic texts used in the classroom. The guiding research question was: How does augmented text impact struggling readers’ perceived motivation, engagement, and confidence in understanding? This study was able to address how the use of an augmented printed text, enhanced with instructional scaffolds and visual aids, influenced three main areas. The areas of investigation were: (1) the level of motivation a design student had to read a design theory text, (2) engagement with vocabulary acquisition and (3) comprehension of academic text in higher education. After analyzing the data, the findings indicated that augmented reading support for academic texts increased perceived motivation, engagement, and confidence in understanding academic text for both struggling and typical readers. From this review, it was noted that 80% of students perceived an increase in confidence when using AR (Figure 4.2). Further, Using AR to add supports, readers -- whose struggles were demonstrated in prior research studies -- showed increased confidence in understanding academic texts. Both of these assumptions were proven though the current study. Additionally, a similar increase in comprehension confidence for typical readers, as well as struggling readers, occurred.

Discussion on Findings

Effects of Augmented Reality on Comprehension Confidence

The addition of AR to a printed text resulted in a marked increase in perceived comprehension confidence for both typical readers and self-identified struggling readers. The
addition of scaffolded reading support using AR was reported to be helpful for both typical and struggling readers. Scaffolding, a component of direct/explicit instruction, provides a struggling student with a support system that fades away as the student becomes more independent. Previous research has proven that scaffolded support is beneficial to readers (Azevedo, Cromley, & Seibert, 2004; Hill & Hannafin, 2001; Huang, Wu, & Chen, 2012). This study used AR supports in such a way that each student was able to choose how much support they wanted to access. A student could opt to spend more time re-visiting the vocabulary section or none at all.

The fading away of support scaffolding is an essential aspect in aiding learning and success (Chen, Kao, & Sheu, 2003; Kim & Hannafin, 2011). A three-step approach was implemented in this study to scaffold reading supports within text using AR. AR content provided: (1) pre-reading support, and chunking information, (2) vocabulary definitions to reference while reading, and (3) scaffolded comprehension questions that redirect back to the text if a question was missed. Research indicates that struggling readers can benefit from individual direct instruction (Rupley, Blair, & Nichols, 2009). Research supports explicit instruction practice, particularly when used for struggling learners (Archer, & Hughes, 2011; Kirschner, Sweller, & Clark, 2006; Marchand-Martella, Slocum, & Martella, 2004; Marchand-Martella, Martella, Modderman, Petersen, & Pan, 2013).

First, the pre-reading AR, which provided chunking (Appendix D) and access to key terms was found to be helpful for all students in the study (Figure 4.12). Most students agreed that having access to the vocabulary was helpful (Figure 4.14). All the students agreed that answering the comprehension questions helped them to better understand the article (Figure 4.15). Second, vocabulary can be a stumbling block for struggling readers. By increasing vocabulary knowledge, students can better comprehend and analyze text. Hall et al. (2014) note
that a student’s comprehension of an academic text should improve with the use of vocabulary acquisition scaffolding. During the focus group interview within this study, a student echoed similar findings stating,

I think the vocabulary was the best use [of the AR]. If I have to look up six words per page, it’s too time-consuming, but if they are right in the text, I can look up the definitions very quickly (Student Response Focus Group 2016).

Further, a student commented on the helpfulness of vocabulary support during the post-activity survey, “For me personally, my range of vocabulary is extremely low. I constantly have to google-search words to make sure I use them in the correct context, so having terms available on Aurasma is more efficient and can directly relate to the article.” Struggling readers reported vocabulary support being helpful at higher rates than typical readers. However, both typical and struggling readers agreed that pre-reading and comprehension questions were helpful at the same rate. Therefore, the results of this study further support what is known within in the field that vocabulary knowledge allows students to access, understand and apply content (Templeton et. al, 2015).

Third, previous research supports the use of direct instruction or the use of scaffolding for struggling readers (Edmonds et al 2009). Therefore it is not surprising that the self-perceived struggling readers found the augmented scaffolding helpful. However, it is interesting to note that the scaffolding was done though augmentation not teacher interaction. A previous study by Chen, Teng, and Lee (2011) showed the importance of scaffolded content beyond providing digital links to background knowledge. The data collected for this study is interesting because not only self-perceived struggling readers but typical readers as well felt the augmented support was helpful. Also, while previous research proves the usefulness of scaffolding, vocabulary and
chucking of information, this study shows it can be done digitally through the use of AR. The AR scaffolding increased the confidence of most students, including the self-identified struggling readers as well as the typical readers (Figure 4.2). This study also points out that some students may feel confident in their abilities to read required academic texts but also feel that they are struggling readers, therefore perceive themselves as struggling readers but at risk of skipping required readings. The data proves the use of scaffolding improves reading comprehension confidence in both struggling and typical readers. By improving comprehension confidence, struggling readers may be more likely to stick with a difficult reading. Also with improved comprehension confidence all students may be more likely to engage more fully in the classroom.

The incorporation of scaffolded resources and digital text affordances, such as TTS and integrated dictionaries, may provide greater aid to struggling readers than what is currently available. For instance: “Text to speech (TTS) engines can help struggling readers improve comprehension, fluency, and accuracy” (Berkeley, & Lindstrom, 2011, p.50). Students build word recognition and vocabulary when they hear words in context without interrupting comprehension (Silver-Pacuilla, Ruedel, & Mistrett, 2004). The current study supports this claim in that during the focus interviews all three students expressed liking the digital text capabilities of e-books especially the TTS option. Students preference for audio books was cross-tabulated with self-perceived struggling readers. The data shows most who preferred audio books over reading were also struggling readers or unsure about being a struggling reader. While not many students used the audio feature for this study, audio features would be more likely to be used by struggling readers. As a result, it is recommended that text to speech audio be provided in scaffolded reading support for struggling readers. Even though students during the focus group
expressed a desire for TTS, elaborating on its importance, the analyzed data revealed hardly any students used the audio feature during the study. This may have been an interface design issue, students may have been unaware of the audio feature or lacked headphones to use it. Since the data showed students who preferred audio books had a higher likelihood of being struggling readers, it is an important feature to add even if not everyone will use it. Having the audio support there will not inhibit typical readers but may have an impact on comprehension for struggling readers.

**Effect of Augmented Reality on Perceived Motivation**

AR in education research has documented increases in motivation and engagement (Billinghurst, & Denser, 2012; Green, Lea, & McNair, 2014). This study also showed that AR increased perceived motivation and engagement. Based on the responses to the IMMS, students agreed that AR was relatable and the AR layout held their attention. Analyzing the data showed a potential increase in both intrinsic and extrinsic motivation. The interactive engagement of AR increases motivation and learning retention (Billinghurst, & Denser, 2012).

Billinghurst, and Denser (2012) looked at using AR in the classroom and showed a significant benefit to students who struggled with traditional printed text-based learning. With the addition of AR, educators can bridge the gap between traditional static paper and digital content. Augmented print has the potential to reach a broader group of students, both those who prefer and benefit from traditional paper-based learning as well as students who struggle with it.

Both struggling and typical readers showed a self-perceived motivational increase in willingness to read class readings if AR support was available, during this study. Adding the AR support improved self-reported motivation to read an academic text. Even more interesting, the
two students who reported they would probably skip any required readings also indicated that they would be “extremely motivated” and “slightly more motivated” to read required class material with AR support. This cross tabulation (see Table 4.3) shows that AR support for reading has the potential to motivate those most at risk for skipping the readings, those who struggle, as well as those who already feel confident in their reading abilities. Most students said they would feel more confident reading an academic text if it had AR support features (see Table 4.4). Potentially, this increased confidence could translate into increased participation during class, with the greatest improvement seen in previously disengaged students. AR has increased the level of engagement for previously disengaged students in other studies as well. For instance, during an AR study by Dunleavy, Dede, Mitchell (2009) a teacher remarked on this. “I saw a lot of the kids...the lower end ones who are sort of turned off of class at this point in the year...those kids were some of the most engaged” (Teacher Interview 6/8/07). The data also indicated that adding the AR text support motivated students to read an academic text and students believe they would use the AR support if provided. To further address change of motivation, future studies should include measuring the current motivation for reading an academic text without AR before performing this study. The four students who said the AR had no effect on their reading motivation might have already been highly motivated to read an academic text for class based on other factors.

This data was also supported by the focus group interview. Students expressed that having access to AR supports could increase motivation to study art history if it could streamline tedious study preparations. Students agreed that the AR supports increased their comprehension of the article as well as assisting with vocabulary. Based on the data is seems likely that most students would not only benefit from augmented text but they would actually use them as well.
Effects of Augmented Reality on Engagement

When asked what they found engaging about the AR support, students’ responses indicated that the increase in motivation and confidence in understanding were the driving factors for engagement. “I felt like I understood more, so I felt like I was actually learning. Not just, oh, I think I'm understanding it. So, I wanted to keep reading because I felt like I was successful. And then being able to take the quiz at the end to make sure I understand the content” (student - focus group interview 2016). This student comment echoes the findings of Chen, Teng, & Lee, (2011) in that scaffolded questions can significantly improve comprehension. It also echoes the previously mentioned concept; students who perceive themselves as confident will want to continue reading as well as engage in class. Similar to an augmented learning activity conducted by Dunleavy, Dede, Mitchell (2009) where teachers reported positive behavior and engagement differences compared to normal classroom behavior, participants within this study expressed ways in which AR enhanced their engagement and understanding of content.

Physical textbooks can have additional interactive content added to them such as images, video, audio, 3D models, text, links to websites, or quizzes. Augmenting physical textbooks allows instructors to use textbooks they are already using. The addition of this content allows students to engage with content beyond what is available in a printed book (Billinghurst, & Denser, 2012). Augmentation of a textbook also provides reading support similar to an e-textbook, while allowing the instructor to tailor that support.
Implications

The results of this study indicate four key ideas: (1) AR increased the motivation for reading academic theory text, (2) students would use similar AR supports in the future if they were provided, (3) both struggling and typical readers felt the AR support of visuals and content questions were helpful, and (4) struggling readers were able to access additional support like vocabulary without hindering typical readers with extra content.

Within this study, I analyzed how to add AR reading support to printed material. Why bother looking at adding AR to printed material instead of providing support through e-books or pdfs? Many educators rely on existing 2D print media, some preferring its flexible, inexpensive and familiar nature (Kesim, and Ozarslan, 2012) while others are bound to currently owned printed textbooks for financial reasons. The use of AR to create interactive printed text can bring many of the same affordances of digital text, audio, and Internet access to a previously static text document. Additionally, the use of 3D models is common with AR and allows for information from a text to be experienced through channels other than 2D printed words (Billinghurst, & Denser, 2012). These 3D models can engage struggling readers and promote deeper comprehension (Billinghurst, & Denser, 2012; Green, Lea, & McNair, 2014). The use of AR bridges the gap in the classroom between existing print documents and the affordances of digital text that assist struggling readers. By incorporating AR into education now, educators can help shape the future of AR and become a driving force in its development (Billinghurst, & Denser, 2012).

With an increase in perceived motivation, engagement, and confidence in understanding established, further research should continue. Research into this line of inquiry will evolve with
the technology. Additionally, if educators communicate their needs to developers/designers the technology can be influenced by the research to provide AR tools tailored for use in the classroom and with print-based text. As the technology evolves, teacher education should incorporate these new technologies into their training. If teachers are familiar with AR technology they will be better equipped to use it in the classroom as well as drive future development. This data implies that researchers should next look into how to best design AR experiences for the classroom as well as how AR learning games could improve comprehension and retention for art history classes in higher education for struggling readers.

**Limitations of this Study**

AR is a relatively new medium but the results of this study indicate its promise to support and motivate students. There were three limitations to the scope of this study including: cost/availability of technology, device size and type, and lack of a pre-AR activity survey. During this study, the simplest, and most cost-effective, way to incorporate AR was to use smartphones or tablets. While this study was limited to the available, and cost effective hand-held mobile devices, the future of AR could evolve rapidly. “Ultimately, we will see extensive use of multisensory AR systems” (Craig, 2013, Location No. 5028-5029). The evolution of how we can bring AR into the classroom could bring even greater improvements for struggling readers, based on the mode of delivery.

The device used for implementing AR also can present challenges. Depending on what you are augmenting, and the size of the device, the act of holding the device in place could prove cumbersome, frustrating or tiring. While mobile AR applications can be conveniently run
through a phone or tablet, the applications are limited to the constraints of that device (Craig, 2013).

Mobile devices such as tablets and smartphones have become more affordable, yet not every classroom has access to a set of devices. Also, when using a bring-your-own-device (BYOD) approach, students may have a range of devices, some with more limitations than others. Additionally, the majority of AR applications used on tablets or smartphones to augment print are set up to create marketing or advertising content. While vast potential exists for what these programs can do in a classroom, they are not designed for educational uses.

This study was limited by a lack of an IMMS measurement for reading a design theory academic text without AR limited this study. IMMS questions addressed the motivation for the whole reading activity including reading a design theory text, not just using AR. No measurement of reading a theory text without AR was taken using the IMMS. Therefore, this study cannot show compared data to measure an increase in motivation to read a text based on using the IMMS results.

**Future Research**

This study aimed to explore if AR could increase perceived motivation, engagement and comprehension confidence. Analysis of the data indicates that AR reading support does increase these areas for higher education students including struggling readers. Knowing that AR can enhance perceived motivation, engagement and comprehension confidence, new studies should look at how best to implement AR reading support to benefit all students.

This study was limited to using AR through mobile devices. In the future, less intrusive ways to offer AR support may exist. Craig (2013) notes that in the future more will be done
through lightweight displays, such as glasses or contact lenses, as well as projected environments, instead of relying on tablets or smartphones. Continuing AR research in the classroom is critical for the development of classroom-appropriate software and hardware. Billinghurst & Denser (2012) study points out the need for more research on AR in a classroom setting and the positive effect of interactive AR experiences on motivation, engagement and learning retention, especially for struggling readers. This AR reading support study also shows a need for future research. If motivation, engagement, and comprehension confidence are improved through AR, more studies should be done to maximize the benefits of AR in the classroom.

After a review of the literature in chapter two, three overall lessons can be taken away from previous studies (1) need for more AR research in the classroom, (2) incorporation of instructional goals/standards, and (3) use of scaffolding. Billinghurst & Denser (2012) shows a significant benefit to struggling readers when using AR in the classroom but more research is needed. Hutchison, Beschorner, & Schmidt-Crawford (2012) pointed out the importance of incorporating instructional goals and core standards when using technology in the classroom. Finally, the Chen, Teng, & Lee (2011) study showed that adding digital resources for background knowledge was not enough to improve literacy; however, incorporating scaffolding provided significant benefits to comprehension.

This study specifically looked at adding scaffolded reading support to printed readings. Future studies could take this several steps further and look at how AR can create a customized learning environment for each student in the classroom. Based on the results of this initial study a number of subsequent studies exploring the use of AR for scaffolded reading support through different lenses can now be employed. A preliminary study would examine the augmented
interface. Before further research is done, a redesign of the interface using user experience research methods, and usability testing should happen. Research questions could include: How can the interface use visual cues most effectively to aid struggling readers. How can other means of interface aid struggling readers, beyond visual cues and reading?

In addition to interface design, there is a need to examine how AR can provide custom scaffolding that removes itself over time. What parts of the scaffolded support should fade over time and which should remain as resources? Once the interface is redesigned to optimize usability and the scaffolding reimagined, a quasi-experiment can measure comprehension effects. Using two art history sections, AR activities and the IMMS survey, this quasi-experiment could explore the use of augmented text on comprehension compared to traditional printed text.

Eventually, a study to explore new tech could look at a range of new ways to access the AR content. Smartphones or tablets can be cumbersome, but they are also familiar. Smartglasses or contacts may require major interface overhauls. What other ways can technology allow us to augment and experience these readings?

Additionally, research should explore how AR could allow for students to learn through experience. Future research based on this study will look at how art history and design theory classes could become more hands-on though AR. Reading academic texts are an important part of higher education; however, by allowing for multimodal ways of experiencing the content, students will be able to participate at a deeper level. For instance, the design of AR games for art history could allow for deeper understanding of how time, place, and historical events influence artwork. Being able to experience art history through an AR game could enable students to engage with the material on a deeper level than only reading about it. The AR game would also
support struggling readers who previously may have avoided art history classes as too much work or too difficult.

Research on struggling readers in higher education is limited, but reported learning disabilities in higher education are increasing. Therefore, it is important to continue researching struggling readers in higher education. Research on AR in the classroom is still limited, even though it has become more common. As AR technology changes, new research is needed to understand AR benefits for the classroom.

Conclusion

This study explored the use of augmented reality to supplement academic text in the classroom. The guiding research question was: How does augmented text impact struggling readers’ perceived motivation, engagement and confidence in understanding?

After exploring the data, the findings indicate that augmented reading supports for academic text increase motivation, engagement, and confidence in understanding as perceived in struggling readers as well as typical readers. Students in this study also indicated that they would use AR reading support if available for other texts. With increased perceived motivation, engagement, and confidence in understanding established, further research should continue. Research into this line of inquiry will evolve with the technology. Additionally, if educators communicate their needs to developers/designers the technology can be influenced by their experience and insights to provide AR tools tailored for use in the classroom and with print-based text. Future research should look into how to best design AR experiences for the classroom as well as how AR learning games could improve comprehension and retention for art history classes in higher education for struggling readers.
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Huang, W., Huang, W., Diefes Dux, H., & Imbrie, P. K. (2006). A preliminary validation of Attention, Relevance, Confidence and Satisfaction model based Instructional Material


APPENDIX A. IRB PAPER WORK

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Date: 4/27/2016
To: Dr. Laura Hulsinga
158 Design

From: Office for Responsible Research

Title: Using Augmented Text for Design Theory

IRB ID: 15-206

Study Review Date: 4/27/2016

The project referenced above has been declared exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b) because it meets the following federal requirements for exemption:

- (1) Research conducted in established or commonly accepted education settings involving normal education practices, such as:
  - Research on regular and special education instructional strategies; or
  - Research on the effectiveness of, or the comparison among, instructional techniques, curricula, or classroom management methods.

- (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey or interview procedures with adults or observation of public behavior where
  - Information obtained is recorded in such a manner that human subjects cannot be identified directly or through identifiers linked to the subjects; or
  - Any disclosure of the human subjects' responses outside the research could not reasonably place the subject at risk of criminal or civil liability or be damaging to their financial standing, employability, or reputation.

The determination of exemption means that:

- You do not need to submit an application for annual continuing review.

- You must carry out the research as described in the IRB application. Review by IRB staff is required prior to implementing modifications that may change the exempt status of the research. In general, review is required for any modifications to the research procedures (e.g., method of data collection, nature or scope of information to be collected, changes in confidentiality measures, etc.), modifications that result in the inclusion of participants from vulnerable populations, and/or any change that may increase the risk or discomfort to participants. Changes to key personnel must also be approved. The purpose of review is to determine if the project still meets the federal criteria for exemption.

Non-exempt research is subject to many regulatory requirements that must be addressed prior to implementation of the study. Conducting non-exempt research without IRB review and approval may constitute non-compliance with federal regulations and/or academic misconduct according to ISU policy.

Detailed information about requirements for submission of modifications can be found on the Exempt Study Modification Form. A Personnel Change Form may be submitted when the only modification involves changes in study staff. If it is determined that exemption is no longer warranted, then an Application for Approval of Research Involving Humans Form will need to be submitted and approved before proceeding with data collection.

Please note that you must submit all research involving human participants for review. Only the IRB or designee may make the determination of exemption, even if you conduct a study in the future that is exactly like this study.

Please be aware that approval from other entities may also be needed. For example, access to data from private records (e.g., student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other...
APPENDIX B. DIRECTIONS OF AR READING ACTIVITY

Participant #006
Please enter your participant number on the comprehension questions and post-survey.

This is an augmented academic reading, after the activity an optional post-survey can be taken. Taking the survey will not affect your grade and is anonymous. Your participant number will not be tied to your name. Survey results will be analyzed after I hand grades in to be used as data in my dissertation.

Thank you for taking the time to help further design education research.:)

1. Before reading text scan with Aurasma app. Click on structure button and view the document over view (scan both pages). Next click on the voc list and review any words you are unsure about.

2. Read the paper article, you can refer back to the voc at anytime though Aurasma, there is also a dictionary widget on the voc page.

3. After reading the article use Aurasma to access the comprehension questions.

4. Finally take the 10-15min post survey. Link in Aurasma at the end of the reading.

(user name: huisinga)
APPENDIX C. SCREENSHOTS OF AR INTERFACE
APPENDIX D. PREREADING SCREEN SHOTS

Visual Literacy and the Design of Digital Media

Susan Roth
Department of Industrial Design
Ohio State University

Introduction:
Creating understanding & communicating using visuals. The same principles & elements used in art can apply to interface design.

Basic Principles and Concepts
Gestalt: principles of "configuration".

The whole is greater than the sum of the parts.

Similarity
Similarity between two or more visual elements: size, shape, pattern, style, or color

Notice app icons size, shape, colors, and line weight.

Positional consistency of Navigation Bar & Tool Bar in ISO apps.

Contrast
High vs. Low Contrast

Proximity
Proximity groups elements, to create understanding.

Noticed the same data set is easier to read with the distance or proximity is changed to create visual groups of information.

Figure-ground
Faces or Vases
Visually seeing the “figure” separated from the larger field of view or “ground”

High contrast between figure & ground is important for text.
**Vocab**

**Structure**

**Questions**

**Visual Hierarchy**

**YOUR EYES HERE**

(then here)

Guide interaction, shape viewing experience by controlling viewing order and focus attention.

**Color interaction**

Color interaction is relative. Colors are affected by surrounding colors.

Color is composed of:
Hue, Value, and Saturation or Chroma

**Value**

Value helps contrast of hues to improve readability.

**Visual Metaphor and Graphic Icons**

Icons are metaphorical symbols, either geometric & abstract or representational.

Concerns about the number of icons displayed on the menu bar. The addition of more icons and functions does not necessarily make an interface easier to use.

*Typographic Considerations*

Research on case in print media has generated rules and recommendations found to result in...

**Type size, style and spacing**

Type size, style and spacing varies depending on screen size and intended use.

Recommended line length consists of approximately 65 characters, including spaces and punctuation.

**Design and Development of Digital Media**

Visual Literacy is important to the design and development of digital media.

I have completed the reading and comprehension questions.

**Click to take post task survey**
APPENDIX E. VOCABULARY SCREEN SHOTS

- Gestalt Movement
- Human Visual Perception
- Synergistic
- Similarity*
- Perceptual grouping
- Salient*, describing which indicates overall trends as well as salient details.
- Proximity*
- Contrast*
- Conspicuity
- Signage
- Fostered
- Legibility
APPENDIX F. SCAFFOLDED COMPREHENSION QUESTIONS

What is your participant number?

What is the Gestalt Principle most concerned with?

A: Singling out individual items or principles that make up a whole.

B: Our visual perception of the unified whole by how we use principles to group elements.

2.) Check all the principles that the article talked about as tools for visual literacy.

- Similarity
- Proximity
- Radiation
- Contrast
- Balance
- Figure-ground
- Visual Hierarchy
- Color Interaction
How does close proximity affect elements visually?

A: Groups elements together.

B: Creates confusion by placing similar items near each other.

When navigating an App is it easier if the navigation is:

A: In a clear consistent menu with all items in close proximity to each other or

B: Links scattered thought out the page far away from each other?
When you have multiple visual elements high contrast can be used to:

A. Make a key element standout
B. Blend elements into the background

Would high or low contrast text be easier to read?

**High contrast** or **Low Contrast**

High Contrast: Black text on white background
Low Contrast: Light gray text on a white background
High contrast for figure and ground relationships is especially important in...

- Background patterns
- Text against a background

Refer back to the Figure-ground section if need. Which scenario would be easier to read?

- Low contrast text on top of a high contrast pattern
- High contrast text on top of a low contrast pattern
According to the article what is an optimum character count for a good line length with a font at 10-12pt?

- 85 characters
- 65 characters
- 50 characters

When reading a publication printed on 8x11 paper how many columns would be easier to read large amounts of text at 10x12pts?

- One large column that spans the whole page.
- 2-3 columns on a page
- 5-7 columns on a page
Refer back to the Figure-ground section if need. Which scenario would be easier to read?

- Low contrast text on top of a high contrast pattern
- High contrast text on top of a low contrast pattern

When you have multiple visual elements high contrast can be used to:

A. Make a key element stand out
B. Blend elements into the background
Please complete this short survey as honestly as possible. The survey is anonymous and the ID number you enter will only be used to tie your survey to the comprehension questions not to you personally. You may exit the survey at anytime if you are uncomfortable. Completion of this survey is completely voluntary and will not affect your grade in this class. By clicking next you are consenting that you are 18yr or older and consenting to participate in this anonymous survey.
APPENDIX H. IMMS

1. There was something interesting at the beginning of this activity that got my attention.

2. The Augmented Overlay and links are eye catching.

3. The quality of the writing in this activity holds my attention.

4. The way the Augmented information is arranged on the pages helped keep my attention.

5. This activity has things that stimulated my
5. This activity has things that stimulated my curiosity.

absolutely absolutely not true not true true true
0 1 2 3 4 5 6 7 8 9

6. The variety of reading passages, vocabulary, illustrations, etc., helped keep my attention on the reading.

absolutely absolutely not true not true true true
0 1 2 3 4 5 6 7 8 9

7. I could relate the content of the activity to things I have learned in class, or learned or thought about in my own life.

absolutely absolutely not true not true true true
0 1 2 3 4 5 6 7 8 9

8. I enjoyed this activity so much that I would like to know more about it.

absolutely absolutely not true not true true true
0 1 2 3 4 5 6 7 8 9
9. I really enjoyed learning with this activity.

absolutely not true absolutely not true true true
0 1 2 3 4 5 6 7 8 9

10. The augmented layer and/or vocab links made me feel rewarded for my effort.

absolutely not true absolutely not true true true
0 1 2 3 4 5 6 7 8 9

11. It was a pleasure to work on this activity.

absolutely not true absolutely not true absolutely false
0 1 2 3 4 5 6 7 8 9

12. It is clear to me how the content of this activity relate to this class.

absolutely not true absolutely not true absolutely false
0 1 2 3 4 5 6 7 8 9

13. There are sufficient vocabulary & visual aids that showed me how this reading activity could
13. There are sufficient vocabulary & visual aids that showed me how this reading activity could be important to some people who struggle with reading academic texts.

absolutely  absolutely
not true  not true  true  true
0 1 2 3 4 5 6 7 8 9

14. The content of the activity will be useful to me in terms of comprehending and retaining the academic article.

absolutely  absolutely
not true  not true  true  true
0 1 2 3 4 5 6 7 8 9

15. This activity was so abstract that is was hard to keep my attention on it.

absolutely  absolutely
not true  not true  true  true
0 1 2 3 4 5 6 7 8 9

16. The exercises in the activity were too difficult.

absolutely  absolutely
not true  not true  true  true
0 1 2 3 4 5 6 7 8 9

17. Many of the pages contained so much...
17. Many of the pages contained so much information that it was hard to pick out and remember the important points.

<table>
<thead>
<tr>
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<tr>
<td>0 1 2 3 4 5 6 7 8 9</td>
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</table>

18. After working with this activity for a while, I was confident that I would be able to explain what this article was about to a peer.

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<tbody>
<tr>
<td>not true</td>
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<tr>
<td>0 1 2 3 4 5 6 7 8 9</td>
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</table>

19. I could not really understand quite a bit of the material in this activity.

<table>
<thead>
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<tbody>
<tr>
<td>not true</td>
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<tr>
<td>0 1 2 3 4 5 6 7 8 9</td>
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</tbody>
</table>

20. The amount of repetition in this activity caused me to be bored sometimes.

<table>
<thead>
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<tr>
<td>not true</td>
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<tr>
<td>0 1 2 3 4 5 6 7 8 9</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX I. POST ACTIVITY QUESTIONNAIRE

Typically, how confident are you with your ability to read art/design history/theory texts?

- Very confident
- Mostly confident
- Not sure
- Not very confident
- I would probably skip any required readings

Did having access to the augmented content improve your confidence in reading this academic design theory text?

- Yes
- Not sure
- No

Have you ever dropped a college level class because of the reading load?

- Yes
- Not sure
- No
Do you enjoy reading for fun outside of required class material?

Yes
not sure
No

Do you prefer listening to audio books over reading on your own?

Yes
not sure
No

Would you consider yourself a struggling reader when reading academic history/theory texts?

Yes
not sure
No

Powered by Qualtrics
Would you use this technique if it were available for other texts?

Yes
No
Maybe

How difficult was it to access the augmented content in general?

Extremely easy
Moderately easy
Slightly easy
Neither easy nor difficult

How difficult was it to access the augmented content in general?

Extremely easy
Moderately easy
Slightly easy
Neither easy nor difficult

How helpful was the pre reading
How helpful was the pre reading structure content for your understanding of the text? (1-least helpful 5 most helpful)

5 Very helpful
4 Helpful
3 Somewhat helpful
2 Not very helpful
1 Pointless

How often did you refer back to augmented vocabulary while reading?

5 or more times
2-4
Once
Never
Didn't realize you could access augmented Vocabulary words while reading.

How helpful was the ability to refer back to vocabulary while reading? (1-
How helpful was the ability to refer back to vocabulary while reading? (1-least helpful 5 most helpful)

5 Very helpful
4 Helpful
3 Somewhat helpful
2 Not very helpful
1 Pointless

Did you find answering the comprehension questions helped you understand the article better?

5 Very helpful
4 Helpful
3 Somewhat helpful
2 Not very helpful
1 Pointless

Did you refer back to the text while answering the questions?

A few times
Did you refer back to the text while answering the questions?

- A few times
- Once
- Never

Did you use the audio feature?

- Listened to text while working on other things or doodling.
- Listened to text while reading the document.
- Did not listen to text with the audio feature.
- Other

Which features did you find the most helpful in understanding the article? (pick 1-3 of the most helpful features)

- The structure overview
- Access to the vocabulary words
- Answering the comprehension questions
- Audio feature
- Using the prompts in the comprehension questions to refer back to specific parts of the text.
- Did not find anything useful.

Why did you find these features
Why did you find these features helpful or not helpful please explain?

If you had access to an augmented art history book would you use it to: (check all that apply)

- Look up vocabulary
- Answer comprehension questions after reading
- Explore expanded information about specific artists
- Explore expanded historic information about specific time periods
- Take a virtual tour of historic places during various time periods
- Play games that tested your art history knowledge.
- I would not use the augmented portion, only read the text
- I wouldn’t read the textbook or used the augmented reality portion.
Would you feel more confident reading academic text if these augmented features were provided?

- Much more confident
- Slightly more confident
- No more confident than normal
- Less confident because it adds a layer of complication
- I would probably skip any required readings

Would you be more motivated to do the readings for a class if these augmented features were provided?

- Extremely motivated
- Slightly more motivated
- No more motivated than normal
- Less motivated, because it adds a layer of complication
- I still wouldn't read the required readings

Thank you for completing this survey, I greatly appreciate your time and effort.